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NBS

PUBLICATION

# PUBLICATIONS OF THE NATIONAL BUREAU OF STANDARDS

U.S. DEPARTMENT OF COMMERCE  
NBS SPECIAL PUBLICATION 305/SUPPLEMENT 12

## 1980 CATALOG



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No. 305

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C.2

## 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 — Thermodynamics and Molecular Science — 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> — Mechanical Engineering and Process Technology<sup>2</sup> — Building Technology — Fire Research — Consumer Product Technology — Field Methods.

**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.



# Publications of the National Bureau of Standards 1980 Catalog

A Compilation of Abstracts and Key Word and Author Indexes

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Betty L. Burris and Rebecca J. Morehouse, Editors

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

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary  
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

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## 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

#### A. Symbols for the Periodicals

Index Symbol			Issue Date	Page Number
NBS Journal of Research	Vol.	No.	1980—Bimonthly	
	J. Res. 85	1	January–February	9
	J. Res. 85	2	March–April	9
	J. Res. 85	3	May–June	10
	J. Res. 85	4	July–August	11
	J. Res. 85	5	September–October	11
	J. Res. 85	6	November–December	12

Journal of Physical and Chemical Reference Data	Index Symbol		Issue Date	Page Number
	Vol.	No.		
	JPCRD 9	1	1980	14
	JPCRD 9	2	1980	14
	JPCRD 9	3	1980	15
	JPCRD 9	4	1980	15

Index Symbol			Issue Date	Page Number
DIMENSIONS/NBS	Vol.	No.	1980—10 issues per year	
	DIM/NBS 64	1	January/February	17
	DIM/NBS 64	2	March	17
	DIM/NBS 64	3	April	17
	DIM/NBS 64	4	May/June	17
	DIM/NBS 64	5	July	17
	DIM/NBS 64	6	August	17
	DIM/NBS 64	7	September	18
	DIM/NBS 64	8	October	18
	DIM/NBS 64	9	November	18
	DIM/NBS 64	10	December	18

## B. Symbols for the Nonperiodicals

NBS Nonperiodical Series	Index Symbol	Page Number
Monographs	Monogr.	19
Handbooks	H	20
Special Publications	SP	22
Applied Mathematics Series	AMS	104
National Standard Reference Data Series	NSRDS	105
Building Science Series	BSS	106
Federal Information Processing Standards Publications	FIPS PUBS	108
Voluntary Product Standards	VPS	110
Technical Notes	TN	111
Consumer Information Series	CIS	116
NBS Interagency Reports	NBSIR	117
Grant/Contract Reports and Patents	GCR and/or NBS Patent	142

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

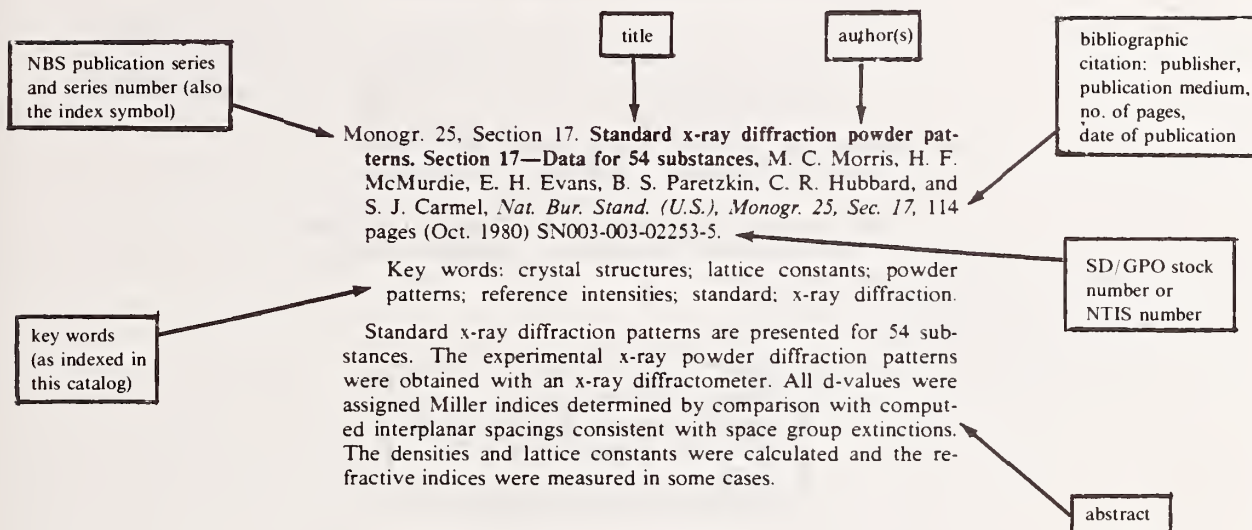
NBS Papers Published in Non-NBS Media	Index Symbol	Page Number
Professional Journals, Books, Book Chapters, Proceedings, etc.	Five-Digit numbers, 19049 through 19961	165

SAMPLE  
ENTRIES  
FOLLOW

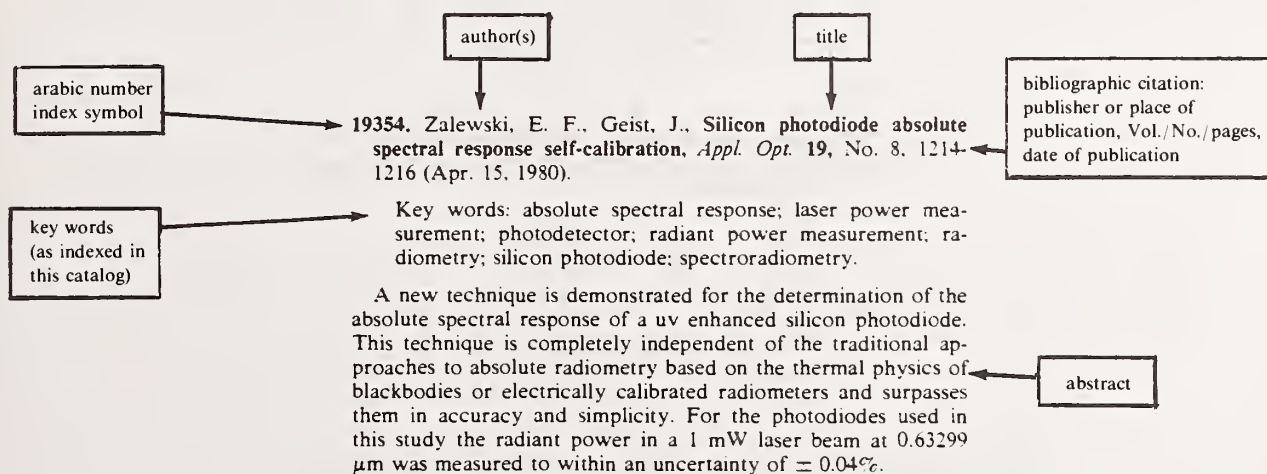


# CATALOG ENTRIES: HOW TO READ THEM

## Abstracts—Sample Entries

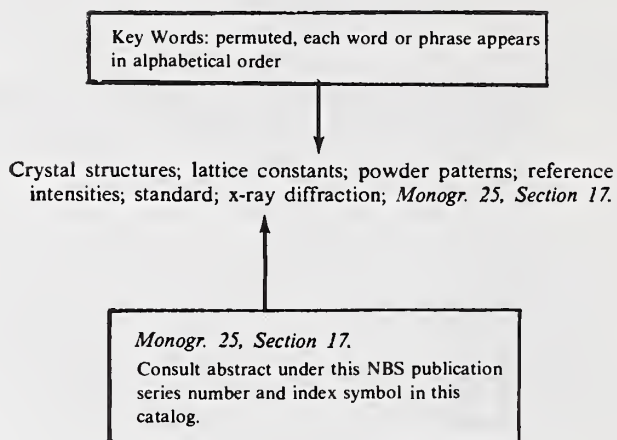


## Example of NBS published paper



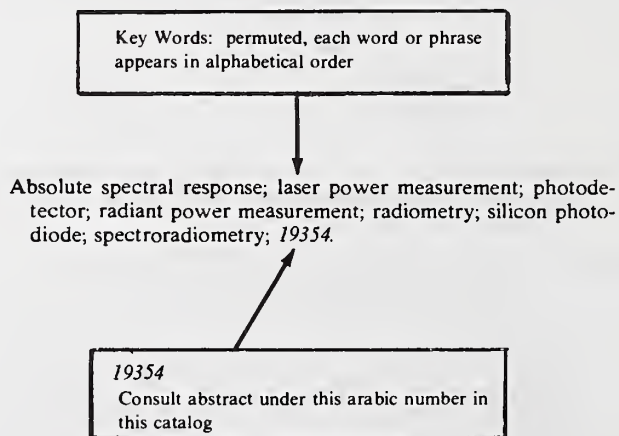
## Example of NBS paper published in non-NBS media

## Key Words—Sample Entries



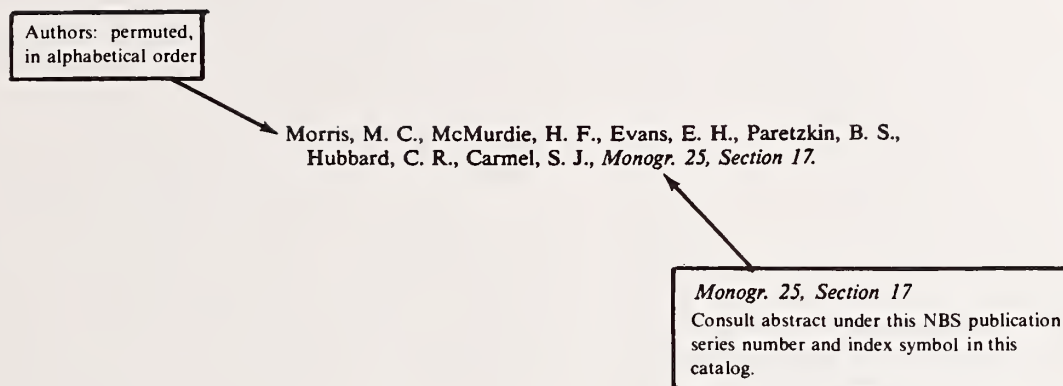
## Example of NBS published paper

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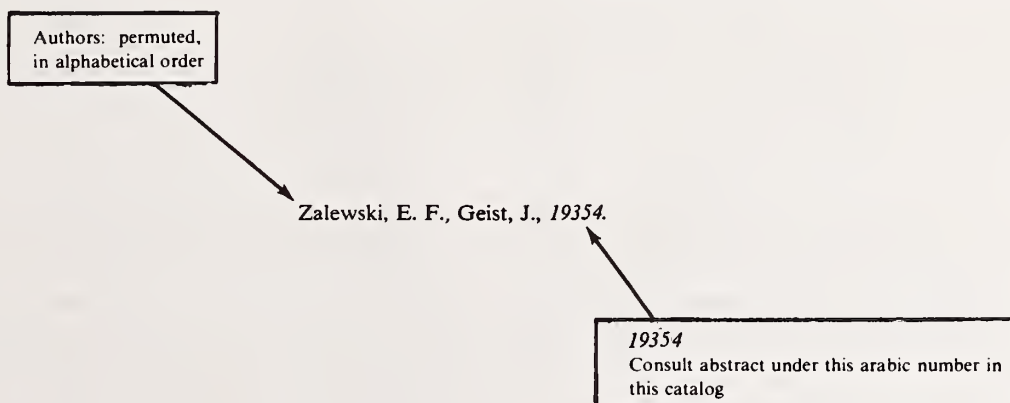
## Example of NBS paper published in non-NBS media

## Authors—Sample Entries



## Example of NBS published paper

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## 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 3 periodicals, its 12 nonperiodical series, and articles in the journals of professional organizations and technological associations.

In 1980, over 56,417 pages were published by NBS in 2,119 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 1979 but not reported in previous issues of this annual catalog.

The NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES, formerly issued by the Cryogenic Data Center of the National Bureau of Standards, Boulder, CO was discontinued in 1980.

This annual catalog, Publications of the National Bureau of Standards, lists the 1980 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:

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**DIMENSIONS/NBS**—This monthly magazine is published to inform scientists, engineers, business and industry leaders, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

The table of contents for each issue is listed in section 5.3.

Editors: Marion S. Cord and Justine A. Williams.

**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, nor for descriptive or primarily theoretical review articles. (See also sec. 5.8 National Standard Reference Data Series.)

## 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. PURCHASE PROCEDURES AND DOCUMENT AVAILABILITY

Most publications of the Bureau are available 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 app. B).

Microfiche copies of all recent NBS publications, and paper copies of many nonperiodicals, may be ordered through 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.** Remittances for publications should be mailed to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, by money order or check. Master Charge and VISA are also accepted. 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

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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

Periodical	Domestic <sup>1</sup>	Foreign <sup>2</sup>
Journal of Research of the National Bureau of Standards:		
Paper covers .....	\$16	\$20
Bound volume (1 volume per year), blue buckram .....	( <sup>3</sup> )	( <sup>3</sup> )
DIMENSIONS/NBS: issued monthly	\$11	\$13.75
single copies.....	1.10	1.40

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 of the bound volumes vary. The Superintendent of Documents will furnish prices on request.

## 4.2 PRICES FOR NONPERIODICALS

Prices are subject to change without notice, and the prices charged on your order will be those in effect as of the date your order is processed. Except for the Federal Information Processing Standards Series (FIPS) and the National Bureau of Standards Interagency Reports (NBSIR's), which are only available by purchase from the National Technical Information Service, Springfield, VA 22161, publications may be ordered from the Superintendent of Documents, U.S. Government Printing Office. SD order forms are included at the end of this publication.

For availability and price of Patents see section 4.

Your nearest depository library may still have a copy of out-of-print NBS publications. (See sec. 4.5.) Many NBS publications may be purchased from the National Technical Information Service. (See sec. 4.)

## 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, \$3.50.

*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 \$63.

*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 \$10 hardcopy and \$3.50 microfiche and N67-14099, at \$6 hardcopy and \$3.50 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 Directory of Testing Laboratories, issued as STP 333D, is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, at \$3.75.

*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 \$22.50 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, 1977 edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2-1977, at \$6.50.

*Handbook 46, Code for Protection Against Lightning.* A United States of America Standards Institute Code for Protection Against Lightning (NFPA-78-1977) is available from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at \$5.25, as ANSI/NFPA78-1977.

*Handbook 48, Control and Removal of Radioactive Contamination in Laboratories.* Reprints of this Handbook can be purchased as NCRP Report 8 at \$4 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 \$4 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 \$4 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 \$7.

*Handbook 58, Radioactive Waste Disposal in the Ocean.* Reprints of this Handbook can be purchased as NCRP Report 16 at \$4 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 \$6 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 \$6 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 \$6 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 \$4 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 \$6.25.

*Handbook 73, Protection Against Radiations from Sealed Gamma Sources (Supersedes H54).* Reprints of this Handbook can be purchased as NCRP Report 40 at \$6 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 \$4 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 \$5.

*Handbook 80, a Manual of Radioactivity Procedures.* Reprints of this Handbook are available as NCRP Report 58, for paper copy at \$12, and buckram at \$14. 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,

1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2-1977, at \$6.50.

*Handbook 84, Radiation Quantities and Units.* Reprints of this Handbook can be purchased as ICRU Report 33 at \$7 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 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 30175, Washington, DC 20014, at \$7.

*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, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2-1977 at \$6.50.

*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 \$5.

#### 4.4 ANNOUNCEMENTS OF NBS PUBLICATIONS

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

*DIMENSIONS/NBS.* In addition to publishing technical news of the Bureau, this magazine announces selected new papers published in the various NBS series. See section 4.1 for subscription information.

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

*NBS Publications Newsletter.* This newsletter is issued approximately six times a year. It presents full citations, including abstracts and availability information, for NBS papers published during the report period. Its primary audience includes librarians, documentalists, and science information specialists. However, other NBS audiences also find it useful as a guide to new NBS publications.

Contact: Editor, NBS Publications Newsletter, Technical Information and Publications Division, National Bureau of Standards, Washington, DC 20234.

*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, \$80; \$100 foreign.

*Selected List of U.S. Government Publications.* Issued monthly by the Superintendent of Documents. Each list is arranged by subject, with annotations, prices, and order form. May be obtained free from the U.S. Government Printing Office, Superintendent of Documents, Mail List Section, Stop SSOM, Washington, DC 20402.

*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, 1980. The catalogs are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, unless otherwise stated, 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 .....	\$8
Supplement 10 to Special Publication 305: Publications of the National Bureau of Standards, 1978. 679 pages including author and key word indexes .....	\$11
Supplement 11 to Special Publication 305: Publications of the National Bureau of Standards, 1979. 615 pages including author and key word indexes .....	\$11
Supplement 12 to Special Publication 305: Publications of the National Bureau of Standards, 1980. 000 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 .....	\$23.75
SP535, Volume 2 .....	\$21.25

\*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.

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 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, 1980

### 5.1 PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 85, JANUARY-DECEMBER 1980

#### January-February 1980

**Absolute isotopic abundance and the atomic weight of a reference sample of thallium**, L. P. Dunstan, J. W. Gramlich, I. L. Barnes, and W. C. Purdy, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 1, 1-10 (Jan.-Feb. 1980).

Key words: absolute ratios; atomic weight; isotopic abundance; reference standard; thallium; thallium chromate.

The accepted atomic weight of thallium has remained at a value of  $204.37 \pm 0.03$  since 1962. At this level of uncertainty, however, the atomic weight becomes a limiting factor to high accuracy analysis.

The new mass spectrometric determination of the atomic weight of thallium has been completed. A high precision assay technique was developed so that accurately known quantities of the  $^{203}\text{Tl}$  and  $^{205}\text{Tl}$  separated isotopes could be mixed to produce standards for calibration of the mass spectrometer. This assay technique involved the gravimetric determination of 99.3 percent of the thallium as  $\text{Tl}_2\text{CrO}_4$ . The soluble thallium was then aliquoted and determined by isotope dilution mass spectrometry. Before making up the final solutions from which the assay and calibration samples would be withdrawn, the separated isotopes were purified by solvent extraction and electrodeposition.

A tungsten filament surface ionization technique was developed for the determination of precise isotopic abundance measurements for thallium. This technique allowed isotopic analysis of the separated isotopes, calibration standards, and a natural thallium reference standard with precisions of better than 0.1 percent. The  $^{205}\text{Tl}/^{203}\text{Tl}$  absolute isotopic abundance ratio of the reference sample was found to be  $2.38714 \pm 0.00101$ , yielding an atomic weight of  $204.38333 \pm 0.00018$ .

**Enthalpies of dilution of aqueous electrolytes: Sulfuric acid, hydrochloric acid, and lithium chloride**, Y. C. Wu and T. F. Young, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 1, 11-17 (Jan.-Feb. 1980).

Key words: calorimetry; electrolytes; enthalpy of dilution; heat; hydrochloric acid; lithium chloride; relative apparent molal enthalpy; relative partial molal enthalpy; sulfuric acid; thermochemistry.

Calorimetric measurements at 25 °C of the enthalpies of dilution of aqueous  $\text{H}_2\text{SO}_4$  (0.00090 to 6.4 mol·kg<sup>-1</sup>), LiCl (0.026 to 6.7 mol·kg<sup>-1</sup>), and HCl (0.018 to 1.6 mol·kg<sup>-1</sup>) have been performed using two different isothermal calorimeters. The results of this work and that of three earlier calorimetric investigations and one Raman spectral investigation have been used to calculate values of the relative apparent molal enthalpies, and relative partial molal enthalpies for these electrolytes.

**Standardization of Iridium-192 gamma-ray sources in terms of exposure**, T. P. Loftus, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 1, 19-25 (Jan.-Feb. 1980).

Key words: exposure standard; iridium-192 seeds; NBS standard graphite chambers; open-air geometry; reentrant chamber.

Iridium-192, in the form of small platinum- or stainless-steel-clad seeds, is used for radiation therapy. Standardization of this radionuclide, for the quantity of exposure was carried out by measuring groups of seeds in an open-air geometry, using the NBS standard graphite cavity ionization chambers, and transferring the exposure data to a re-entrant ionization chamber.

Tables are provided from which the corrections for the graphite chamber have been calculated along with corrections for room scattering.

Radiographs of the source arrays are shown and details of the re-entrant chamber source measurements and construction are provided.

As assessment of the errors involved in establishing this standard leads to a statement of 2 percent for the overall uncertainty in the calibration of an iridium seed for the quantity exposure.

**A practical test of the air density equation in standards laboratories at differing altitude**, R. M. Schoonover, R. S. Davis, R. G. Driver, and V. E. Bower, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 1, 27-38 (Jan.-Feb. 1980).

Key words: air density equation; buoyancy correction; double substitution weighing; uncertainty in weighing.

A number of weighings of kilogram artifacts have been completed at sites of differing altitude. The artifacts and altitude difference were chosen to amplify the role of the necessary buoyancy corrections and thereby to uncover systematic errors in those corrections as they are usually applied. Small systematic effects were discovered but these are not explainable by buoyancy errors. Rather, we suggest their source is a lack of thermal equilibrium between the artifacts and the balance chamber.

#### March-April 1980

**Pseudo-oxocarbons. Synthesis of 2,1,3-bis-, and 1,2,3-tris (dicyanomethylene) croconate salts. New bond-delocalized dianions, "Croconate Violet" and "Croconate Blue"**, A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 2, 73-86 (Mar.-Apr. 1980).

Key words: acid; aromatic; bond-delocalized; croconic; dianion; malononitrile; nonbenzenoid; oxocarbon; salt; synthesis.

Synthesis and characterization of new bond-delocalized dianions, e.g., 2,1,3-bis-, 1,2,3-tris(dicyanomethylene) croconate salts have been described. The dianions reported represent a new class of aromatic, nonbenzenoid compounds, named pseudo-oxocarbons. A study of their physical, analytical and chemical properties offer a new direction in the chemistry of oxocarbons.

**New bond-delocalized dianions: The crystal structure of 1,3-bis (dicyanomethylene) croconate salt ( $\text{C}_{11}\text{N}_4\text{O}_3\text{K}_2 \cdot 2\text{H}_2\text{O}$ )**, V. L. Himes, A. D. Mighell, C. R. Hubbard, and A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 2, 87-97 (Mar.-Apr. 1980).

Key words: bond delocalized dianion; oxocarbon; single-crystal; structure refinement; x-ray diffraction.

$\text{C}_{11}\text{N}_4\text{O}_3\text{K}_2 \cdot 2\text{H}_2\text{O}$  crystallizes in the triclinic space group  $\bar{P}1$  with  $a = 8.568(2)$ ,  $b = 9.105(4)$ ,  $c = 9.818(4)\text{\AA}$ ,  $\alpha = 103.61(3)$ ,  $\beta = 107.63(3)$ ,  $\gamma = 101.58(3)^\circ$ ;  $Z = 2$ ,  $\rho_{\text{calc}} = 1.716$ ,  $\rho_{\text{obs}} = 1.72(2)\text{g cm}^{-3}$  (floatation). The structure was solved by direct methods and was refined by full-matrix least-squares pro-

<sup>1</sup>The various NBS publications series are grouped under subheadings within this section. If a particular publications series is sought, consult the table of contents or the edge index on the back cover.



cedures to a final  $R$  of 0.074 for 1989 observed reflections. The five-membered ring is planar and pentagonal. The two  $=C(CN)_2$  groups define separate planes which form angles of  $3.36$  and  $6.30^\circ$  with the plane of the five-membered ring. The dianions form stacks along the  $a$ -axis. In a given stack, there is an alternating sequence of perpendicular distances ( $3.32, 3.42\text{\AA}$ ) between the planes defined by the ring atoms.

**Radial distribution studies under highly constrained conditions, R. G. Munro, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 2, 99-108 (Mar.-Apr. 1980).**

Key words: diamond pressure cell; radial distribution functions; truncation error.

The consequences of limited scattering data are considered for the determination of radial distribution functions. Such considerations are important, e.g., when substances are held at extreme pressure in a pressure vessel like the diamond anvil cell. By means of formal relations, alternatives to the direct Fourier inversion of the scattering data are considered, but it is found that they do not usefully circumvent the problems resulting from the truncation of data. Using an ideal set of data, five numerical procedures for inverting the data are compared as a function of the degree of data limitation. An extended-integral method is found to be the most reliable.

**High temperature elastic constants and the evaluation of effective pair potentials, R. D. Mountain and D. C. Knauss, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 2, 109-112 (Mar.-Apr. 1980).**

Key words: aluminum; anharmonic effects; effective potentials for metals; elastic constants; fluctuations; high temperature properties; Monte Carlo simulations.

It is shown by example that the predicted temperature dependence of the elastic constants is a useful measure of the ability of an effective pair potential to estimate the high temperature thermal properties of a metal. Our example is based on a model pair potential constructed for aluminum. This potential predicts the low temperature elastic constants and phonon dispersion relations with good accuracy ( $\pm$  a few percent). The high temperature elastic constants for this model potential are determined using the Monte Carlo method and are found to be approximately independent of temperature. Since the elastic constants of aluminum are strongly decreasing functions of temperature, this potential is seen to be a poor one for determining the properties of aluminum. We conclude that the temperature dependence of the elastic constants is a useful further test of pair potentials which satisfy the low temperature tests currently employed.

## May-June 1980

**The electrochemical equivalent of pure silver—A value of the Faraday, V. E. Bower and R. S. Davis, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 3, 175-191 (May-June 1980).**

Key words: coulometry; electrochemical equivalent; electrochemistry; Faraday; fundamental constants; silver.

Oxygen-free high-purity samples were used in a precise determination of the electrochemical equivalent of silver. A comprehensive mass spectrometric analysis for impurities was performed. Our value agrees well with prior measurements of the same quantity at the National Bureau of Standards (NBS) by Craig and coworkers. We find the electrochemical equivalent of pure silver to be  $1.1179648 \text{ mg C}^{-1}_{\text{NBS}}$ . Attached to this figure is an uncertainty whose random component (standard deviation of the mean of 8 determinations) is  $9.5 \times 10^{-7} \text{ mg C}^{-1}$  (0.85 ppm). The root-sum-square of systematic uncertainties of known origin is  $1.07 \times 10^{-6} \text{ mg C}^{-1}$  (0.96 ppm). The above value for the electrochemical equivalent of silver leads us to calculate the Faraday to be:  $F = 96486.33(24) A_{\text{NBS}} \cdot \text{s} \cdot \text{mol}^{-1}$  (2.5 ppm).

**A microcalorimeter for measuring self-discharge of pacemakers and pacemaker power cells, E. J. Prosen and J. C. Colbert, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 3, 193-203 (May-June 1980).**

Key words: battery; microcalorimeter; pacemaker; power cell; self-discharge.

The self-discharge heat losses of cardiac pacemaker power cells and pacemakers were investigated by microcalorimetry. Results were obtained with small alkaline, mercury and lithium-iodine batteries under opencircuit and external load conditions to monitor their heat loss characteristics and to gather information on the self-discharge mechanism. Results obtained with "complete pacemakers" are also reported.

**Dixanthylurea ( $N,N'$ -di-9H-Xanthen-9-ylurea), C. R. Hubbard, A. D. Mighell, and A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 3, 205-210 (May-June 1980).**

Key words: crystal structure; molecular structure; single crystal x-ray diffraction; standard test; urea complex; urea in sera.

$C_{27}H_{20}N_2O_3$ , MW = 420, orthorhombic,  $Pbc2_1$ ,  $a = 4.686(2)$ ,  $b = 16.784(8)$ ,  $c = 25.924(10)\text{\AA}$ ,  $V = 2039\text{\AA}^3$ ,  $d_{\text{obs}} = 1.37 \text{ g cm}^{-3}$  (floatation),  $d_{\text{calc}} = 1.369 \text{ g cm}^{-3}$ ,  $Z = 4$ . The structure has been determined by direct methods and refined to  $R = 0.045$  based on 1419 independent reflections. No crystallographic symmetry element is present in the dixanthylurea molecule. In fact, the molecule is considerably distorted from any possible mirror symmetry. The molecules are hydrogen bonded in an infinite chain along the  $a$ -axis. The compound is of interest because of its role in the analytical determination of urea.

**A low-noise potentiostat for the study of small amplitude signals in electrochemistry, R. W. Shideler and U. Bertocci, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 3, 211-217 (May-June 1980).**

Key words: electrochemical measurements; galvanostat; impedance measurements; noise; potentiostat.

A low-noise potentiostat, developed and built at NBS, is described. The instrument, which has built-in an ac current amplifier, is particularly suited for detecting small current fluctuations in the frequency range between 0.1 and 2000 Hz. The noise in the dc control voltage is of the order of  $2.5 \times 10^{-8} \text{ V}/\sqrt{\text{Hz}}$ , and the instability of the ac amplifier corresponds to a signal of  $3 \times 10^{-11} \text{ A}/\sqrt{\text{Hz}}$ . The performance characteristics of the instrument are fully described as well as its use in impedance measurements by means of a swept frequency signal. The instrument can also be used as a galvanostat.

**In-tank measurement of solution density, F. E. Jones, R. M. Schoonover, and J. F. Houser, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 3, 219-221 (May-June 1980).**

Key words: accountability tanks; differential pressure; in-tank density determination; nuclear process solutions; solution density.

This paper presents the results of an experiment which established the feasibility of in-tank determination of the density of nuclear process solutions in the field with a precision competitive with the precision claimed for laboratory determinations of the density of samples taken from a tank. The in-tank determination is made by inferring the density from the differential pressure measured between two probes immersed at different heights in the tank. The differential pressure was measured using a null-operated quartz bourdon type electromanometer. The work provided a calibration factor, with a precision (estimate of the relative standard deviation of the mean) of 2.2 parts in 10,000, which can be used to infer density from differential pressure measurements in the particular accountability tank. The technique eliminates one error in the laboratory determination



of density and minimizes another. It also can be used to indicate the homogeneity of the tank solution and thus determine when a sample should be taken for determination of the concentration of nuclear material in the solution.

**Response of smoke detectors to monodisperse aerosols**, G. W. Mulholland and B. Y. H. Liu, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 3, 223-238 (May-June 1980).

Key words: aerosol generators; aerosols; detector sensitivity; fire detectors; ionization detectors; light scattering detectors; monodisperse aerosols; particle size; photo-electric detectors; smoke detectors.

The response of three light scattering smoke detectors (photo-electric detectors) and three ionization smoke detectors were determined as a function of particle size and concentration for nearly monodisperse dioctyl phthalate aerosol ( $\sigma_g = 1.25$ ). The range in particle diameter was about 25 to 1 (0.05 to 1.3  $\mu\text{m}$ ) while the range in concentration was about two orders of magnitude ( $2 \times 10^4$  to  $3 \times 10^6$  particles/ $\text{cm}^3$ ). Detailed descriptions of the aerosol generation system and the smoke detector test chamber are given. The responses of the ionization detectors were found to have a nearly linear dependence on particle size as predicted by Hosemann's theory. The ionization detectors responded to the smallest particles generated. The light scattering detectors did not respond to particles with diameters of 0.1  $\mu\text{m}$  or less and were found to have a strong dependence on particle size, the fourth to fifth power of particle diameter, for particle sizes less than 0.5  $\mu\text{m}$ . It was found that ionization detectors generally had a higher response than the light scattering detectors to particles smaller than 0.3  $\mu\text{m}$ , which size range is typical of flaming combustion, and that the light scattering detectors had a higher response to particles larger than 0.3  $\mu\text{m}$ , which size range is typical of smoldering combustion.

## July-August 1980

**A proposed coil system for the improved realization of the absolute ampere**, P. T. Olsen, W. D. Phillips, and E. R. Williams, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 4, 257-272 (July-Aug. 1980).

Key words: absolute ampere; current balance; magnetic force; radial magnetic field; superconducting coils.

In order to resolve the discrepancies which presently exist between the directly measured values of the absolute or SI ampere and the calculated values obtained indirectly from other fundamental physical constant determinations, one must design an absolute ampere experiment which will produce a result with an uncertainty of one half part per million or less. A new approach recently proposed by Kibble promises such sub-ppm accuracy. Presented here is the design and evaluation of a coil system which will fulfill the requirements of this new approach.

**The polymer in a cone—A model for the surface free energy of polymer crystal with emergent cilia**, C. M. Guttman, E. A. DiMarzio, and J. D. Hoffman, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 4, 273-282 (July-Aug. 1980).

Key words: constrained polymer; polymer; polymer in a cone; polymer interference; small polymer crystal; surface free energy.

A model is proposed to estimate the surface free energy of a small polymer crystal with numerous emergent cilia. For such a model the partition function of a polymer constrained to remain in a cone is computed. The partition function of the polymer in a cone is found to behave similarly to the polymer in a wedge discussed by Lauritzen and DiMarzio. The estimated end surface free energy per unit area for the small extended chain crystal is found to increase with increasing area, implying the presence of cumulative surface stress in such crystals. The

forces between the cilia are reduced if folds are inserted in the surface.

**Representation of long-time creep in a pure-gum rubber vulcanizate**, L. A. Wood, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 4, 283-293 (July-Aug. 1980).

Key words: rubber, creep of; rubber, long-time creep of; rubber, mechanical properties of; rubber, relaxation of; rubber; time effects in.

Creep may be expressed as  $\Delta E/E_1 = A \log t + B(t-1)$  where  $\Delta E$  is the increase of elongation above  $E_1$  the one-minute value, during the time  $t$ . The initial slope of a plot of  $\Delta E/E_1$  against  $\log t$  is  $A$ , a measure of physical creep. The limit of the final slope of a plot of  $\Delta E/E_1$  against  $(t-1)$  is  $B$ , a measure of chemical creep. The validity of the equation is determined by the linearity of a plot of  $(\Delta E/E_1 - A \log t)$  against  $(t-1)$  after  $A$  has been determined by the first plot.  $B$  is obtained as the slope. The equation is almost always valid and simultaneous equations can be used to determine  $A$  and  $B$  from only three observations, if desired.  $A$ , usually between 1 and 10 percent/unit  $\log t$ , is strongly dependent on cross-linking and nearly independent of temperature.  $B$ , ranging from  $0.1 \times 10^{-5}$  to  $10,000 \times 10^{-5}$  percent/min is nearly independent of cross-linking and strongly dependent on temperature and specimen thickness. With an activation energy of 84-125 kJ (mol) $^{-1}$  (20-30 kcal (mol) $^{-1}$ ) it probably reflects oxidative degradation of the network, often initiated by ozone. The appearance time at which the creep is first observed to exceed  $A \log t$  can be taken as equal to  $B^{-1}$ . At high temperatures  $B$  is drastically increased with a corresponding strong reduction in appearance time. Creep in excess of that given by the equation is sometimes observed during a period immediately before rupture.

**Design aspects of Scheffé's calibration theory using linear splines**, C. H. Spiegelman and W. J. Studden, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 4, 295-304 (July-Aug. 1980).

Key words: calibration curve; experiments; finite elements; Scheffé, design; spline; volume.

The measurement process uncertainty is propagated through the use of a calibration curve. The magnitude and direction of this uncertainty depends on the choice of the controllable variable in producing the calibration curve; in other words, the design of the calibration experiment. In this paper this design is discussed in the context of Scheffé's approach to the uncertainties of a calibration curve and in particular for the case in which the calibration curve is a linear spline. A class of appropriate designs is given, which depend on the location of the knots and the slopes of the segments. One of these designs is quickly calculable and can be found without a computer. Based on these results, a design approach is suggested for the case in which the knots are not known exactly.

## September-October 1980

**A simple gravimetric method to determine barometer corrections**, R. M. Schoonover, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 5, 341-346 (Sept.-Oct. 1980).

Key words: air density; air density equation; barometer calibration; barometric pressure; displacement volume; gravimetric method; mass artifacts; weighing.

Presented here is a gravimetric method to calibrate barometers. The difference in forces exerted on the pan of a balance is observed for two well characterized artifacts of nearly equal masses but different volumes. During the weighing, air temperature and relative humidity are measured; the ambient pressure is then calculated from an air density equation. A barometer correction is derived and then compared to an independent value based on a standard barometer. The data indicate that pressure



can be calculated with an uncertainty (1 S.D.) of not more than 400 ppm at one atmosphere.

**Investigation of epitaxy relationships between  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  and other calcium ortho-phosphates**, B. Dickens and L. W. Schroeder, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 5, 347-362 (Sept.-Oct. 1980).

**Key words:** computer assessment; crystal structures; epitaxy; inter-layerings; nonstoichiometry; structural considerations; twinning.

A procedure for generating and quantitatively comparing possible cases of epitaxy and twinning has been devised and applied to the study of epitaxy between  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  and other calcium orthophosphates. For any two given lattices, pairs of nets which match dimensionally within prescribed limits are found and sorted in order of increasing mismatch. The crystal structural parameters are used to generate and match atomic patterns corresponding to each pair of nets. Pattern matching is done by comparing magnitudes of vectors describing the immediate environment of each atom in turn, and does not require orienting the two patterns relative to one another. Atomic charges related by each vector are also considered. Use of the vector sets introduces the limitation that twinning involving reorientation in a contact plane cannot be distinguished from no reorientation (identity match). An additional method which uses these results to match complete patterns is suggested. The procedure is general in nature and has been applied here to the study of possible epitaxies between  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  and  $\text{Ca}_8\text{H}_2(\text{PO}_4)_6 \cdot 5\text{H}_2\text{O}$ ,  $\text{Ca}_4\text{O}(\text{PO}_4)_2$ ,  $\text{CaHPO}_4$ ,  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ ,  $\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ ,  $\beta\text{-Ca}_3(\text{PO}_4)_2$  and  $\text{Ca}_5(\text{PO}_4)_2\text{SiO}_4$ . Of these cases, only the epitaxies  $\text{Ca}_5(\text{PO}_4)_3\text{OH}/\text{Ca}_8\text{H}_2(\text{PO}_4)_6 \cdot 5\text{H}_2\text{O}$  and  $\text{Ca}_5(\text{PO}_4)_3\text{OH}/\text{Ca}_4\text{O}(\text{PO}_4)_2$  appear to have sufficient structural similarity to occur in practice.

**A univariate extension of Jensen's inequality**, C. H. Spiegelman, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 5, 363-366 (Sept.-Oct. 1980).

**Key words:** blood lead levels; concave; geometric mean; Jensen's inequality.

The result in this paper explains some of the qualitative nature of Jensen's inequality. It is shown that the more disperse the distribution of a random variable is, the smaller is the expectation of any concave function of it. This result can be used to show the inadequacy of some current methods of reporting environmental data by using geometric means, and it extends the result of I. Billick, D. Shier, and C. H. Spiegelman, where symmetry of the error in environmental measurements is assumed.

**The numerical solution of a nonseparable elliptic partial differential equation by preconditioned conjugate gradients**, J. G. Lewis and R. G. Rehm, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 5, 367-390 (Sept.-Oct. 1980).

**Key words:** conjugate gradient algorithm; elliptic partial differential equations; iterative methods for linear algebraic equations; Neumann boundary conditions; sparse matrices.

In this report the combination of an iterative technique, the conjugate gradient algorithm, with a fast direct method, cyclic reduction, is used to solve the linear algebraic equations resulting from discretization of a nonseparable elliptic partial differential equation. An expository discussion of the conjugate gradient and preconditioned conjugate gradient algorithms and of their use in the solution of partial differential equations is presented. New results extending the use of the preconditioned conjugate gradients technique to singular linear equations which arise from discretized elliptic equations with Neumann boundary conditions are also given. The algorithms are applied to solve a specific elliptic equation which arises in the study of buoyant convection produced by a room fire. A code was developed to

implement the algorithms for this application. Numerical results obtained through testing and use of the code are discussed.

**Player aggregation in noncooperative games**, A. J. Goldman and D. R. Shier, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 5, 391-428 (Sept.-Oct. 1980).

**Key words:** aggregation; equilibrium; game theory; mathematical economics; noncooperative games.

A condition is given, under which subsets of the players of a noncooperative game can be combined into "aggregate players" without changing the set of equilibrium-point solutions of the game. The condition is that an individual player's payoff does not depend on the strategy choices of the other players forming the same aggregate player. "Approximate" versions of this result are also formulated and proven.

## November-December 1980

**Observations on the mechanisms of high resistance junction formation in aluminum wire connections**, D. Newbury and S. Greenwald, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 6, 429-440 (Nov.-Dec. 1980).

**Key words:** aluminum wiring; duplex connectors; high resistance junctions; junction resistance; scanning electron microscopy; x-ray microanalysis.

The basic mechanism of high resistance junction formation in duplex connectors wired with aluminum was investigated. Laboratory experiments to simulate loose connections were made both in actual duplex connectors and in an experimental apparatus. Microstructural observations were made by scanning electron microscopy and x-ray microanalysis of the structures formed at the interfaces between the circuit components during high resistance junction formation. At the iron screw/aluminum wire interface, the arcing process which occurs in a loose connection causes high temperatures in excess of 1500 °C and material transport between the components. Under these conditions, aluminum and iron react to form intermetallic compounds such as  $\text{Fe}_3\text{Al}$  and  $\text{FeAl}_3$ . The formation of an extensive zone of these compounds adjacent to the iron-aluminum interface in duplex connectors was revealed by electron metallography. In duplex connectors tested to glow failure, the formation of intermetallic compounds such as  $\text{CuAl}_2$  and  $\text{Cu}_2\text{ZnAl}$  was observed at the brass plate/aluminum wire interface. These intermetallic compounds have a resistivity of the order of  $100 \times 10^{-6}$  ohm-cm or higher which may provide sufficient resistance at the current-carrying interface to lead to significant  $I^2R$  heating losses at the interface.

**On the calculation of critical liquid-vapor lines of binary mixtures**, P. Wielopolski, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 6, 441-448 (Nov.-Dec. 1980).

**Key words:** conformational solution theory; corresponding states; critical point; gas/gas equilibria; mixtures; Van der Waals one fluid model.

The critical lines of binary mixtures of conformational fluids are calculated on the basis of the one fluid Van der Waals theory. The conditions for the existence of the gas/gas equilibrium of the first and second type are shown and discussed. The analytical expressions for partial derivatives of Gibbs free energy with respect to concentration, up to the third order, are given in the appendix.

**The enthalpy of solution of SRM 1655 (KCl) in  $\text{H}_2\text{O}$** , M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 6, 449-465 (Nov.-Dec. 1980).

**Key words:** adiabatic calorimeter; calorimetry,  $\Delta C_p$ , endothermic reaction; enthalpy of dilution; enthalpy of solu-

tion; KCl; SRM 1655; standard reference material; thermochemistry.

The value for the enthalpy of solution of SRM 1655 (KCl),  $\Delta H^\circ(500 \text{ H}_2\text{O}, 298.15\text{K}) = (235.86 \pm 0.23)\text{J}\cdot\text{g}^{-1}$  or  $(17.584 \pm 0.017)\text{kJ}\cdot\text{mol}^{-1}$ , was obtained from measurements in an adiabatic calorimeter, and confirmed by measurements in an isoperibol calorimeter.

Enthalpy of solution measurements are reported in the temperature range 296 K to 358 K, at molalities between 0.005 and  $0.18 \text{ mol}\cdot\text{kg}^{-1}$ , for various ranges of particle size up to  $1000 \mu\text{m}$ , and in  $\text{CO}_2$ -saturated solutions. Observations were also made relative to the hygroscopicity, removal of occluded  $\text{H}_2\text{O}$ , and homogeneity of SRM 1655. Between 296 K and 303 K,  $\Delta C_p = -(2.076 \pm 0.087) \text{ J}\cdot\text{g}^{-1}\cdot\text{K}^{-1}$  or  $-(154.8 \pm 6.4) \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$  for the reaction of SRM 1655 in 500  $\text{H}_2\text{O}$ .

**Systematic errors in an isoperibol solution calorimeter measured with standard reference reactions**, M. V. Kilday, *J. Res. Nat. Bur. Stand. (U.S.)*, **85**, No. 6, 467-481 (Nov.-Dec. 1980).

Key words: calorimetry; enthalpy of solution; KCl; solution calorimetry; standard reference materials; thermochemistry; tris(hydroxymethyl)aminomethane.

Systematic errors in an isoperibol calorimeter of a widely-used design, amounting to about 0.5 percent of the endothermic enthalpy of solution of SRM 1655 (KCl) in  $\text{H}_2\text{O}$ , were found to be the result of errors in heat leak corrections due to inadequate stirring and commonly used calorimetric procedures.

Other systematic errors were found in measurements of the enthalpy of solution of the exothermic reaction of tris(hydroxymethyl)aminomethane in aqueous HCl solution.

Recommended procedures are summarized.



## 5.2 PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 9, JANUARY-DECEMBER 1980

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.

### Volume 9, No. 1

**Energy levels of magnesium, Mg I through Mg XII**, W. C. Martin and R. Zalubas, *J. Phys. Chem. Ref. Data* 9, No. 1, 1-58 (1980).

Key words: atomic energy levels; atomic spectra; electron configurations; ionization potentials; magnesium.

Energy level data are given for the atom and all positive ions of magnesium ( $Z = 12$ ). These data have been critically compiled, mainly from published material on measurements and analyses of the optical spectra. We have derived or recalculated the levels for a number of the ions. In addition to the level value in  $\text{cm}^{-1}$  and the parity, the  $J$  value and the configuration and term assignments are listed if known. Leading percentages from the calculated eigenvectors are tabulated wherever available. Ionization energies are given for all spectra.

**Microwave spectra of molecules of astrophysical interest. XVIII. Formic acid**, E. Willemot, D. Dangoisse, N. Monnanteuil, and J. Bellet, *J. Phys. Chem. Ref. Data* 9, No. 1, 59-160 (1980).

Key words: formic acid; interstellar molecules; line strengths; microwave spectra; molecular constants; radioastronomy; rotational transitions.

The available data on the microwave spectrum of formic acid are critically reviewed for information applicable to radioastronomy. Molecular data such as the derived rotational constants, centrifugal distortion constants and electric dipole moment are tabulated. The observed rotational transitions are presented for the astronomically interesting isotopic forms. Calculated rotational transitions up to 300 GHz are presented for the ground vibrational state of  $\text{H}^{12}\text{C}^{16}\text{O}^{16}\text{OH}$ ,  $\text{H}^{12}\text{C}^{16}\text{O}^{16}\text{OD}$ ,  $\text{D}^{12}\text{C}^{16}\text{O}^{16}\text{OH}$  and  $\text{H}^{13}\text{C}^{16}\text{O}^{16}\text{OH}$ . Some observed transitions are also listed for  $\text{H}^{12}\text{C}^{16}\text{O}^{18}\text{OH}$  and  $\text{H}^{12}\text{C}^{18}\text{O}^{16}\text{OH}$ . Estimated error limits have been reported for all measured transitions.

**Refractive index of alkaline earth halides and its wavelength and temperature derivatives**, H. H. Li, *J. Phys. Chem. Ref. Data* 9, No. 1, 161-290 (1980).

Key words: alkaline earth halides; optical constants; refractive index; temperature coefficient of refractive index.

Available data on the refractive index and its temperature derivative for alkaline earth halides were exhaustively surveyed, compiled, and analyzed. The most probable values of the refractive index at 293 K for the transparent region were generated for the materials for which experimental data were sufficiently abundant and reliable. Provisional values were also generated for the wavelength regions where available data were less abundant.

Reasonable estimations of refractive index for the very scantily measured materials were made by incorporating the dielectric constants and wavelengths of absorption peaks into a simplified dispersion equation. It was found that of the twenty alkaline earth halides only seven, namely,  $\text{MgF}_2$ ,  $\text{CaF}_2$ ,  $\text{SrF}_2$ ,  $\text{BaF}_2$ ,  $\text{CaCl}_2$ ,  $\text{SrCl}_2$ , and  $\text{BaCl}_2$ , appear in the open literature with refractive index measurements. Most of the available data are for the first four of the seven materials. Temperature derivatives of refractive index for most of the alkaline earth halides were unavailable. As a result, data analysis on  $dn/dT$  was limited to  $\text{CaF}_2$ ,  $\text{SrF}_2$ , and  $\text{BaF}_2$ .

### Volume 9, No. 2

**Evaluated kinetic and photochemical data for atmospheric chemistry**, D. L. Baulch, R. A. Cox, R. F. Hampson, Jr., J. A. Kerr, J. Troe, and R. T. Watson, *J. Phys. Chem. Ref. Data* 9, No. 2, 295-472 (1980).

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

This paper contains a critical evaluation of the kinetics and photochemistry of gas phase chemical reactions of neutral species involved in middle atmosphere chemistry (10-55 km altitude). 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 148 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 dependency 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.

**Energy levels of scandium, Sc I through Sc XXI**, J. Sugar and C. Corliss, *J. Phys. Chem. Ref. Data* 9, No. 2, 473-512 (1980).

Key words: atomic energy levels; atomic spectra; scandium energy levels.

The energy levels of the scandium atom in all of its stages of ionization, as derived from the analyses of atomic spectra, have been critically compiled. In cases where only line classifications are reported in the literature, level values have been derived. Electron configurations, term designations,  $J$ -values, experimental  $g$ -values, and ionization energies are included. Calculated percentages of the two leading components of the eigenvectors of the levels are given, where available.

**Revised values of the osmotic coefficients and mean activity coefficients of sodium nitrate in water at 25 °C**, Y. C. Wu and W. J. Hamer, *J. Phys. Chem. Ref. Data* 9, No. 2, 513-518 (1980).

Key words: activity coefficients; critically evaluated data; excess Gibbs energy for electrolytes; osmotic coefficients; sodium nitrate.

Additional data on the freezing point depression of  $\text{NaNO}_3$  are taken into consideration to obtain an improved data for the osmotic and activity coefficients of this substance.



## Volume 9, No. 3

**A compilation of kinetic parameters for the thermal degradation of *n*-alkane molecules**, D. L. Allara and R. Shaw, *J. Phys. Chem. Ref. Data* 9, No. 3, 523-560 (1980).

**Key words:** addition; chemical kinetics; decomposition; disproportionation; H-transfer; initiation; isomerization; *n*-alkane pyrolysis; rate constants; recombination.

A list of several hundred free-radical reactions which occur during the low temperature (700-850 K) pyrolysis of small *n*-alkane molecules has been assembled and a set of reliable, self-consistent Arrhenius rate parameters has been assigned on the basis of experiment, theory, thermochemical estimates and structural analogy. Rate parameters have been recommended for the following types of reactions, with the number of each type in parentheses: initiation (32), recombination (135), disproportionation (108), H-transfer (112), decomposition (41), addition (58), and isomerization (11), giving a total of 505 reactions. This compilation is intended for use in assembling reaction matrices in computational modeling studies of the thermal reactions of hydrocarbon molecules.

**Refractive index of silicon and germanium and its wavelength and temperature derivatives**, H. H. Li, *J. Phys. Chem. Ref. Data* 9, No. 3, 561-658 (1980).

**Key words:** germanium; optical constants; refractive index; silicon; temperature coefficient of refractive index.

Refractive index data for silicon and germanium were searched, compiled, and analyzed. Recommended values of refractive index for the transparent spectral region were generated in the ranges 1.2 to 14  $\mu\text{m}$  and 100-750 K for silicon, and 1.9 to 16  $\mu\text{m}$  and 100-550 K for germanium. Generation of these values was based on a dispersion equation which best fits selected data sets covering wide temperature and wavelength ranges. Temperature derivative of refractive index was simply calculated from the first derivative of the equation with respect to temperature. The results are in concordance with the existing  $dn/dT$  data.

**Microwave spectra of molecules of astrophysical interest. XIX. Methyl cyanide**, D. Boucher, J. Burie, A. Bauer, A. Dubrulle, and J. Demaison, *J. Phys. Chem. Ref. Data* 9, No. 3, 659-720 (1980).

**Key words:** interstellar molecules; line strengths; methyl cyanide; microwave spectra; molecular constants; radio astronomy; rotational transitions.

The microwave spectrum of methyl cyanide is critically reviewed for information applicable to radio-astronomy. Molecular data such as the derived rotational constants, centrifugal distortion parameters, hyperfine coupling constants, electric dipole moment and molecular structure are tabulated. The observed rotational transitions are presented for the astronomically interesting isotopic forms and the lowest lying vibrational state of methyl cyanide. Calculated rotational transitions are presented for the ground vibrational state of  $^{12}\text{CH}_3^{12}\text{C}^{14}\text{N}$ ,  $^{13}\text{CH}_3^{12}\text{C}^{14}\text{N}$ ,  $^{12}\text{CH}_3^{13}\text{C}^{14}\text{N}$ ,  $^{12}\text{CH}_3^{12}\text{C}^{15}\text{N}$ , and for the vibrationally excited state  $\nu_8$  of  $^{12}\text{CH}_3^{12}\text{C}^{14}\text{N}$ .

**A review, evaluation, and correlation of the phase equilibria, heat of mixing, and change in volume on mixing for liquid mixtures of methane + propane**, R. C. Miller, A. J. Kidnay, and M. J. Hiza, *J. Phys. Chem. Ref. Data* 9, No. 3, 721-734 (1980).

**Key words:** binary mixtures; data correlation; excess volumes; heat of mixing; liquid-vapor equilibria; methane + propane.

The available experimental data for liquid-vapor equilibria, heat of mixing, and change in volume on mixing for the

methane + propane system have been reviewed and where possible evaluated for consistency. The derived properties chosen for analysis and correlation were liquid mixture excess Gibbs free energies, Henry's constants, and *K* values. Data sets, selected on the basis of the consistency tests applied, were correlated as a function of temperature and composition to provide internally consistent sets of property values suitable for engineering design calculations.

**Saturation states of heavy water**, P. G. Hill and R. D. C. MacMillan, *J. Phys. Chem. Ref. Data* 9, No. 3, 735-750 (1980).

**Key words:** enthalpy of water; heavy water; *PvT*; saturation states; thermodynamic properties of water; vapor pressure; virial coefficients; water.

A study has been made of the saturation properties of  $\text{D}_2\text{O}$  from the triple point temperature to 325  $^\circ\text{C}$ , in the light of information on the saturation properties of  $\text{H}_2\text{O}$ . Saturated liquid volumes have been determined by extrapolation to saturation pressure of relatively abundant liquid phase data (corrected to 100%  $\text{D}_2\text{O}$ ). Saturated liquid enthalpy has been determined by extrapolation of liquid phase specific heat data, and integration along the saturation line, allowing for the compressibility effect. Saturated vapor volumes have been determined by use of an extended virial equation formulated for  $\text{H}_2\text{O}$  and corrected for  $\text{D}_2\text{O}$ . Saturated vapor enthalpies have been determined by use of the Clapeyron equation, and compared to vapor enthalpies calculated from the extended virial equation. Saturated liquid and vapor volumes have been extrapolated to the critical temperature to allow an inference of the critical density.

**The solubility of some sparingly soluble lead salts: An evaluation of the solubility in water and aqueous electrolyte solution**, H. L. Clever and F. J. Johnston, *J. Phys. Chem. Ref. Data* 9, No. 3, 751-784 (1980).

**Key words:** aqueous solubility of lead salts; lead carbonate; lead halides; lead nitrate; lead phosphates; lead sulfate; lead sulfide; solubility; solubility product; sparingly soluble lead salts.

The literature on the solubility of sparingly soluble lead salts in water and in aqueous electrolyte solution was reviewed. Solubility data were compiled and evaluated. Recommended and tentative values of the solubilities are presented. A partial compilation of solubility products and of complex ion formation constants are given. Where possible the solubility product values have been checked for consistency against thermodynamic data from sources other than solubility measurements.

## Volume 9, No. 4

**Molten salts data as reference standards for density, surface tension viscosity and electrical conductance:  $\text{KNO}_3$  and  $\text{NaCl}$** , G. J. Janz, *J. Phys. Chem. Ref. Data* 9, No. 4, 791-830 (1980).

**Key words:** calibration-quality standards; density; electrical conductance; molten salts; potassium nitrate; sodium chloride; surface tension; viscosity.

Accuracy estimates for physical property measurements are usually based on somewhat subjective quality judgments, and the difficulties encountered in interpreting accuracy statements in the literature are frequently compounded through lack of details on the methods of measurements, chemical purity, and related experimental aspects. In the present communication we report the results of a Standards Program initiated in 1973 with participating laboratories in Czechoslovakia, German Democratic Republic-DDR, Japan, Norway, Poland, Rumania, and USA. Potassium nitrate (m. 335  $^\circ\text{C}$ ) and sodium chloride (m. 800  $^\circ\text{C}$ ) were selected as the two reference salts for the properties: density, surface tension, viscosity, and electrical conductance. The results of the measurements have been critically examined,



and are reported herewith. It has been possible to resolve some of the difficulties encountered in accuracy estimates through this "round-robin" series of measurements, and to up-grade some of the data-sets to calibration-quality reference standards.

**Molten salts: Volume 5, Part 1—Additional single and multi-component salt systems. Electrical conductance, density, viscosity, and surface tension data,** G. J. Janz and R. P. T. Tomkins, *J. Phys. Chem. Ref. Data* 9, No. 4, 831-1022 (1980).

Key words: carbonates; density; electrical conductance; hexafluoraluminates; metaphosphates; molten salts; molybdates; sulfates; sulfides; surface tension; tungstates; viscosity.

Data on the electrical conductance, density, viscosity, and surface tension of more than ninety additional multi-component salt systems have been systematically collected and evaluated. Results are given for mixtures over a range of compositions and temperatures. Values of the above properties for some sixty single salt systems are also reported.

**Pair, triplet, and total atomic cross sections (and mass attenuation coefficients) for 1 MeV-100 GeV photons in elements  $Z = 1$  to 100,** J. H. Hubbell, H. A. Gimm, and I. Øverbø, *J. Phys. Chem. Ref. Data* 9, No. 4, 1023-1148 (1980).

Key words: attenuation coefficient; coherent scattering; Compton scattering; gamma rays; pair production; photoelectric absorption; photons; triplet production; x rays.

Tables of photon cross sections and mass attenuation coefficients for all elements  $Z = 1$  to 100 are given for photo energies in the range 1 MeV to 100 GeV. The pair and triplet production cross sections take into account recent theoretical work, including atomic form factor and incoherent scattering function data, as well as extensive new total attenuation coefficient measurements at Mainz. Cross section values for the atomic photoeffect and coherent and incoherent (Compton) scattering are explicitly listed and are included in the total cross sections (excluding photonuclear) and mass attenuation coefficients.

**Tables of molecular vibrational frequencies—Part 10,** T. Shimanouchi, H. Matsuura, Y. Ogawa, and I. Harada, *J. Phys. Chem. Ref. Data* 9, No. 4, 1149-1254 (1980).

Key words: force constants; fundamental frequencies; infrared spectra; normal vibrations; polyatomic molecules; Raman spectra; vibrational frequencies.

Fundamental vibrational frequencies of 94 molecular forms of 23 polyatomic chain molecules of halogenoalkanes and halogenoalkyl ethers consisting of the  $\text{CH}_3$ ,  $\text{CH}_2$ , O, F, Cl, Br, and I groups are given as an extension of tables of molecular vibrational frequencies published in the NSRDS-NBS publication series and in this journal. On preparing the tables in this part, an approach, similar to that in Part 9 but different from that in earlier parts, based on the calculations of normal vibration frequencies was adopted. A set of force constants which explains all the frequencies of small molecules for which the assignments had been established was obtained and then the frequencies of larger molecules were calculated and compared with the frequencies observed in the infrared and Raman spectra. The tables provide a convenient source of information for those who require vibrational energy levels and related properties in molecular spectroscopy, thermodynamics, analytical chemistry, and other fields of physics and chemistry.

**An improved representative equation for the dynamic viscosity of water substance,** J. T. R. Watson, R. S. Basu, and J. V. Sengers, *J. Phys. Chem. Ref. Data* 9, No. 4, 1255-1290 (1980).

Key words: correlation length; critical region equation of state; critical viscosity enhancement; steam; viscosity; water; water vapor.

Experimental evidence for steam and other fluids has demonstrated the existence of an anomalous enhancement of the dynamic viscosity in the close vicinity of the critical point. A reanalysis of the experimental evidence for the viscosity of steam indicates that the observed behavior of the critical viscosity enhancement is consistent with current theoretical predictions. An interpolating equation for the dynamic viscosity of water substance is presented which is in good agreement with the experimental viscosity data in a large range of temperatures and pressures. The equation contains a smaller number of coefficients than the current international equation for the viscosity of water substance and incorporates the enhancement of the viscosity in the close vicinity of the critical point.

**Static dielectric constant of water and steam,** M. Uematsu and E. U. Franck, *J. Phys. Chem. Ref. Data* 9, No. 4, 1291-1306 (1980).

Key words: critically evaluated data; critical review; data compilation; International Formulation; static dielectric constant; steam; water.

This paper reviews and evaluates the experimental works of the static dielectric constant (permittivity) of water and steam over the century. The critically evaluated experimental data are represented by a function of temperature and density. This representation was carefully examined in the light of the criteria for smoothness and physical plausibility. As a result of this work, which was largely stimulated by the activities of the International Association for the Properties of Steam, a new International formulation for the static dielectric constant of water and steam was adopted. This formulation covers a temperature range from 0 to 550 °C and a pressure range up to 500 MPa.

**Compilation and evaluation of solubility data in the mercury (I) chloride-water system,** Y. Marcus, *J. Phys. Chem. Ref. Data* 9, No. 4, 1307-1330 (1980).

Key words: compilation of solubility data; disproportionation of mercury (I); electromotive force measurements; mercury (I) chloride; solubility; solubility product; standard electrode potentials; standard thermodynamic functions.

The more than one dozen papers dealing with the solubility of mercury (I) chloride in water or in aqueous chloride solutions have been compiled in the format set by the IUPAC Solubility Data Project, and have been evaluated. Mercury (I) chloride dissolves in water, forming the following species:  $\text{Hg}(\text{OH})_2$ ,  $\text{HgCl}_2$ ,  $\text{HgOH}^+$ ,  $\text{HgCl}^+$ ,  $\text{Hg}_2^{2+}$  and  $\text{Hg}_2\text{OH}^+$ , in addition to  $\text{H}^+$  and  $\text{Cl}^-$ . In excess chloride solutions it dissolves to give, mainly,  $\text{HgCl}_3^-$  and  $\text{HgCl}_4^{2-}$ . Thus, many homogeneous equilibria have to be considered beside the two heterogeneous ones:  $\text{Hg}_2\text{Cl}_2(\text{s}) = \text{Hg}_2^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$  and  $\text{Hg}_2^{2+}(\text{aq}) = \text{Hg}^{2+}(\text{aq}) + \text{Hg}(\text{l})$ , of which  $K_{\text{so}}^\circ$  and  $(K^\circ)^{-1}$ , respectively, are the equilibrium constants. The papers in which the total solubility (sum of all the mercury containing aqueous species) and the solubility product (derived from e.m.f. data) are reported do not give as accurate and reliable quantities as are obtained from the appropriate standard electrode potentials. The following values are recommended as valid at 298.15 K:  $\log (K_{\text{so}}^\circ/\text{mol}^2\text{kg}^{-2}) = -17.844 \pm 0.017$ ,  $d \log (K_{\text{so}}^\circ/\text{mol}^2\text{kg}^{-2})/dT = (0.0622 \pm 0.0002) - (6.0 \pm 0.4) \times 10^{-4} (T/\text{K} - 298.15)$ ,  $\Delta G_{\text{so}}^\circ = 101.86 \pm 0.10 \text{ kJ mol}^{-1}$ ,  $\Delta S_{\text{so}}^\circ = -12.7 \pm 0.9 \text{ JK}^{-1} \text{ mol}^{-1}$ ,  $\Delta H_{\text{so}}^\circ = 98.08 \pm 0.18 \text{ kJ mol}^{-1}$ ,  $\Delta C_{p,\text{so}}^\circ = -0.36 \pm 0.04 \text{ JK}^{-1} \text{ mol}^{-1}$  (this item, tentatively), and  $c_{\text{Hg}} = (8.4 \pm 1.6) \times 10^{-6} \text{ mol dm}^{-3}$  (the total aqueous solubility).

## 5.3 DIMENSIONS/NBS, ARTICLE TITLES ONLY

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS.

DIMENSIONS/NBS highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, DIMENSIONS/NBS reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

### January-February 1980

DIM/NBS 64, No. 1, 1-24 (1980).

Key words: atomic properties; computers; emissions testing; energy; fundamental constants; gas; grants; marketplace; measurement seminars; photon-recoil components; SRM's.

Equity Beyond the Marketplace, D. Johnson  
Energy Forecasting: Improving on the Crystal Ball, M. Baum  
In the Pursuit of Precision, M. Baum  
NBS Measurement Seminars, M. Baum  
Gas SRM's for Emissions Testing of Heavy Duty Vehicles, G. Porter  
Eddy Current Imaging System, B. Fields  
Economical and Accurate Method for Calculation of Atomic Properties, S. Younger  
Resolution of Photon-Recoil Components of Visible Spectral Line, R. Barger  
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### March 1980

DIM/NBS 64, No. 2, 1-36 (1980).

Key words: antifouling coating; communication; gamma-ray measurement; human serum; industrial development; industrial furnace; measurement; polarized electrons; secondary standards; signs; symbols.

Signs of the Times, L. Chen and B. Plocinik  
Measurement and Industrial Development in the 1980's, T. Dillon  
The End of the Free Ride, G. Porter  
Improved X-Ray and Gamma-Ray Measurements Have Several Applications, R. Deslattes  
NBS Opens New Industrial Furnace Facility, M. Baum  
Surface Magnetism Studied Using Polarized Electrons, D. T. Pierce  
Definitive Measurements of Constituents of Human Serum, E. White  
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### April 1980

DIM/NBS 64, No. 3, 1-24 (1980).

Key words: budget; calibration service; chain reactions; gamma rays; gas flow meters; microwaves; radio antennas; trace characterization.

So Near, Yet so Far, F. McGehan  
NBS Budget Request, M. Heyman  
These Are Gamma Rays Color Them Blue, M. Baum  
New NBS Gas Flow Calibration Service is Referenced to Mass Flow Standards, K. Higgins  
Laser-Initiated Chemical Chain Reactions, S. Leone  
Trace Characterization of Drugs of Abuse, J. Blaha  
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### May-June 1980

DIM/NBS 64, No. 4, 1-28 (1980).

Key words: acoustic emission; additive migration; bond energies; neutrons; nondestructive evaluations; nuclear fuel; oyster tissue; SRMs; weights and measures.

Wrapping It Right, G. Porter  
Report from the International Bureau of Weights and Measures, L. Barbrow  
The Sounds of Failure, M. Baum  
NBS and Martin Marietta Develop Program for Nondestructive Evaluations, G. Porter  
Bond Energies and Chemical Reactivity, W. Tsang  
Nuclear Fuel Assay Using Resonance Neutrons, R. Schrack  
Standard for Lead on Filter Media, SRM  
Oyster Tissue Standard Reference Material, SRM  
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Publications  
News Briefs

### July 1980

DIM/NBS 64, No. 5, 1-28 (1980).

Key words: alternate fuels; data communications; energy; erosion; instrument landing; measurements; radio frequency; surface science; tetrafluoroethylene powder; water conservation.

Some Like It Very Hot!, G. Porter  
Water, Water Everywhere...And Not a Drop to Spare, M. Heyman  
Happy Landings, F. McGehan  
New Surface Science Research Tool Developed by NBS and IBM, G. Porter  
New Federal Standard Defines Data Communications Link Control Procedures, S. Lichtenstein  
Trace Level Organic Constituents in Alternate Fuels, W. May  
Erosion of Brittle Materials by Solid Particle Impact, S. Wiederhorn  
Reflectance Properties of Pressed Tetrafluoroethylene Powder, J. Hsia  
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### August 1980

DIM/NBS 64, No. 6, 1-24 (1980).



Key words: compact range; data; daylighting; energy; environmental; shale oil; SRM; weights and measures; x-ray exams.

#### Decade of the Marketplace

Are You a Daylighter?, K. Kuo

Chill-Cast Stainless Steel Standard Reference Materials, S. Lichtenstein

New Shale Oil Reference Materials, SRM

Planar Near-Field Measurements on a Compact Range, A. Repjar

Toward Safer Medical X-Ray Exams, J. Motz

XNDM: An Experimental Network Data Manager, S. Kimbleton

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### September 1980

**DIM/NBS 64, No. 7, 1-28 (1980).**

Key words: awards; computers; didymium glass filters; energy efficiency; inventors; innovation; labels; standards; sulfuric acid; tools.

Honors for Innovation, M. Baum

The Inventor as Artist, E. Rudin

Do Not Remove This Label, K. Kuo

Voluntary Product Standards, S. Lichtenstein

NBS Announces I/O Interface Verification Guidance, S. Radack

Gas Phase Structure of Sulfuric Acid, R. Kuczkowski

Didymium Glass Filters, SRM

Numerical Control Machine Tools, B. Smith

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### October 1980

**DIM/NBS 64, No. 8, 1-28 (1980).**

Key words: automation; computers; electrical wiring; radiation exposure; solar absorber coatings; SRM's; structural safety.

A Look at Federal Office Automation, S. Radack

Safer Practice Makes Perfect, K. Kuo

Electrical Wiring: Staying on the Safe Side, G. Porter

I-C Test Structures for Random Faults, M. Baum

Temperature Reference Materials Available, SRM

Degradation of Solar Absorber Coatings, L. Masters

Test of Radiation Exposure Calculation for Reactor Pressure Vessels, E. McGarry

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### November 1980

**DIM/NBS 64, No. 9, 1-28 (1980).**

Key words: Alaskan pipeline; atmospheric chemistry; bare electrodes; multichannel detectors; nondestructive evaluation; optical; temperature; trace elements; water.

Putting It All Together, C. Smith

Testing Without Destruction, H. Berger

Progress Toward A New Scale of Temperature, J. F. Schooley

New Raman Microprobe with Multichannel Optical Detector, E. Etz

Kinetic Data Base for Atmospheric Chemistry, R. Hampson

Breakdown Between Bare Electrodes with an Oil-Paper Interface, E. Kelley

Optical Nondestructive Evaluation, A. Feldman

Trace Elements in Water, SRM

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### December 1980

**DIM/NBS 64, No. 10, 1-32 (1980).**

Key words: fire; fluidic sensors; ionizing radiation; neutron; passive solar; radiography; safety; temperature; tracealloy; vapor detectors; wood heating.

An Effective National Program, M. Baum

Southern Exposure, G. Metz

Arson Sniffers, E. Rudin

Neutron Radiography Used for Inspecting Jet Engines, G. Porter

"Tracealloy" Standard Issued, SRM

Activities in Wood-Heating Safety, R. Peacock

Fluidic Temperature Sensors, T. Negas

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## 5.4 MONOGRAPHS

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

Monogr. 25, Section 17. **Standard x-ray diffraction powder patterns. Section 17—Data for 54 substances**, M. C. Morris, H. F. McMurdie, E. H. Evans, B. S. Paretsky, C. R. Hubbard, and S. J. Carmel, *Nat. Bur. Stand. (U.S.), Monogr. 25, Sec. 17*, 114 pages (Oct. 1980) SN003-003-02253-5.

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

Standard x-ray diffraction patterns are presented for 54 substances. The experimental x-ray powder diffraction patterns were obtained with an x-ray diffractometer. All d-values were assigned Miller indices determined by comparison with computed interplanar spacings consistent with space group extinctions. The densities and lattice constants were calculated and the refractive indices were measured in some cases.

Monogr. 166. **Evaluating the impact of securities regulation on venture capital markets**, J. R. Barth, J. J. Cordes, and G. Tasse, *Nat. Bur. Stand. (U.S.), Monogr. 166*, 43 pages (June 1980) SN003-003-02241-1.

Key words: capital asset; capital market; market model; pricing model; SEC regulations; venture capital.

A detailed and analytical assessment is provided of the economic techniques used by researchers to evaluate the efficiency of capital markets. The application of these techniques to that portion of the capital market which supplies venture funds to small, technology-based firms is emphasized. The primary elements of such analysis are the "efficient market hypothesis" and the "capital asset pricing model." The empirical analogue of the latter is commonly referred to as the "market model."

There have been several previous reviews of capital market theory but this is the first one to apply these techniques to a particular segment of the capital market and the existing policy structure affecting its operation. This policy structure is the set of regulations imposed on venture capital flows by the Securities and Exchange Commission. The important SEC regulations and the analytical approaches to assessing their impacts on capital market efficiency are discussed. Because such analysis cannot be effectively utilized by policymakers such as the SEC if it is conducted on an ad hoc basis or in isolation of the decision-making process, a monitoring system is described, which is based on the market model and which is designed to provide timely and decision-relevant information to the SEC.



## 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, 1980 Edition. Specifications, tolerances, and other technical requirements for weighing and measuring devices, H. F. Wollin, Ed., *Nat. Bur. Stand. (U.S.), Handb. 44, 1980 Edition*, 205 pages (Sept. 1980) SN003-003-02230-6.**

Key words: length-measuring devices; liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; volume-measuring devices; weighing 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 1980 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 65th National Conference on Weights and Measures during its annual meeting in 1980. Handbook 44 is published in its entirety each year following the annual meeting of the National Conference on Weights and Measures. The National Bureau of Standards has a statutory responsibility for "Cooperation with the States in securing uniformity of weights and measures laws and methods of inspection." In partial fulfillment of this responsibility, the Bureau is pleased to publish these recommendations of the National Conference.

**H130, 1979 Edition. Model State laws and regulations, H. F. Wollin, Ed., *Nat. Bur. Stand. (U.S.), Handb. 130, 1979 Edition*, 107 pages (Feb. 1980) SN003-003-02152-1.**

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

This Handbook is the first of its kind produced for the National Conference on Weights and Measures. It is a compilation of the latest Model State Laws and Regulations adopted by the NCWM. The compilation itself was approved by the 64th National Conference on Weights and Measures in 1979 and is recommended to the States for promulgation. Recommended changes to the Handbook upon adoption by the NCWM will be made a part of subsequent annual editions of this Handbook.

**H130, 1980 Edition. Model State laws and regulations, H. F. Wollin, Ed., *Nat. Bur. Stand. (U.S.), Handb. 130, 1980 Edition*, 102 pages (Sept. 1980) SN003-003-02240-3.**

Key words: basic weights & measures law; method of sale of commodities; open dating; packaging & labeling; registration of servicemen; unit pricing; weighmaster law.

This Handbook compiles the latest Model State Laws and Regulations adopted by the National Conference on Weights and Measures. The compilation itself was approved by NCWM in 1979, and the edition includes amendments adopted at the annual meeting in 1980. The Conference recommends the compilation to the States for promulgation.

**H131. Using ANS FORTRAN, G. E. Lyon, Ed., *Nat. Bur. Stand. (U.S.), Handb. 131*, 106 pages (Mar. 1980) SN003-003-02165-2.**

Key words: ANS FORTRAN; FORTRAN 77; standard programming language; transferability.

This FORTRAN volume presents, in order: a set of quick and clear reference charts for ANS FORTRAN 66 syntax; observations on using only standard FORTRAN 66 features; instructions on circumventing and extending FORTRAN 66 with the least harm; an appraisal of the new FORTRAN 77 in terms of FORTRAN 66 constructs. Although the chapters comprise much material that has appeared in other technical memoranda or published articles, heavily recast sections have been refereed.

The four chapters address programmers concerned with FORTRAN transportability, managers engaged in programming standards, and other practitioners interested in system influences upon languages. Since the text touches upon several general programming aspects (input/output, storage allocation, storage lifetimes and protection, control structures), the volume's appeal will extend beyond the immediate FORTRAN community.

**H132. Energy conservation in buildings: An economics guidebook for investment decisions, H. E. Marshall and R. T. Ruegg, *Nat. Bur. Stand. (U.S.), Handb. 132*, 149 pages (May 1980) SN003-003-02192-0.**

Key words: benefit cost; building economics; discounting; economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows.

Energy conservation in buildings has become critical in the planning and design of buildings due to increasing energy prices and the threat of fuel shortages. Architects, engineers, builders, and others concerned with the design and operation of buildings need principles and guidelines for making economically efficient investment decisions in energy conservation. This guidebook provides principles, techniques, step-by-step illustrations, and sample problems on how to evaluate the economics of energy conservation and solar energy investments. Techniques of economic evaluation including life-cycle costing, net benefits, savings-to-investment ratio, internal rate-of-return, and discounted payback analyses are described and compared in terms of their advantages and disadvantages. Discounting, a procedure for taking into account the time value of money, is illustrated in the analysis of an investment in heat pumps. Practice problems for discounting and for applying each of the five techniques are presented. Factors that affect benefits and costs, including time horizons, discount rates, inflation, incentives, taxes, salvage values, and measures of uncertainty, are discussed, and guidance is provided for selecting appropriate values for these factors when making economic evaluations. Comprehensive case illustrations for solar heating and for window design management are described. Appendices provide tables and formulae for evaluating the economics of alternative conservation investments.

**H134. Fire investigation handbook, F. L. Brannigan, R. G. Bright, and N. H. Jason, Eds., *Nat. Bur. Stand. (U.S.), Handb. 134*, 197 pages (Aug. 1980) SN003-003-02223-3.**

Key words: accelerants; arson; building fires; electrical fires; explosions; fire investigations; fire investigators; hydrocarbons; photography.

The Handbook is a reference tool designed to be used by the beginning or by the experienced fire investigator. How each person uses this book will depend upon a particular need and level of experience. The broad areas covered are: Fire Ground Procedures; Post-Fire Interviews; The Building and Its Makeup; Ignition Sources; the Chemistry and Physics of Fire and Sources of Information. The appendices have sections on how

to organize an arson task force; the expert witness; independent testing laboratories and selective bibliography.

**H135. Life-cycle costing manual for the Federal energy management programs**, R. T. Ruegg, *Nat. Bur. Stand. (U.S.), Handb. 135*, 234 pages (Dec. 1980) SN003-003-02274-8.

Key words: cost effectiveness; economic evaluations; energy conservation; Federal energy management program; life-cycle costing; public buildings; renewable energy; solar energy; solar photovoltaic.

This manual is a guide to understanding the life-cycle costing method and an aid to calculating the measures required for evaluating energy conservation and renewable energy investments in all Federal buildings. It expands upon the life-cycle costing criteria contained in the Program Rules of the Federal Energy Management Program (Subpart A of Part 436, Title 10, U.S. Code of Federal Regulations) and is consistent with those criteria. Its purpose is to facilitate the implementation of the Program Rules by explaining the life-cycle costing method, defining the measures, describing the assumptions and procedures to follow in performing evaluations, and giving examples. It provides worksheets, a computer program, and instructions for calculating the required measurements.

The life-cycle costing method and evaluation procedures set forth in the Federal Energy Management Program Rules and described in greater detail in this guide are to be followed by all Federal agencies for all energy conservation and renewable energy projects undertaken in new and existing buildings and facilities owned or leased by the Federal government, unless specifically exempted. The establishment of the methods and procedures and their use by Federal agencies to evaluate energy conservation and solar energy investments are required by Section 381(a)(2) of the Energy Policy and Conservation Act, as amended, 42 U.S.C. 6361(a)(2); Section 10 of Presidential Executive Order 11912, amended; and by Title V of the National Energy Conservation Policy Act, 92 Stat. 3275.

**H137. Examination of distance measuring devices**, S. Hasko, *Nat. Bur. Stand. (U.S.), Handb. 137*, 63 pages (Dec. 1980) SN003-003-02276-4.

Key words: calibration; distance; fifth wheel; inspection; measured course; odometer; taximeter; test procedure; tire pressure; tolerances.

This is a manual for State and local weights and measures officials, describing distance measuring devices such as odometers and taximeters to be tested, testing equipment and its calibration, inspection and testing procedures, and a reporting system. Provision is made for accommodating a changeover to metric units of device examination in the definitions, tables, procedures, and in reporting a test.



## 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.

**SP260-68. Standard reference materials: Metal-on-quartz filters as a standard reference material for spectrophotometry—SRM 2031,** R. Mavrodineanu and J. R. Baldwin, *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-68*, 116 pages (Apr. 1980) SN003-003-02167-9.

Key words: filters for spectrophotometry; metal-on-fused silica filters; optical transmittance accuracy; polarization; reflections; spectral bandpass; standard reference materials in spectrophotometry; stray radiation; transmittance stability.

This publication describes in detail the selection, production, testing, and certification of the semi-transparent evaporated metal-on-fused silica filters as a Standard Reference Material for spectrophotometry. Particular attention is given to various factors that can affect the accuracy of the transmittance values established for these filters, such as: reflections, polarization, angle of incidence, and stability in time. Adequate procedures were devised and are described for the protection of the exposed metal layer surface using optical contact, and for the protection of the filter aggregate, by the use of metal holders provided with shutters and of metal storage containers.

The data from several interlaboratory tests are also discussed, together with the results obtained on transmittance measurements on 19 sets of chromium-on-fused silica filters, protected by optical contact, which were studied over a period of two years. An Appendix contains the reproduction of several publications relevant to the subject discussed in this work.

**SP260-69. Standard reference materials: A reference method for the determination of lithium in serum,** R. A. Velapoldi, R. C. Paule, R. Schaffer, J. Mandel, L. A. Machlan, E. L. Garner, and T. C. Rains, *Nat. Bur. Stand. (U.S.), Spec. Publ. 260-69*, 114 pages (July 1980) SN003-003-02214-4.

Key words: accuracy; clinical analysis; clinical chemistry; definitive method; electrolytes; flame atomic absorption spectroscopy; interlaboratory testing; precision; reference method; semiautomated pipetting; serum lithium analysis; statistical analysis.

A reference method was established for the determination of serum lithium based on flame atomic absorption spectroscopy (FAAS). Its accuracy was evaluated by comparing the values obtained by use of the method in 14 laboratories against the results obtained by a definitive analytical method based on isotope dilution-mass spectrometry (IDMS). Ten serum pools with lithium concentrations in the range 0.534 to 2.954 mmol/L were analyzed. Manual and semiautomated pipetting alternatives were tested using sample sizes of 4.00 and 2.00 mL, respectively.

The laboratories used several different FAAS instruments. The results showed that the standard error for a single laboratory's performance using either pipetting procedure was about 1.5 percent with a negative bias of about 2.0 percent over the range of serum lithium concentrations studied. These values are within the accuracy and precision goals that had been set. The calibration curve data showed excellent linearity over the total concentration range, with 24 of 25 curves having standard deviations of fit of 0.025 mmol/L or less.

With appropriate experimental design, the reference method may be used to establish the accuracy of field methods as well as to determine reference lithium values for pooled sera.

**SP305. Supplement 11. Publications of the National Bureau of Standards 1979 Catalog.** A compilation of abstracts and key word and author indexes, B. L. Burris and R. J. Morehouse, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 11*, 615 pages (Feb. 1980) SN003-003-02194-6.

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

This 11th supplement to Special Publication 305 of the National Bureau of Standards lists the publications of the Bureau issued between January 1-December 31, 1979. It includes an abstract of each publication (plus some earlier papers omitted from Special Publication 305 Supplement 10), key-word and author indexes; and general information and instructions about NBS publications.

**SP363. Supplement 2. Bibliography on atomic energy levels and spectra (July 1975 through June 1979),** R. Zalubas and A. Albright, *Nat. Bur. Stand. (U.S.), Spec. Publ. 363, Suppl. 2*, 119 pages (Oct. 1980) SN003-003-02267-5.

Key words: atomic energy levels; atomic spectra; bibliography; energy levels, atomic; spectra, atomic; wavelengths, atoms and ions.

This is the second supplement to NBS Special Publication 363, "Bibliography on Atomic Energy Levels and Spectra, July 1968 through June 1971." Supplement 1 covered the period from July 1971 through June 1975, and this bibliography covers the literature from July 1975 through June 1979. It contains approximately 1200 references classified by subject for individual atoms and atomic ions. A number index identifies the references. An author index is included. References included contain data on energy levels, classified lines, wavelengths, Zeeman effect, Stark effect, hyperfine structure, isotope shift, ionization potentials, or theory which give results for specific atoms or atomic ions.

**SP400-16. Semiconductor measurement technology: Modulation measurements for microwave mixers,** J. M. Kenney, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-16*, 86 pages (Feb. 1980) SN003-003-02154-7.

Key words: conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; measurement uncertainties; microwave mixer diodes; modulation; point-contact diodes; reflectometer; return loss; Schottky-barrier diodes; semiconductor diodes; standing-wave ratio (SWR).

The measurement of mixer conversion loss using periodic or incremental modulation of the local oscillator, and the evaluation and minimization of the associated systematic and random uncertainties, are discussed in terms of an X-band mixer measurement system constructed at NBS. It is shown that the systematic uncertainty in the incremental modulation method of measuring conversion loss results largely from the uncertainties in the calibration of microwave attenuation and power.

It is also shown that the "modulation" (periodic modulation) and "incremental" (incremental modulation) methods of measuring conversion loss are essentially identical, the only practical distinction being in the somewhat different instrumentation required by the different modulation rates.

Several improvements in the periodic and incremental modulation techniques are introduced. Novel circuits for measuring intermediate-frequency output conductance and local-oscillator return loss are described which may also be useful for other immittance measurements.



**SP400-43. Semiconductor measurement technology: Accurate linewidth measurements on integrated-circuit photomasks,** J. M. Jerke, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-43*, 166 pages (Feb. 1980) SN003-003-02151-2.

**Key words:** filar eyepiece; image-shearing eyepiece; integrated circuits; linewidth measurements; microelectronics; micrometrology; optical microscope; photoelectric microscope; photomask; scanning electron microscope; semiconductor technology.

The progress of the NBS program to develop improved theory for accurate linewidth measurements with optical microscopes, to develop primary linewidth calibration of 1- to 10- $\mu\text{m}$  wide lines on integrated-circuit (IC) photomasks, and to provide calibrated measurement artifacts and measurement procedures to the IC industry is discussed. This report covers the initial period from September 1974 through December 1976.

Using coherence theory, line-image profiles are calculated for real optical-microscope systems. The effects of defocus, spherical aberration, and finite transmission of opaque mask areas on the line-image profiles and the location of the line edges are discussed.

A primary linewidth-calibration system, consisting of an interferometer located in a scanning electron microscope (SEM), has been fabricated and used to make measurements of nominally 1-, 2-, and 3- $\mu\text{m}$  wide opaque and clear lines on antireflective chromium artifacts. A secondary linewidth calibration system, which is a modified photometric optical microscope, has been fabricated and provides line-image profiles that compare very well with optical theory. A comparison of measurements on opaque lines between the SEM/interferometer and the photometric optical microscope shows differences of only 0.05  $\mu\text{m}$ .

Linewidth measurements on optical microscopes equipped with filar and image-shearing eyepieces are presented. A preliminary effort shows that differences between linewidth measurements with these two eyepieces are significantly reduced when a linewidth artifact measured on the photometric optical microscope is used to calibrate the eyepieces.

Collaborative tests between NBS and the IC industry to evaluate procedures for accurate linewidth measurements with calibrated artifacts are discussed. Some of the methods for transferring NBS-measured values to the industry are summarized. The plans for the continuing micrometrology program include accurate linewidth measurements on opaque wafers with reflected light and on see-through masks with transmitted light and submicrometer linewidth calibration.

**SP400-45. Semiconductor measurement technology: April 1, 1977 to September 30, 1977,** W. M. Bullis, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-45*, 43 pages (Aug. 1980) SN003-003-02220-9.

**Key words:** capacitance-voltage methods; deep level transient spectroscopy; electrical properties; electronics; electron irradiation; hole mobility; integrated circuits; ion knock-on effect; ion microprobe mass analysis; Irvin's curves; isothermal transient capacitance method; linewidth measurements; measurement technology; microelectronics; phosphorus pileup; photolithography; pull test; random fault test structures; resistivity; scanning acoustic microscope; scanning electron microscope; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds.

This progress report describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Both in-house and contract efforts are included. The emphasis is on silicon device technologies. Principal accomplishments during this reporting period included (1) development of theoretical expressions for

computing resistivity and hole mobility for boron-doped silicon; (2) completion of a study of problems associated with use of a scanning electron microscope for total dose testing of semiconductor devices; (3) completion of a pilot study to evaluate procedures for measuring 1- to 10- $\mu\text{m}$  wide clear and opaque lines viewed with transmitted illumination; (4) completion of a preliminary study of test structures for estimating densities of process-induced random faults in device wafers; and (5) completion of an interlaboratory evaluation of the destructive wire bond pull test. Also reported is other ongoing work on materials characterization by electrical and physical analysis methods, materials and procedures for wafer processing, photolithography, test patterns, and device inspection and test procedures.

**SP400-60. Semiconductor measurement technology: Technical impediments to a more effective utilization of neutron transmutation doped silicon for high-power device fabrication,** D. R. Myers, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-60*, 33 pages (May 1980) SN003-003-02181-4.

**Key words:** defects; neutron transmutation doping; power device materials; radiation damage; silicon; thyristors.

Neutron transmutation doping (NTD) is a promising technique for the production of uniformly doped silicon needed to optimize power device performance. This report summarizes the problems involved in the neutron transmutation doping process and elaborates the concerns related to damage in transmutation doped silicon resulting from the neutron irradiation. Suggestions for future research are presented.

**SP400-61. Semiconductor measurement technology: Metrology for submicrometer devices and circuits,** W. M. Bullis, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-61*, 41 pages (June 1980) SN003-003-02198-9.

**Key words:** dimensional metrology; electronics; integrated circuits; materials characterization; measurement methods; microelectronics; microstructures; semiconductors.

The metrological requirements of semiconductor microelectronics, always challenging, are made even more stringent by the trend toward submicrometer devices and structures. This comes about not only because of the obvious demands associated with the smaller feature sizes of circuit elements but also because of the attendant requirements for more efficient design verification aids, computer simulations, and process validation and control techniques and because of the concurrent trend toward larger die and package sizes. This paper examines the types of metrological requirements associated with submicrometer devices and structures, summarizes the present state of the art in selected critical areas of metrology, and reviews current research and development efforts on advanced measurement technology, especially those at the National Bureau of Standards.

**SP400-62. Semiconductor measurement technology: Method to determine the quality of sapphire,** M. T. Duffy, P. J. Zanzucchi, W. E. Ham, J. F. Corboy, and G. W. Cullen, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-62*, 74 pages (Aug. 1980) SN003-003-02222-5.

**Key words:** infrared reflectance; optical reflectance; polishing; silicon on sapphire; surface roughness; ultraviolet reflectance; work damage.

Specular reflectance measurements were used in the quantitative characterization of sapphire and silicon surfaces. Residual polishing damage in sapphire surfaces can be easily detected by infrared multiple reflectance measurements in the lattice-band region of sapphire, nominally 300 to 900  $\text{cm}^{-1}$ . Specular reflectance measurements in the ultraviolet, at a photon energy of 4.3 eV (corresponding to the  $X_4-X_1$  silicon transition), have been used for the surface characterization of bulk silicon surfaces and silicon films on sapphire. This measurement is sensitive to crys-



talline quality, polishing damage, and surface texture which cause light-scattering effects. The reflectance methods are fast, nondestructive, and can be used for quality control and research purposes.

The reflectance methods were applied to the characterization of variously polished sapphire surfaces and to the characterization of heteroepitaxial silicon films grown on the substrates. The results of these measurements were correlated with various parameters of silicon-on-sapphire (SOS) devices fabricated in the silicon films. Measured device parameters include drain current, extrapolated threshold voltage, leakage current, and drain breakdown voltage. Most device data were automatically recorded using a special device test pattern and simple statistical data were computed for the various device parameters.

**SP400-63. Semiconductor measurement technology: A FORTRAN program for calculating the electrical parameters of extrinsic silicon,** R. D. Larrabee, W. R. Thurber, and W. M. Bullis, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-63*, 54 pages (Oct. 1980) SN003-003-02260-8.

Key words: carrier density; computer program; electrical properties of silicon; Hall effect; mobility; resistivity; silicon.

Many electrical properties of silicon are strongly dependent upon the specific nature and density of the active impurities present. Calculation of these electrical properties hinges on the solution of the charge balance equation to determine the position of the Fermi level for each specific case of interest. A FORTRAN program is presented that performs this determination and then calculates some of the often-used electrical parameters of silicon as a function of temperature. Results obtained from this program have proven useful in interpreting Hall effect data, determining the degree of ionization of the separate dopant states as a function of temperature, predicting the behavior of specimens when the dopant picture is intentionally (or conceptually) changed, and understanding the variations in the relative roles of the different scattering mechanisms on carrier mobility as the temperature is changed.

**SP432, 1979 Edition. NBS time and frequency dissemination services,** S. L. Howe, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 432*, 20 pages (Sept. 1979) SN003-003-02105-9.

Key words: broadcast of standard frequencies; frequency calibrations; GOES satellite; high frequency; low frequency; satellite time code; standard frequencies; television color subcarrier; time calibrations; time signals.

Detailed descriptions are given of the time and frequency dissemination services of the National Bureau of Standards (NBS). These services include the broadcasts from radio stations WWV, WWVH, and WWVB, and time and frequency calibration services using television and satellites. This publication shows services available on April 1, 1979.

**SP446-3. Building technology project summaries 1979,** M. Olmert and N. Raufaste, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 446-3*, 82 pages (Feb. 1980) SN003-003-02150-4.

Key words: building research; building technology; codes; criteria; project summaries; standards; 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 while conserving building materials and energy. The Center's activities support building technology programs of the Federal, State and local governments; assists design professions, building officials and the research community by developing design criteria that improve buildings; and assists manufacturers of building products by developing criteria for evaluating innovative building materials. This report summarizes the Center's projects for calendar years

1978-79. It enables individuals to get a clear impression of CBT research activities.

**SP446-4. Building technology project summaries 1979-1980,** N. Raufaste and M. Olmert, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 446-4*, 79 pages (July 1980) SN003-003-02236-5.

Key words: building research; building technology; codes; criteria; project summaries; standards; technical bases.

The Center for Building Technology's (CBT) mission is to increase the usefulness, safety, and economy of buildings through the advancement of building technology and its application to the improvement of building practice. CBT's research activities support the building technology programs of Federal, state, and local governments; assist design professions, building officials, and the research community by developing improved design criteria; and assist manufacturers of building products by developing methods for evaluating innovative materials, components, and systems.

This report summarizes CBT's research for 1979-1980. Each summary lists the project title, its progress, point of contact within CBT, and sponsor.

The summaries presented in this report are arranged according to the 11 prime research areas that comprise the scope of work at CBT. This year the report also features a Building Community Index, which keys CBT research to individual segments of the industry.

**SP457-4. Building technology publications—Supplement 4: 1979,** K. Porterfield, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457-4*, 74 pages (June 1980) SN003-003-02205-5.

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

This report presents NBS' Center for Building Technology (CBT) publications for 1979. It is the fourth supplement to NBS Special Publication 457, *Building Technology Publications 1965-1975*, and lists CBT documents issued or recorded during January 1-December 31, 1979. It includes titles and abstracts of each NBS publication and each paper 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), data of publication, selected key words, and an abstract of each NBS publication and each paper published in an outside source. The *Author Index* cites each CBT author and gives the publication number which references documents 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, which are listed alphabetically, the user is able to locate reports of interest through the subject-related words found in the key word index.

**SP474. Building for people—Behavioral research approaches and directions,** A. I. Rubin and J. Elder, *Nat. Bur. Stand. (U.S.), Spec. Publ. 474*, 315 pages (June 1980) SN003-003-01803-1.

Key words: architecture; audition; built environment; color; environmental psychology; illumination; perception; questionnaires; research methodology; sensory environment; social sciences; thermal environment.

The primary goal of this report is to acquaint the practicing architect and the architectural student with the potential contributions of the social sciences to the solution of building design problems. The report is divided into seven major parts, each part containing several chapters.

Part I explores problems connected with today's buildings and advocates a design approach based on a team concept including architects, behavioral researchers, and engineers.



Part II takes up the scientific approach to research, stressing the need for employing experimental controls and systematic procedures to collect objective data.

Parts III, IV, and V describe methods employed by researchers to collect Man/Environment (M/E) data. The emphasis is on the need to develop systematic procedures to collect information, because only in this way can significant progress be made in developing a discipline of M/E studies.

Part VI summarizes the major points and indicates approaches and directions for developing such a discipline.

Part VII contains reference information to broaden the perspective of the reader with respect to M/E issues. The final part of the work contains a glossary, bibliographic information, and an index.

**SP480-23. Selection and application guide to police photographic equipment**, C. C. Grover, *Nat. Bur. Stand. (U.S.), Spec. Publ. 480-23*, 65 pages (Aug. 1980) SN003-003-02224-1.

Key words: cameras; exposure meters; film; filters; law enforcement photography; lenses; lighting equipment; photographic equipment.

This user guide provides a basis for the selection of photographic equipment that meets the needs of law enforcement. Typical police photographic assignments are discussed to identify those aspects of the tasks that influence equipment needs. Each of the available types of cameras is described, including operation, required operator skill, advantages and disadvantages. Lenses, film, lighting equipment, filters, exposure meters and other accessories are also discussed.

**SP500-20, Revised 1980. Computer science & technology: Validating the correctness of hardware implementations of the NBS Data Encryption Standard**, J. Gait, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-20*, 46 pages (Revised Sept. 1980) SN003-003-02249-7.

Key words: communications security; computer security; cryptography; encryption standard; interface requirements; Monte-Carlo testing; testbed; test cases; validating correctness.

This publication describes the design and operation of the NBS testbed that is used for the validation of hardware implementations of the Federal Information Processing Data Encryption Standard (DES). A particular implementation is verified if it correctly performs a set of 291 test cases that have been defined to exercise every basic element of the algorithm. As a further check on the correctness of the implementation an extensive Monte-Carlo test is performed. This publication includes the full specification of the DES algorithm, a complete listing of the DES test set, and a detailed description of the interface to the testbed.

**SP500-56. Computer science & technology: Validation, verification, and testing for the individual programmer**, M. A. Branstad, J. C. Cherniavsky, and W. R. Adrion, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-56*, 26 pages (Feb. 1980) SN003-003-02159-8.

Key words: program verification; software development; testing.

Guidelines are given for program testing and verification to insure quality software for the programmer working alone in a computing environment with limited resources. The emphasis is on verification as an integral part of the software development. Guidance includes developing and planning testing as well as the application of other verification techniques at each lifecycle stage. Relying upon neither automated tools nor formal quality assurance support, the guidelines should be appropriate for applications programmers doing small development projects.

**SP500-57. Computer science & technology: Audit and evaluation of computer security II: System vulnerabilities and controls**. Proceedings of the NBS Invitational Workshop held at Miami Beach, FL, Nov. 28-30, 1978, Z. G. Ruthberg, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-57*, 210 pages (Apr. 1980) SN003-003-02178-6.

Key words: applications controls; computer vulnerabilities; data base controls; data base management systems controls; EDP audit; internal audit; operating system controls; system controls; system vulnerabilities; terminal controls.

The National Bureau of Standards, with the support of the U.S. General Accounting Office, sponsored a second invitational workshop on computer security audit, entitled "Audit and Evaluation of Computer Security II: System Vulnerabilities and Controls," in Miami Beach, Florida, on November 28-30, 1978. A cross-section of highly qualified people in the computer science and EDP audit fields was assembled to develop material that would be directly usable for a Federal Information Processing Standard (FIPS) Guideline on the subject. In order to cover the material in a systematic fashion, the workshop was partitioned into three management sessions and five technical sessions. The management sessions addressed Managerial and Organizational Vulnerabilities and Controls at the Staff Level (1 session) and the Line Level (2 sessions). The technical sessions addressed vulnerabilities and controls in the areas of Terminal and Remote Peripherals, Communication Components, Operating Systems, Applications and Non-Integrated Data Files, and Data Base/Data Base Management Systems. These Proceedings are the reports developed by the eight sessions of the workshop.

**SP500-58. Computer science & technology: Application of measurement criteria in the selection of interactive computer services**, P. D. Amer, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-58*, 90 pages (Apr. 1980) SN003-003-02174-1.

Key words: binary selection; computer comparison; computer measurement; computer service; data analysis; performance evaluation; ranking and selection; selection methodology.

This publication addresses the data analysis component of the computer service selection process. A computer service selection model, introduced in NBS Special Publication 500-44, is presented and three binary type selection procedures applicable in the measurement phases of that model are given. A binary type procedure determines which of a set of competing computer services perform above and which perform below a specified performance level. As a result of employing these procedures, those services that perform below the performance level can be eliminated or penalized depending on whether the performance specification is mandatory or desirable in nature. The procedures explicitly specify prior to measurement an appropriate selection rule and/or the number of test measurements required in a comparison effort to attain a given level of statistical confidence in the results. Experimental data from a previous case study are reanalyzed to illustrate application of the selection procedures.

**SP500-59. Computer science & technology: Data abstraction, databases, and conceptual modelling: An annotated bibliography**, M. L. Brodie, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-59*, 86 pages (May 1980) SN003-003-02179-2.

Key words: abstract data types; artificial intelligence; data abstraction; database management systems; data structures; programming languages; software engineering.

This bibliography contains entries for over 350 books, articles, and papers on issues within the area of conceptual modelling of dynamic systems of complex data. The entries have been drawn from recent work in the areas of database management, programming languages, artificial intelligence, and software engi-



neering. The bibliography has two purposes: to present a comprehensive list of annotated references to research into issues of data abstraction, databases, and conceptual modelling; and second, to encourage the cross-fertilization of the three research areas of database management, programming languages, and artificial intelligence.

**SP500-60. Computer science & technology: Sizing distributed systems: Overview and recommendations**, S. A. Mamrak, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-60*, 21 pages (May 1980) SN003-003-02190-3.

Key words: benchmarking; distributed systems; hybrid models; queueing analysis; system sizing.

Computer system sizing is a complicated process for which a variety of tools have been developed. The choice of tools for a particular sizing exercise is guided by many considerations such as cost, available data and the expertise of the analyst. This report presents an overview of sizing techniques, a brief discussion of the factors that affect choosing one or a combination of techniques, and a set of recommendations for choosing tools for sizing distributed systems. The report is aimed at managerial-level personnel who have developed technical competence with regard to single-processor computer systems and are faced with procurement decisions regarding distributed computer systems or services.

**SP500-61. Computer science & technology: Maintenance testing for the Data Encryption Standard**, J. Gait, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-61*, 28 pages (Aug. 1980) SN003-003-02225-0.

Key words: communications security; computer security; cryptography; Data Encryption Standard; in-service testing; maintenance tests; Monte-Carlo testing; stuck-fault testing; test cases; validation vs. maintenance.

This publication describes the design of maintenance tests for the Federal Information Processing Data Encryption Standard (DES). The test consists of an iterative procedure that completely tests the operation of DES devices by using a small program and minimum data. The tests are designed to be independent of implementation and to be fast enough to test devices during actual operation. The tests are defined as four stopping points in a general testing process, and satisfy four testing requirements depending on the thoroughness of testing desired.

**SP500-62. Computer science & technology: Conversion of Federal ADP systems: A tutorial**, J. Collica, M. Skall, and G. Bolotsky, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-62*, 73 pages (Aug. 1980) SN003-003-02226-8.

Key words: conversion costs; conversion problems; conversion tools; database management; Federal agencies; language translators; maintenance; portability.

This tutorial report was undertaken to provide a better understanding of conversion of Federal Government ADP Systems. Three sources were used for gathering the required information to prepare this tutorial: (1) interviews with commercial conversion experts; (2) interviews with Federal Government agency personnel who have recently experienced conversions; (3) current literature. The first three chapters comprise the tutorial. The next three chapters discuss the information gathered from the above three sources. The last chapter summarizes the authors' conclusions, while highlighting the major problem areas requiring guidance.

**SP500-63. Computer science & technology: A testbed for providing uniformity to user-computer interaction languages**, S. Treu, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-63*, 74 pages (Aug. 1980) SN003-003-02234-9.

Key words: bibliographic retrieval systems; command language; interaction language; language transformation; lan-

guage uniformity; user-computer interaction; user-oriented system design.

The differing user-computer interaction languages, implemented for conducting the same applications-specific functions on different systems, represent significant stumbling blocks to users. Toward alleviating this problem area, the use of an intermediary processor to "uniformize" interaction languages is presented. A framework for such processing is characterized in terms of the required intermediary actions and the logical capabilities needed to perform those actions. The testbed software facilities, centered on the NBS Network Access Machine, are then portrayed. Throughout, an example application, using a common command language subset to access five bibliographic retrieval systems, is described.

**SP500-64. Computer science & technology: Data base directions—The conversion problem**. Proceedings of the Workshop of the National Bureau of Standards and the Association for Computing Machinery, held at Fort Lauderdale, FL, Nov. 1-3, 1977, J. L. Berg, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-64*, 178 pages (Sept. 1980) SN003-003-02248-9.

Key words: conversion; data base; data-description; data-dictionary; data-directory; data-manipulation; DBMS; languages; query.

What information can help a manager assess the impact a conversion will have on a data base system, and of what aid will a data base system be during a conversion? At a workshop on the data base conversion problem held in November 1977 under the sponsorship of the National Bureau of Standards and the Association for Computing Machinery, approximately seventy-five participants provided the decision makers with useful data.

Patterned after the earlier Data Base Directions Workshop, this workshop, *Data Base Directions—the Conversion Problem*, explores data base conversion from four perspectives: management, previous experience, standards, and system technology. Each perspective was covered by a workshop panel that produced a report included here.

The management panel gave specific direction on such topics as planning for data base conversions, impacts on the EDP organization and applications, and minimizing the impact of the present and future conversions. The conversion experience panel drew upon ten conversion experiences to compile their report and prepared specific checklists of "do's and don'ts" for managers. The standards panel provided comments on standards needed to support or facilitate conversions and the system technology panel reports comprehensively on the systems and tools needed with strong recommendations on future research.

**SP500-65. Computer science & technology: Computer performance evaluation users group (CPEUG)**. Proceedings of the Sixteenth Meeting held at Orlando, FL, Oct. 20-23, 1980, H. J. Highland, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-65*, 316 pages (Oct. 1980) SN003-003-02250-1.

Key words: benchmarking; capacity planning; computer performance evaluation; computer performance measurement; computer performance prediction; computer system acquisition; CPE in auditing; installation management; on-line system evaluation; queueing models; simulation; workload definition.

The Proceedings record the papers that were presented at the Sixteenth Meeting of the Computer Performance Evaluation Users Group (CPEUG 80) held October 20-23, 1980, in Orlando, Florida. With the theme "CPE Trends in the 80's," CPEUG 80 focused on new applications that are expected to grow in the 80's and changes that may occur in traditional areas during the 80's. The program was divided into two parallel sessions and included technical papers on previously unpublished work, case studies, tutorials, and panels. Technical papers are presented in



the Proceedings in their entirety. *These proceedings include the following papers (indented):*

On the simulation modeling of network DBMS, J. A. Aitken and H. T. Hsu, *SP500-65*, pp. 3-10 (Oct. 1980).

Key words: CODASYL; data base; data base management systems; data description language; data manipulation language; performance evaluation; schema; simulation modeling.

This paper describes an approach to the simulation modeling of Data Base Management Systems (DBMS)—specifically, those DBMS which are based on the CODASYL DBMS concepts and specifications.

The modeling approach provides the system designer (or data base administrator) with a powerful tool for the prediction and evaluation of DBMS performance. Modeling language statements corresponding directly to actual data description language (DDL) and data manipulation language (DML) statements allow the straightforward definition of data base structures (schemas) and representation of application program behavior. A pre-defined model structure which includes representations of DBMS control functions (e.g., data base access control, space management, buffer management) and DML operations, facilitates DBMS modeling. The use of a simulation-time "replica" of a modeled data base enables detailed modeling of data base navigation and accessing.

The DBMS model supports the investigation of many factors affecting DBMS performance, including: workload composition, logical data base structure, physical data base organization, data base size, data base page size, number of buffers and buffer management strategies, data base loading factors, and secondary storage device characteristics.

DBMS performance prediction and evaluation is supported by the automatic collection and reporting of a variety of performance statistics pertaining to (1) data base area queuing, utilization, and accessing, (2) run-unit execution time and data base I/O, (3) buffer utilization and queuing, and (4) run-unit DML request queuing.

An approach to benchmarking DBMS, B. N. Anderson, *SP500-65*, pp. 11-20 (Oct. 1980).

Key words: constructing program; DBMS benchmarking; interface functions.

This paper presents a data base management system (DBMS) benchmarking methodology developed by FEDSIM to support an acquisition of both a computer mainframe and a DBMS. The DBMS benchmarking methodology provides procedures for: 1. defining a logical data base structure; 2. constructing programs to generate files incorporating the logical relationships; and 3. constructing batch and on-line benchmark programs which incorporate the logical DBMS relationships through the use of vendor-independent interface functions.

In order to execute the benchmark programs, the vendor must implement the logical data base structure in the proposed physical data base structure, by replacing the interface functions with appropriate DBMS commands. The vendor may implement any physical data base structure, as long as the functional requirements specified by the benchmark programs are met.

The benchmark data base and programs were implemented and tested by an agency team of programmer/analysts, with the agency team performing vendor functions. This test of the DBMS benchmarking methodology is described in this paper. Potential problems and benefits of this approach to benchmarking data base management systems are also discussed. Finally, a comparison of the similarities and differences between the U.S. Department of Agriculture's

DBMS benchmark methodology and the benchmark methodology presented in this paper is presented.

EDP auditing in the 1980's or the vanishing paper trail, R. E. Andersen, *SP500-65*, pp. 23-32 (Oct. 1980).

Key words: audit-in-depth; auditing; auditing aids; internal controls; security.

This paper is designed to provide an overview of (1) traditional auditing methodology and (2) the reasons why these methods must be modified and adapted in order to cope with the "vanishing paper trail" inherent in today's (and tomorrow's) increasingly on-line, data base-oriented, distributed processing, EDP environment.

The three basic types of audits (general, administrative, and applications) will be discussed. Examples of flagrant, and not-so-flagrant, computer crimes will be presented. Practical and proposed solutions for the reduction of these types of DP crimes in the 1980's will be examined.

The major thrust of the paper, however, will address the importance of the applications-oriented audit. The paper will discuss the concept of Computer Management Technology (CMT), and show that this is in reality a type of on-going auditing task. Alternatives will be examined for measuring, managing and controlling key functional areas that have a definite interactive effect on the availability of resources and the performance of system components (or both) in a data processing installation.

Tracking potential security violations, R. L. Lehmann, *SP500-65*, pp. 33-46 (Oct. 1980).

Key words: audit trails; computer fraud; computer security; job tracking; security violations; SMF retrieval.

Security concerns not only involve providing restricted access to computer resources, but frequently require investigative studies to track suspicious utilization for potential company violations. For such studies it is important to have pertinent information for the entire job in order to trace what is being done. Sometimes very little information is available to use as a key for isolating the jobs in question. This paper describes a tool developed at Union Carbide Corp. to enhance such investigations on IBM MVS systems.

Measuring programming productivity, P. F. Zoll, *SP500-65*, pp. 49-52 (Oct. 1980).

Key words: metaprogramming; operationalism; programmer measurement; programmer productivity.

The paper begins by characterizing the current era as one of decreasing hardware costs and increasing software costs. These trends make the improvement of programmer productivity a critical consideration. The paper proceeds with a review of the historical methods of measurement that use statistics such as programs, lines of code, limited lines of code, program correctness, data division lines plus verbs, and project control history. The consequences of imposing these various measures are considered from the aspects of generation of quality programs and impact on programmer morale.

The second section of the paper advances the position that available methodologies depend on the assumption that programmers should be evaluated on their ability to produce a program, as opposed to a product such as a report or a screen. An operationalist methodology suitable for metaprogramming is defined with the key constituents being a data elements dictionary and a set of software routines that generate sections of programs. The paper concludes with some suggested methods for measuring the efficiency of metaprograms' output as well as measuring the programmer's productivity in the new milieu.



**Comparative performance of COBOL vs. PL/1 programs, P. J. Jalics, *SP500-65*, pp. 53-59 (Oct. 1980).**

**Key words:** benchmark; COBOL; PL/1.

The comparative performance of COBOL versus PL/1 programs on the IBM/370 is studied on the basis of a substantive benchmark test which has been implemented in both languages. The benchmark program was written so as to use identical data-types and language facilities where they exist, and close approximations elsewhere. Measurement results from each of eleven atomic tests are then used to gain insight into the relative merits of code generated for each language in that particular area. A number of surprising results were found, which in turn necessitated the running of additional experiments to explain the results. These, then, all contribute to give substantial insights into the relative performance of COBOL versus PL/1 Programs.

**NBS network measurement methodology applied to synchronous communications, M. D. Abrams and D. C. Neiman, *SP500-65*, pp. 63-70 (Oct. 1980).**

**Key words:** data communications; protocol validation; synchronous; teleprocessing service evaluation.

This paper focuses on the application of the NBS Network Measurement Instrument (NMI) to synchronous data communication. The suitability of the underlying Stimulus—Acknowledgement—Response (SAR) model to support the implementation of this methodology permitting quantitative evaluation of interactive teleprocessing service delivered to the user is described. The logic necessary to interpret SAR components and boundaries depends on character time sequence for asynchronous data communications traffic but entails protocol decomposition and content analysis for character synchronous data traffic. The decomposition and analysis rules necessary to evaluate synchronous communications are discussed and the level of protocol violation detection which results as a byproduct is cited. Extensions to the utility of the Network Measurement Instrument (NMI), deriving from additional workload profiling measures desirable for character synchronous communications, are also presented.

**Introduction to data communications system performance parameters, D. S. Grubb, *SP500-65*, pp. 71-75 (Oct. 1980).**

**Key words:** computer communications; computer networking; data communications; networks; performance requirements; telecommunications.

This paper is an introduction to a set of user-oriented data communication system performance parameters that will permit the user to specify, compare, and measure data communication service. The set of parameters is designed to be universal in application for any digital data communication system regardless of the control protocol or network topology used. This set of parameters is also selected to provide a comprehensive specification of data communication requirements. The parameters are the subject of a proposed ANSI standard. The parameters are based on a similar set of parameters contained in Interim Federal Standard 1033. The primary parameters are specific measures of speed (delay and rate), accuracy, and reliability associated with the three primary functions: access, transfer, and disengagement.

**User-oriented carrier sense multiple access bus simulator, M. Krajewski, *SP500-65*, pp. 79-85 (Oct. 1980).**

**Key words:** bus networks; bus performance; computer programs; contention; CSMA; GPSS; local area networks; packet switching; simulation.

This paper describes a general purpose, user-oriented

Carrier Sense Multiple Access (CSMA) bus simulation program written in GPSS-V. Designed to fill a need to quickly and easily predict bus performance, it provides the capability to simulate local area computer communication networks governed by one of the CSMA protocols. Simplicity, flexibility, and run-time economy were the key criteria employed in the formulation.

CSMA protocols are a class of stochastic packet switching techniques which allow multiple independent network subscribers to share a single communications channel with reasonably high efficiency. All are based upon the original ALOHA protocol. They possess their greatest potential in meeting the communication needs of bursty, terminal-dominated networks operating over a limited geographical area. In general, these networks consist of low rate devices requiring extremely short response times.

The simulator was designed to be quickly adaptable to different network characteristics. It is user-oriented in that all simulation parameters are documented and initialized in a single section of the program. Subscriber populations can range in size from few to many thousands of terminals. Outputs from a simulation run consist of the system characteristics input by the user and statistical channel performance information gathered automatically by GPSS. This includes the average throughput, subscriber traffic, and deferred and retransmitted packet statistics. Statistics concerning individual packet delays and overall end-to-end response times are formatted and output in the form of delay distribution tables.

The program's primary application domain is the prediction and evaluation of those bus performance characteristics relevant to initial local area network design decisions. These include packet size, bus capacity, and the general suitability of CSMA protocols.

**A comparative evaluation of local area communication technology, R. L. Larsen, J. R. Agre, and A. K. Agrawala, *SP500-65*, pp. 87-97 (Oct. 1980).**

**Key words:** communications; comparative study; local area network; performance.

The builder of a local area network is immediately confronted with the selection of a communications architecture to interconnect the elements (hosts and terminals) of the network. This choice must often be made in the presence of great uncertainty regarding the available alternatives and their capabilities, and a dearth of comparative information. This was the situation confronting NASA upon seriously considering local area networks as an architecture for mission support operations. As a result, a comparative study was performed in which alternative communication architectures were evaluated under similar operating conditions and system configurations. Considered were: (1) the ring, (2) the cable-bus, (3) a circuit-switching system, and (4) a shared memory system. The principle performance criterion used was the mean time required to move a message from one host processor to another host processor. Local operations within each host, such as interrupt service time, were considered to be part of this overall time. The performance of each alternative was evaluated through simulation models and is summarized in this paper.

**Some properties of a simple deterministic queueing model, R. Turner, *SP500-65*, pp. 101-109 (Oct. 1980).**

**Key words:** fixed service time; queueing network.

A simple queueing network with fixed service times is defined. This network might be an appropriate model for two asynchronous devices sharing the use of a single resource, where all service times are fixed. An algorithm permitting efficient computation of system behavior is de-



scribed. Certain general properties of the system are determined.

**A highly parameterized tool for studying performance of computer systems**, H. D. Hughes, *SP500-65*, pp. 111-128 (Oct. 1980).

**Key words:** cumulative distribution function; events; hardware configuration; model validation; queue; scheduling policies; simulation model; system performance; workloads.

A highly parameterized simulation model is described which allows experiments to be performed for computer performance evaluations studies. The results of these experiments can be used to evaluate the effect of changing the hardware configuration, the workload, the scheduling policy, the multiprogramming level, etc. The model is constructed to function either as a batch or time-sharing system, or as a combination of both. This simulation model also has the potential of providing dynamic feedback for the scheduler. A discussion of the design, implementation, and use of the model is presented. Examples are provided to illustrate some possible uses of the model and verifications of the results obtained from the model.

**Optimal selection of CPU speed, device capacities, and allocation of files with variable record size**, K. S. Trivedi and R. A. Wagner, *SP500-65*, pp. 129-135 (Oct. 1980).

**Key words:** capacity planning; configuration planning; file assignment problem; optimization; performance evaluation; performance oriented design; queueing networks.

This paper extends a previous model for computer system configuration planning developed by the authors. The problem is to optimally select CPU speed, device capacities, and file assignments so as to maximize system throughput subject to a fixed cost constraint. In our earlier paper we assumed that the record sizes for all files are equal, the block sizes of all devices are equal and these two in turn are equal. In this paper we extend our earlier results to allow each file a distinct record size and each device a distinct block size.

**MVS performance prediction using mechanically-generated queueing models**, R. J. Feil and B. A. Ketchledge, *SP500-65*, pp. 139-156 (Oct. 1980).

**Key words:** capacity; planning; queueing models.

A central issue in capacity planning for IBM MVS environments is the prediction of system performance under varying workload and configuration assumptions. This paper addresses the issue of performance prediction in the context of a general approach to capacity planning for MVS environments. In particular, the paper covers: a. Definition of an RMF-based measurement strategy for MVS environments; b. Software for mechanical generation of BEST/1 queueing models of MVS systems. (BEST/1 is a proprietary product of BGS Systems, Inc.); c. Calibration and use of the resulting BEST/1 models for capacity planning studies. An actual case study will be presented.

**An I/O system model for 303X processors**, S. Bhatia and P. Carroll, *SP500-65*, pp. 157-163 (Oct. 1980).

**Key words:** input/output system; shared resources.

In the 303X input/output system certain jobs are critical in the sense that the system pays a penalty in reduced performance if they are not finished in some maximum allowable time. The purpose of the model is to determine the extent of the penalty a system will pay in a heavily loaded environment.

The model of the input/output system of the 303X processors decomposes the system into a three level hierarchy

of server/requestors. The levels are: 1. (highest) the teleprocessing controllers, 2. the byte channel interface, and 3. (lowest) the director of the 303X channel group. Each server services requests from the next higher level of the hierarchy (in a strict priority order defined by the system design) and makes requests to the next lower level of the hierarchy.

In a typically heavily loaded situation, the rare situations when the queues for the shared resources become excessive, some jobs may pay a performance penalty. The analytic techniques used to determine the probability of these rare situations of excessive queue length and the model validation results will be described.

**Configuration and capacity planning in a distributed processing system**, K. C. Sevcik, G. S. Graham, and J. Zahorjan, *SP500-65*, pp. 165-171 (Oct. 1980).

**Key words:** asymptotic bound analysis; benchmark tests; capacity planning; configuration analysis; queueing network modeling.

The distributed health claims processing system of a major insurance company was based on hardware that soon proved inadequate for the processing load. A decision was made to replace the entire system with new hardware and software through an acquisition and development process scheduled to take three years. We were asked to undertake a study with the goals of (1) comparing alternative proposed configurations for the replacement system, and (2) assessing the adequacy of alternative transitional systems based on the existing software intended for use during the development of the replacement system. In this paper, we describe the latter aspects of the study. Using analytic modelling and simple asymptotic bound analysis, we were able to show that the performance of a proposed transitional system was likely to deviate significantly from the expectations based on intuition and information from the hardware vendor. Subsequent benchmark tests, motivated by the results of our study, conformed closely to our predictions. Without the information that resulted from our brief study, the company might have purchased hardware inadequate for its intended purpose.

**File allocation methodology for performance enhancement**, S. R. Kumar, R. B. Lake, and C. T. Nute, *SP500-65*, pp. 175-188 (Oct. 1980).

**Key words:** file binding; I/O resource allocation; logical storage to physical device mapping; O.S. performance prediction; O.S. tuning; storage partitioning; systems performance modeling; systems storage restructuring.

Storage device configuration is an important issue in the performance of computer systems. The designer or installation manager has to map user and system demands for storage space across the range of I/O devices available on the system. We present here a methodology for optimizing such mapping. A generalized performance model for interactive systems is developed and validated. The model incorporates the device organization, and given the descriptors for storage devices, predicts performance figures for a broad range of system configurations and workloads. Alternately, given the target performance figures for the installation, it helps work out alternative system configuration for improved performance. We present cost benefit tradeoff studies based on hypothetical scenarios to determine optimal file storage strategies from the point of view of the user as well as the installation.

**Capacity analysis of shared DASD control units**, F. L. Pedriana, *SP500-65*, pp. 189-198 (Oct. 1980).

**Key words:** capacity; control units; queueing model.



The IBM DASD control unit is an expensive and important component in an IBM 370 processing system. As is the case with most computer equipment, the data handling capacity is not well defined in terms of its impact on system throughput. Defining this is an especially difficult task where the control unit is connected to several CPU's. A queueing model can address this situation, however, the standard modeling equations do not account for a multipath environment. In addition, the collection of model input data is not a simple process. The data collection and model verification procedures are discussed in detail in this paper. In addition, some significant observations are made regarding the operation of the control units. This study resulted in a recommendation of limiting the control unit load to less than 50 SIO's per second.

**A note on computer system capacity planning through material requirements planning**, K. O. Salawu, *SP500-65*, pp. 199-203 (Oct. 1980).

Key words: capacity planning; computer installation; workload.

A computer installation is likened to an industrial production factory. Demands for goods and services are either not met (shortage, disservice) or oversupplied (inventory or waste). For given shortage and wastage costs, a smoothed, short-term production/service plan can be drawn from predicted demand or workload. This brief note employs simple graphical methods used by production engineers for aggregate production scheduling and the arithmetic of materials requirement planning to impute measures of disservice to users and poor utilization of computer resources. Noting that production/service objectives are hardly unique, the methods of goal programming that incorporate the satisfaction of multiple objectives are judged to be more appropriate for formulating production/service plans.

**Adaptive load control in batch-interactive computer systems**, S. T. Chanson and P. S. Sinha, *SP500-65*, pp. 207-213 (Oct. 1980).

Key words: load control; multiprogramming; operational analysis; optimization; queueing theory; response time; saturation point; throughput rate.

This paper presents a systematic approach to estimate the saturation point of a large computer installation using operational analysis. An expression for saturation point as defined by Kleinrock is derived in terms of measurable and operational quantities. Using stochastic programming and time series analysis the optimal number of batch jobs that should be activated within next interval is then computed, so that the system is neither underutilized nor over-saturated.

**Sensitivity analysis and forecasting for large scale IBM computer systems: A methodological approach and case study**, C. Steidtmann, *SP500-65*, pp. 215-229 (Oct. 1980).

Key words: Box-Jenkins; forecasting; multiple regression; sensitivity analysis; simultaneous equations.

This paper outlines the development and use of a new method of forecasting computer capacity for large scale IBM computer systems at Mountain Bell. The model that was developed to accomplish this task uses three different statistical techniques. A representation of the computer system is developed using two stage least squares multiple regression. An autoregressive integrated moving average process is then used to individually forecast the level of use for each of the components of the system. These values are then placed into a system of simultaneous equations which are then solved to give the desired results. The data that

was used in this project was collected over the course of a year by hardware monitors off of an IBM 3033 that was the global processor in a MVS/JES3 triplex in Mountain Bell's Colorado/Wyoming processing center.

**A performance evaluation study of UNIX**, L. F. Cabrera, *SP500-65*, pp. 233-243 (Oct. 1980).

Key words: comparison; performance of computer systems; UNIX; upgrading changes.

Different performance aspects of computer systems on which the time-sharing operating system UNIX runs are presented.

A comparison of the performance of three installations is made and the method discussed. The effects of distinct upgrading changes made in the systems, namely, the addition of a cache memory, of a disk drive and of main memory are also reported.

**I/O performance measurement on CRAY-1 and CDC 7600 computers**, I. Y. Bucher and A. H. Hayes, *SP500-65*, pp. 245-254 (Oct. 1980).

Key words: compute-and-test loop; CPU transfer rates; I/O performance; overhead CPU.

Disk I/O transfer rates and overhead CPU times were measured as functions of buffer size and number of logically independent I/O channels for several operating systems and 16 I/O routines on the Cray-1 and CDC 7600 computers. By parameterizing the codes for a variable number of channels, buffer sizes, and words transmitted, the effect of these variables is observed for buffered, nonbuffered, and random-access I/O transmissions. To measure CPU-overlapped performance, I/O was performed concurrently with a pretimed compute loop. Rates, sector overhead, and CPU transmission speeds were calculated upon completion of I/O. Effects of memory blocking due to vector operations were observed. Methods and results are presented in this paper.

**Forecasting computer processing requirements: A case study**, R. D. Tomberlin, *SP500-65*, pp. 255-261 (Oct. 1980).

Key words: benchmark; capacity management; capacity planning; workload forecasting; workload update.

This case study describes a recent experience the author had in updating a computer workload forecast. It presents an example of a workload forecast developed without regard for future update requirements and the subsequent problems encountered when trying to perform an update on the original study. The update methodology used is described and a series of recommendations is provided to help the reader avoid problems of the type experienced by the author.

**Data processing user service management**, P. S. Eisenhut, *SP500-65*, pp. 265-276 (Oct. 1980).

Key words: computer performance evaluation; data processing performance; data processing service; information system design; information system usability; performance management.

After 30 years since the advent of the electronic computer, we are fast entering the era of the information society. The trend is towards increasing use and dependence of business upon data processing. Data processing professionals must provide applications which perform adequately with respect to the business needs of users. Data processing professionals who concern themselves with the functional and technological aspects of data processing must now concern themselves with the performance of effectiveness of data processing in the business environment.



To do this requires a coordinated management process. This management process starts during the development of new data processing applications with user oriented service objectives. The process includes measurements, problem diagnosis, reporting of service and follow-up action, all on a regular basis. It also includes a formal capacity planning process which relates to committed levels of service as well as computing load.

Making the transition to an information society requires a new attitude among data processing professionals and a commitment from data processing management. Good data processing managers will view User Service Management as being critical to their own success.

**Performance evaluation of computer operations procedures,** P. A. Drayton, *SP500-65*, pp. 279-287 (Oct. 1980).

**Key words:** measurements; operations; performance.

A discussion of the measurements required for an evaluation of the operating procedures of a large computer system data center. Included are the guideline values which should be achievable with good operating techniques and solutions to frequently encountered problem situations.

**Evaluating total computer performance for top management,** R. L. Fidler, *SP500-65*, pp. 289-293 (Oct. 1980).

**Key words:** ADP management; computer performance evaluation.

Computer performance evaluations, installation reviews and EDP audits have all focused on an individual data processing system. It is rare that any evaluation is made of all computer systems and related functions on an organization-wide basis. Consequently, there is an abundance of technical and management information for use at the installation level but a dearth of management information for use at the organization's top level.

At the Department of Commerce we are initiating a new program of installation reviews, to provide useful information not only to installation management but more importantly to the Assistant Secretary for Administration, the top Commerce official responsible for the management of computer resources. A three-phase approach will be used. First, all data processing installations will complete an annual questionnaire about their operations. Second, several installations will be selected each year for on-site reviews. Other, more technical evaluations may be made as necessary. Finally, using the summary information provided by the bureaus and based on the installations' questionnaire responses, an annual report will be produced for the Assistant Secretary.

**The Air Force base level computer performance management program,** J. K. Graham, Jr., *SP500-65*, pp. 295-300 (Oct. 1980).

**Key words:** Air Force Data Systems Design Center; Computer Performance Management Technical Center; CPM project officer.

The Air Force base level Computer Performance Management (CPM) program is 10 years old this year. More than 100 operating locations around the world are within the scope of the program. This paper describes the history and current status of the program. It also speculates about the future course of Computer Performance Management within the base level environment.

**RTE's—Past is prologue,** M. G. Spiegel, *SP500-65*, pp. 303-310 (Oct. 1980).

**Key words:** applications; remote terminal emulators (RTEs); technology.

This paper surveys the evolution of Remote Terminal Emulators (RTEs). Major developments in RTE technology are separated into three "generations" of products. Each generation's unique applications and features are highlighted. Recent developments are noted and a prediction of future use for RTEs is provided.

**Application prototyping: A case study,** C. W. Jenkins, *SP500-65*, pp. 311-315 (Oct. 1980).

**Key words:** application prototyping; Congressional Budget Office; interactive systems; user requirements.

Accurate specification of user requirements for interactive systems is especially difficult in an environment where the demand for information is intense, short-fused and largely unpredictable.

The Congressional Budget Office was created in 1975 by an Act of Congress. Its primary mandate is to serve the Budget and Appropriation committees of both the Senate and the House of Representatives. The Act also defined a Congressional Budget process specifying a calendar of events and specific completion dates for major activities. This pacing of budgetary actions produces a highly charged environment in which CBO must be able to respond immediately to information needs with information that is both accurate and consistent.

In approaching a redesign of some of these highly visible information systems, CBO decided to follow a strategy of prototyping these systems in order to facilitate the involvement of the user, highlight the user's real needs and to demonstrate the feasibility, effectiveness and any shortfalls of the proposed system before risking either a management or design commitment.

**Performance evolution in a large scale system,** R. S. Brice and J. W. Anderson, *SP500-65*, pp. 319-330 (Oct. 1980).

**Key words:** capabilities; message overhead; modular design; system tuning.

This paper documents the evolution of system performance in an operating system from its initial use by a few friendly users in October 1978 to its present state. The system, DEMOS, was developed for the Cray Research Inc. (CRI) Cray-1 computer at the Los Alamos Scientific Laboratory (LASL) by staff members in the LASL Computer Science and Services Division. Some important features of DEMOS architecture are described. It is shown how the robustness in the design permitted major reduction in overhead to be achieved with only minor software changes. Particular emphasis is placed on file system design and performance because much of the system overhead reduction occurred as a result of changes to this system component. Also, some predictions are made regarding performance resulting from proposed modifications.

**SP500-67. Computer science & technology: The SRI hierarchical development methodology (HDM) and its application to the development of secure software,** K. N. Levitt, P. Neumann, and L. Robinson, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-67*, 54 pages (Oct. 1980) SN003-003-02258-6.

**Key words:** design methodology; formal specification; formal verification; hierarchical design; programming methodology; security.

This document provides an introduction to the SRI Hierarchical Development Methodology (HDM). The methodology employs a staged decomposition of the development process, which separates design, data representation, and implementation. For any given system development, HDM employs a hierarchical decomposition of the design and formal specifications of modules and their interconnections. Extensive tools are used



throughout the development to check the appropriateness of the design and its implementation.

The role of HDM in developing secure systems is considered, and various current efforts using HDM to develop such systems are summarized. The use of the methodology is illustrated by a simple but complete example. A somewhat larger example of part of a secure data management system is also discussed.

Verification is not considered in this document, although HDM does facilitate verification. The consistency of formal specifications and their formal requirements can be formally shown, as can the consistency of programs with their specifications.

**SP500-68. Computer science & technology: The Expert Assistance System for the NBS Network Access Machine, S. W. Watkins, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-68*, 47 pages (Nov. 1980) SN003-003-02275-6.**

**Key words:** command languages; communications; computer access; computer networks; minicomputers; protocols; user interfaces.

The Expert Assistance System (EAS) was developed at the National Bureau of Standards as a prototype to assist network users. Network users are faced with the problem of learning different procedures in order to access similar services on different host systems. A great deal of research has been precipitated by the desire to simplify network usage and many tools have been developed to assist the network user.

One of the approaches taken in network assistance has been to implement an intermediary machine. The intermediary machine translates simple user commands into the sequences of network and system commands required for execution on a target host system; thus, the user learns one set of commands which are applicable on different systems and networks. An ironic consequence of such an approach is that if the user desires to expand the basic set of functions provided by the intermediary machine or to tailor existing functions to individual needs, the user has to learn another command language—that of the intermediary machine itself.

The EAS addresses the problem of building procedures for an intermediary machine. The EAS automatically generates procedures by recording an interaction between a user and network system and then translating this interaction into the commands required for execution on the intermediary machine. Development of the EAS was facilitated by the existence of an intermediary machine at the National Bureau of Standards—the NBS Network Access Machine (NAM).

This report briefly describes the motivation for the development of a network assistance technique, discusses the design and implementation of the EAS at NBS, and then concludes with a view of future enhancements to the current EAS. The context for the description of the EAS is the NBS NAM; however the concepts are applicable to the general field of network user assistance.

**SP500-69. Computer science and technology: An analytic study of a shared device among independent computing systems, A. Mink, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-69*, 176 pages (Nov. 1980) SN003-003-02227-3.**

**Key words:** approximate queueing models; computer architecture; modular expansion analysis; performance evaluation; performance modeling; queueing models; queueing networks.

Global queueing network performance models are developed for the increasingly important class of computer networks comprising a number of independent computing systems sharing a single resource. An extensive bibliography and survey of prior work relating to this topic are included. Analytic expressions of performance measures for this class of systems are derived from the general theory of multiclass queueing networks, and new

computational algorithms for evaluating them are presented that are memory-space efficient (linear vs. exponential) compared with known algorithms for the general theory. This exact analytic model, called the Shared Central Server Model, incurs approximately the same exponential time complexity in its evaluation as do all models based on the general theory; because of this, a simple heuristic approximate model of this class of systems is also presented that is computationally efficient in both time and space. Modular expansion of this class of systems is investigated using the approximate model, and a useful relationship is derived between the number of additional independent computing systems and the incremental increase in capability of the shared resource required to maintain the existing level of system performance.

**SP500-70/1. Computer science and technology: NBS minimal BASIC test programs—Version 2, User's manual, Volume 1—Documentation, J. V. Cugini, J. S. Bowden, and M. W. Skall, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-70/1*, 79 pages (Nov. 1980) SN003-003-02262-4.**

**Key words:** BASIC; language processor testing; minimal basic; programming language standards; software standards; software testing.

This publication describes the set of programs developed by NBS for the purpose of testing conformance of implementations of the computer language BASIC to the American National Standard for Minimal BASIC, ANSI X3.60-1978. The Department of Commerce has adopted this ANSI standard as Federal Information Processing Standard 68. By submitting the programs to a candidate implementation, the user can test the various features which an implementation must support in order to conform to the standard. While some programs can determine whether or not a given feature is correctly implemented, others produce output which the user must then interpret to some degree. This manual describes how the programs should be used so as to interpret correctly the results of the tests. Such interpretation depends strongly on a solid understanding of the conformance rules laid down in the standard, and there is a brief discussion of these rules and how they relate to the test programs and to the various ways in which the language may be implemented.

**SP500-70/2. Computer science and technology: NBS minimal BASIC test programs—Version 2, User's manual, Volume 2—Source listings and sample output, J. V. Cugini, J. S. Bowden, and M. W. Skall, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-70/2*, 487 pages (Nov. 1980) SN003-003-02263-2.**

**Key words:** BASIC; language processor testing; minimal basic; programming language standards; software standards; software testing.

This publication describes the set of programs developed by NBS for the purpose of testing conformance of implementations of the computer language BASIC to the American National Standard for Minimal BASIC, ANSI X3.60-1978. The Department of Commerce has adopted this ANSI standard as Federal Information Processing Standard 68. By submitting the programs to a candidate implementation, the user can test the various features which an implementation must support in order to conform to the standard. While some programs can determine whether or not a given feature is correctly implemented, others produce output which the user must then interpret to some degree. This manual describes how the programs should be used so as to interpret correctly the results of the tests. Such interpretation depends strongly on a solid understanding of the conformance rules laid down in the standard, and there is a brief discussion of these rules and how they relate to the test programs and to the various ways in which the language may be implemented.



SP500-71. **Computer science & technology: Remote record access: Requirements, implementation and analysis**, H. M. Wood and S. R. Kimbleton, *Nat. Bur. Stand. (U.S.), Spec. Publ. 500-71*, 46 pages (Dec. 1980) SN003-003-02273-0.

Key words: computer networking; data conversion; data transfer; data transformation; data translation; network operating systems.

A key support component for network-wide data sharing is the ability of a process to access remotely stored data at runtime. In order for the accessed data to be useful, a means of overcoming differences in data representation and format is necessary. Such a capability is termed remote record access. This paper identifies some of the problems inherent in the sharing of data among dissimilar computer and data systems. Implementation issues and alternatives are presented, followed by a description of XRRRA, the Experimental Remote Record Access component which has been implemented as part of the Experimental Network Operating System (XNOS) at the National Bureau of Standards.

SP505-1. **Bibliography on atomic transition probabilities (November 1977 through March 1980)**, B. J. Miller, J. R. Fuhr, and G. A. Martin, *Nat. Bur. Stand. (U.S.), Spec. Publ. 505-1*, 121 pages (Aug. 1980) SN003-003-02230-6.

Key words: allowed; atomic; discrete; forbidden; intensity; lifetime; line strength; oscillator strength; transition probability.

This is the first supplement to the NBS Special Publication 505, *Bibliography on Atomic Transition Probabilities* (1914 through October 1977), and it covers the literature on the subject from November 1977 through March 1980. It contains approximately 600 references, with each article assigned a number, and is divided into five main sections. The first section contains a listing, by number, of articles of general interest. The second section lists by number all articles containing numerical data; it is arranged by element and stage of ionization and is further subdivided according to theoretical and experimental methods, comments, and compilations. The third section contains a listing of all articles, including numbers, authors, title, and journal reference; it is arranged by year of publication and alphabetically by authors' names within the year. All foreign language papers are identified, and their titles are translated into English. The fourth section contains a listing of all authors and the numbers of the papers they have authored or co-authored. A final section provides corrections or additions to the preceding bibliography.

SP533. **Characterization of particles**. Proceedings of the Particle Analysis Session of the 13th Annual Conference of the Microbeam Analysis Society held at Ann Arbor, MI, June 22, 1978, K. F. J. Heinrich, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 533*, 222 pages (Apr. 1980) SN003-003-02175-0.

Key words: biological fluids; electron microprobe; electron microscopy; ion probe; light microscopy; microanalysis; microdroplets; particles; particulate matter.

This document contains a series of invited papers on the subject of Particle Characterization. Part of the material presented here was presented orally at the Thirteenth Annual Conference of the Microbeam Analysis Society, at Ann Arbor, Michigan, on June 22, 1978. The publication describes microscopic and analytical techniques for the characterization of single microscopic particles. Applications of these techniques to problems of general interest are also included. *These proceedings include the following papers (indented):*

**Characterization of particles**, K. F. J. Heinrich, *SP533*, pp. 1-3 (Apr. 1980).

**Optical microscopy of particles**, E. B. Steel, *SP533*, pp. 5-11

(Apr. 1980).

**Variation in x-ray intensity ratios used to identify asbestos fibers**, J. C. Russ, *SP533*, pp. 13-19 (Apr. 1980).

**Quantitative analysis of small particles using wavelength and energy dispersive systems in an electron beam instrument**, J. Gavrilovic, *SP533*, pp. 21-27 (Apr. 1980).

**Procedure for the quantitative analysis of single particles with the electron probe**, J. A. Small, K. F. J. Heinrich, D. E. Newbury, R. L. Myklebust, and C. E. Fiori, *SP533*, pp. 29-38 (Apr. 1980).

**Monte Carlo electron trajectory simulation—An aid for particle analysis**, D. E. Newbury, R. L. Myklebust, K. F. J. Heinrich, and J. A. Small, *SP533*, pp. 39-61 (Apr. 1980).

**Quantitative characterization of particulates by scanning and high voltage electron microscopy**, R. J. Lee and R. M. Fisher, *SP533*, pp. 63-83 (Apr. 1980).

**Characterization of coal gasification particulates by SEM, EDS, AES, XPS, and its relevance to inhalation toxicology**, D. L. Davidson and E. M. Gause, *SP533*, pp. 85-99 (Apr. 1980).

**Accuracy of electron microprobe analysis of biological fluids: Choice of standard solutions, and range of linearity of the calibration curves**, N. Roinel, L. Meny, and J. Henoc, *SP533*, pp. 101-130 (Apr. 1980).

**Application of auger-electron spectroscopy and x-ray photoelectron spectroscopy to the characterization of pollutant particles**, C. J. Powell, *SP533*, pp. 131-137 (Apr. 1980).

**Secondary ion mass spectrometry for the analysis of single particles**, D. E. Newbury, *SP533*, pp. 139-152 (Apr. 1980).

**Scope and limitations of single particle analysis by Raman microprobe spectroscopy**, E. S. Etz and J. J. Blaha, *SP533*, pp. 153-197 (Apr. 1980).

**Laser microprobe mass analysis (LAMMA) in particle analysis**, R. Kaufmann and P. Wieser, *SP533*, pp. 199-223 (Apr. 1980).

SP544. **Simplified energy design economics: Principles of economics applied to energy conservation and solar energy investments in buildings**, H. E. Marshall, R. T. Ruegg, and F. Wilson, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 544*, 54 pages (Jan. 1980) SN003-003-02156-3.

Key words: benefit-cost; building design; construction economics; discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio.

This publication introduces the architect and engineer to economic analysis techniques for evaluating alternative energy conservation investments in buildings. Life-cycle cost, benefit-cost, savings-to-investment, payback, and rate-of-return analyses are explained and illustrated. The procedure for discounting is described for a heat pump investment. Formulas, tables of discount factors, and detailed instructions are provided to give the reader all information required to make economic evaluations of energy conserving building designs.

SP546, 1980 Edition. **Catalog of Federal metrology and calibration capabilities**, K. O. Leedy, *Nat. Bur. Stand. (U.S.), Spec. Publ. 546*, 1980 Edition, 69 pages (Sept. 1980) SN003-003-02251-9.

Key words: calibration; Federal Government; laboratory; measurement; metrology; precision; test equipment.

This publication lists Federal laboratories involved in metrology and calibration. Included is the name of a person at each



laboratory to contact for more information as well as the laboratory telephone number and address. The capabilities of each laboratory are indicated in a tabular listing by agency. To provide geographical distribution, the laboratories are listed by States. In addition, the laboratories are shown on a map by coded number. Other references are described.

**SP560. Wind and seismic effects.** Proceedings of the Tenth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources held at the National Bureau of Standards, Gaithersburg, MD, May 23-26, 1978, H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 560*, 644 pages (Oct. 1980) SN003-003-02252-7.

Key words: accelerograph; codes; design criteria; disaster; earthquakes; ground motion; seismology; standards; storm surge; structural engineering; structural response; tsunami; wind loads; winds.

This volume includes thirty-eight technical papers presented at the Tenth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects. It also includes the formal resolutions and the reports of the Panel's eight task committees. The subjects covered in the Joint Meeting include: (1) natural wind characterization and extreme wind records, (2) characterization of earthquake ground motions and strong-motion earthquake data, (3) engineering seismology, (4) response of hydraulic and earth structures to seismic forces, (5) structural responses to wind loading, (6) recent developments in seismic design criteria, (7) design and analysis of special structures, (8) damage evaluation, repair and retrofit, (9) earthquake hazard mitigation, and (10) storm surge and tsunami. *These proceedings include the following papers (indented):*

On the distribution of extreme winds expected in Japan, T. Okubo and N. Narita, *SP560*, pp. 1-1—1-12 (Oct. 1980).

Boundary layer winds, D. A. Haugen, *SP560*, pp. 2-1—2-4 (Oct. 1980).

On the damage to buildings in Oki-erabu from the September 1977 typhoon, T. Murota and Y. Ishiyama, *SP560*, pp. 3-1—3-27 (Oct. 1980).

Recent developments in atmospheric remote sensing and their implication for wind engineering, W. H. Hooke, *SP560*, pp. 4-1—4-16 (Oct. 1980).

Extreme wind data base development at the National Climatic Center, M. Changery, *SP560*, pp. 5-1—5-7 (Oct. 1980).

A strong-motion record information retrieval system, A. M. Converse and R. B. Matthiesen, *SP560*, pp. 6-1—6-2 (Oct. 1980).

Integration of strong-motion accelerograms, S. Iai, E. Kurata, H. Tsuchida, and S. Hayashi, *SP560*, pp. 7-1—7-16 (Oct. 1980).

Some recent developments in national and international seismic data exchanges, J. F. Lander, *SP560*, pp. 8-1—8-6 (Oct. 1980).

Report on the International Workshop on Strong-Motion Earthquake Instrument Arrays, May 2-5, 1978, at Hawaii, T. Okubo and H. Tsuchida, *SP560*, pp. 9-1—9-3 (Oct. 1980).

Expectancy of maximum earthquake motions in Japan, M. Watabe and Y. Kitagawa, *SP560*, pp. 10-1—10-8 (Oct. 1980).

Determination of design earthquake for the dynamic analysis of the Fort Peck Dam, W. F. Marcuson III, and E. L. Krinitzky, *SP560*, pp. 11-1—11-12 (Oct. 1980).

The Izu-Ohshima Kinkai earthquake of January 1978, M.

Tajima, H. Sato, M. Otsuka, K. Sudo, and K. Ishibashi, *SP560*, pp. 12-1—12-13 (Oct. 1980).

Empirical and analytical methods of estimating soil liquefaction risk, R. K. McGuire, F. Tatsuoka, T. Iwasaki, and K. Tokida, *SP560*, pp. 13-1—13-8 (Oct. 1980).

A practical procedure for assessing earthquake-induced liquefaction of sandy deposits, M. Ohashi, T. Iwasaki, F. Tatsuoka, and K. I. Tokida, *SP560*, pp. 14-1—14-22 (Oct. 1980).

Wind-resistant design of cable-stayed bridges in Japan, T. Okubo, N. N. Narita, and M. M. Katsuragi, *SP560*, pp. 15-1—15-14 (Oct. 1980).

Aerodynamic stability of proposed Ohio River cable-stayed bridge, L. R. Cayes, *SP560*, pp. 16-1—16-16 (Oct. 1980).

Some aerodynamic considerations in the design of the Ruck-a-Chucky Bridge, R. H. Scanlan, *SP560*, pp. 17-1—17-5 (Oct. 1980).

A summary of wind-tunnel test results for the Luling, Louisiana, cable-stayed bridge, H. R. Bosch, *SP560*, pp. 18-1—18-15 (Oct. 1980).

A technique for measuring fluctuating wind loads on a tall-building model irrespective of model motion, T. A. Reinhold, *SP560*, pp. 19-1—19-15 (Oct. 1980).

A study of building damage caused by wind, J. R. McDonald and P. A. Lea, *SP560*, pp. 20-1—20-9 (Oct. 1980).

Recent earthquake-resistant design methods for different types of bridge foundations in Japan, Y. Shioi, T. Furuya, M. Okahara, and Y. Mitsuie, *SP560*, pp. 21-1—21-10 (Oct. 1980).

Recent developments in seismic design codes, R. L. Sharpe, *SP560*, pp. 22-1—22-17 (Oct. 1980).

Logical analysis of seismic design provisions, J. Harris, *SP560*, pp. 23-1—23-7 (Oct. 1980).

Highlights of California school and hospital building regulations, J. F. Meehan, *SP560*, pp. 24-1—24-12 (Oct. 1980).

Summary of research projects in the Large-Structures Testing Laboratory from 1967-1977, M. Hirose, Y. Ishiyama, and T. Goto, *SP560*, pp. 25-1—25-25 (Oct. 1980).

Dynamic behavior of rectangular water tanks assembled with panels, K. Ohtani and C. Minowa, *SP560*, pp. 26-1—26-12 (Oct. 1980).

Part 1—Inelastic behavior of non-bearing walls in an 11-story steel-reinforced concrete frame, and Part 2—Aseismic safety of external surface finishes and coatings, M. Watabe, T. Kutoba, A. Baba, T. Fukuta, and H. Ito, *SP560*, pp. 27-1—27-16 (Oct. 1980).

Seismic evaluation of existing multistory residential buildings, G. R. Fuller, *SP560*, pp. 28-1—28-7 (Oct. 1980).

Damage to engineering structures during the near Izu-Ohshima earthquake of January 1978, K. Nakazawa, T. Iwasaki, K. Kawashima, M. Watabe, H. Yamanouchi, and Y. Yamazaki, *SP560*, pp. 29-1—29-27 (Oct. 1980).

Repair and retrofit of buildings, J. K. Wight and R. D. Hanson, *SP560*, pp. 30-1—30-6 (Oct. 1980).

The distribution of property losses caused by historical earthquakes, E. Kuribayashi and T. Tazaki, *SP560*, pp. 31-1—31-36 (Oct. 1980).

The disaster-resistance of cities and their lifelines, K. Na-

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- SP564. Systematic relationships among binary phase diagrams of the transition elements, R. M. Waterstrat, *Nat. Bur. Stand. (U.S.), Spec. Publ. 564* (May 1980) SN003-003-02193-8.
- Key words: alloy theory; crystal chemistry; intermediate phases; phase diagrams; phase equilibria; solid solutions.
- A color chart is compiled showing binary phase diagrams of the transition elements. Binary combinations of elements occurring to the right and to the left of the Mn column (column VII B) in the periodic table are arranged in a format related to the arrangement of these elements in the periodic table. The purpose of this chart is to reveal systematic relationships in the occurrence of the various phases and in the solid solubilities which are seldom apparent in the available handbooks. The chart is also intended as a convenient reference to the types of diagrams existing in these binary systems.
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- Key words: consumer affairs; education; electronic devices; International Organization of Legal Metrology; legal metrology; measurement assurance; metrication; model laws and regulations; moisture loss; packaging and labeling; specifications and tolerances; weights and measures.
- This is a report of the proceedings (edited) of the Sixty-fourth National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Portland, Oregon, July 23-27, 1979, and attended by State, county, and city weights and measures officials, and representatives of the Federal Government, business, industry, and consumer organizations.
- Major issues discussed at this conference included metric conversion in the United States, particularly the conversion of gasoline dispensers, problems relating to the quantity fill of packaged commodities, especially as affected by moisture loss, statistical approach to package checking, Federal grain inspection, and a legal metrology control system. *These proceedings include the following papers (indented):*
- Planning for the 1980 International Conference on Legal Metrology, D. E. Edgerly, *SP566*, pp. 1-2 (Mar. 1980).
- Statistics made uncomplicated, E. E. Wolski, *SP566*, pp. 3-19 (Mar. 1980).
- Confidence in package checking results, S. Hasko, *SP566*, pp. 20-25 (Mar. 1980).
- Equity on the move, K. J. Simila, *SP566*, pp. 26-31 (Mar. 1980).
- Equity beyond the marketplace, D. R. Johnson, *SP566*, pp. 32-37 (Mar. 1980).
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- National Conference of Standards Laboratories, its roles and mission, R. E. Kidd, *SP566*, pp. 45-48 (Mar. 1980).
- Tradition in transition, A. D. Tholen, *SP566*, pp. 49-57 (Mar. 1980).
- A legal metrology control system applicable to the United States, K. F. Hammer, *SP566*, pp. 58-87 (Mar. 1980).
- Metric update—USA, S. D. Andrews, *SP566*, pp. 89-98 (Mar. 1980).
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- National Association of State Departments of Agriculture, J. A. Graham, *SP566*, p. 124 (Mar. 1980).
- Weighing programs of the Federal Grain Inspection Service, R. R. Pforr, *SP566*, p. 126 (Mar. 1980).
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- Key words: applications; lattice parameters; peak shape; powder diffraction; profile fitting; x-ray neutron.
- The proceeding of the Symposium on Accuracy in Powder Diffraction presents the papers, abstracts and discussions of the symposium held at NBS, Gaithersburg, Maryland, on June 11-15, 1979. The symposium was jointly sponsored by the NBS, the National Research Council of Canada, and the International Union of Crystallography. These proceedings contain a total of 24 invited and contributed abstracts. Many papers are followed by an edited discussion. The proceedings are divided into the following topics: Total Pattern, Instrumentation and Automation, Profile Fitting, Analysis of Peak Shape, Lattice Parameters and Indexing, Applications, and Future Opportunities in Powder Diffraction. *These proceedings include the following papers (indented):*
- Components of the total x-ray scattering, P. Suortti, *SP567*,



pp. 1-20 (Feb. 1980).

Neutron diffraction—The total powder pattern, T. M. Sabine, *SP567*, pp. 21-32 (Feb. 1980).

Synchrotron radiation and energy-dispersive diffraction, B. Buras, *SP567*, pp. 33-54 (Feb. 1980).

Accuracy in x-ray wavelengths, R. Deslattes, A. Hening, and E. G. Kessler, Jr., *SP567*, pp. 55-71 (Feb. 1980).

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Position-sensitive detectors for powder diffractometry, R. W. Hendricks, M. K. Kopp, and A. H. Narten, *SP567*, p. 85 (Feb. 1980).

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Profile refinement of neutron powder diffraction patterns, A. W. Hewat, *SP567*, pp. 111-141 (Feb. 1980).

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A new pattern fitting structure refinement program for x-ray powder data, C. Baerlocher and A. Hepp, *SP567*, p. 165 (Feb. 1980).

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Determination of compositional variations by x-ray diffrac-

tion line profile analysis, E. J. Mittemeijer and R. Delhez, *SP567*, pp. 271-314 (Feb. 1980).

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Accuracy in methods of lattice-parameter measurement, A. J. C. Wilson, *SP567*, pp. 325-351 (Feb. 1980).

Some statistical aspects of lattice parameter evaluation, J. Mandel, *SP567*, pp. 353-360 (Feb. 1980).

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Successive dichotomy method for indexing powder patterns, D. Louer, *SP567*, p. 383 (Feb. 1980).

The determination of the precise lattice parameter of a diffuse minor phase in a dilute binary uranium alloy, D. A. Carpenter and C. M. Davenport, *SP567*, p. 385 (Feb. 1980).

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A simple graphical method for obtaining reasonably accurate cell dimensions from x-ray powder photographs of hexagonal and tetragonal minerals, E. E. Fejer, *SP567*, p. 391 (Feb. 1980).

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X-ray powder diffraction identification of crystal phases with superimposed lines by their selective crystallization, I. Mayer, I. Gedalia, and B. Laufer, *SP567*, p. 405 (Feb. 1980).

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Analysis and topography of lattice defects in powder diffraction patterns, S. Weissmann, *SP567*, pp. 411-431 (Feb. 1980).

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Stress analysis from powder diffraction patterns, J. B. Cohen, H. Dolle, and M. R. James, *SP567*, pp. 453-477 (Feb. 1980).

X-ray residual stress evaluation by an energy dispersive system, M. Kuriyama, W. J. Boettinger, and H. E. Burdette, *SP567*, pp. 479-487 (Feb. 1980).

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**X-ray powder diffraction**, L. D. Calvert, *SP567*, pp. 543-546 (Feb. 1980).

**Future of powder neutron diffraction**, M. H. Mueller, *SP567*, pp. 547-549 (Feb. 1980).

**JCPDS—International center for diffraction data: Present and future activities**, G. McCarthy and D. K. Smith, *SP567*, pp. 551-555 (Feb. 1980).

**Design of a high-accuracy goniometer for x-ray powder diffractometry at controlled temperature**, J. F. Berar, G. Calvarin, J. Chevreul, M. Gramond, and D. Weigel, *SP567*, pp. 557-558 (Feb. 1980).

**The effect of twinning on particle size broadening in some oxides derived by dehydration reaction**, F. Watari, *SP567*, pp. 559-564 (Feb. 1980).

**SP568. Laser induced damage in optical materials: 1979.** Proceedings of a Symposium Sponsored by: National Bureau of Standards, American Society for Testing and Materials, Office of Naval Research, Department of Energy, and Defense Advanced Research Project Agency, NBS, Boulder, CO, Oct. 30-31, 1979, H. E. Bennett, A. J. Glass, A. H. Guenther, and B. E. Newnam, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 568*, 530 pages (July 1980) SN003-003-02217-9.

**Key words:** laser damage; laser interaction; optical components; optical fabrication; optical materials and properties; thin film coatings.

The Tenth Anniversary Symposium on Optical Materials for High Power Lasers (Boulder Damage Symposium) was held at the National Bureau of Standards in Boulder, Colorado, 30-31 October 1979. The Symposium was held under the auspices of ASTM Committee F-1, Subcommittee on Laser Standards, with the joint sponsorship of NBS, the Defense Advanced Research Project Agency, the Department of Energy, and the Office of Naval Research. About 150 scientists attended the Symposium, including representatives of the United Kingdom, France, Canada, Japan, West Germany, and Denmark. The Symposium was divided into sessions concerning Transparent Optical Materials and the Measurement of Their Properties, Mirrors and Surfaces, Thin Film Characteristics, Thin Film Damage, Considerations for High Power Systems, and finally Theory and Breakdown. As in previous years, the emphasis of the papers presented at the Symposium was directed toward new frontiers and new developments. Particular emphasis was given to materials for high power apparatus. The wavelength range of prime interest was from 10.6  $\mu\text{m}$  to the uv region. Highlights included surface characterization, thin film substrate boundaries, and advances in fundamental laser-matter threshold interactions and mechanisms. The scaling of damage thresholds with pulse duration, focal area, and wavelength was discussed in detail. Harold E. Bennett of the Naval Weapons Center, Alexander J. Glass of the Lawrence Livermore Laboratory, Arthur H. Guenther of the Air Force Weapons Laboratory, and Brian E. Newnam of the Los Alamos Scientific Laboratory were co-chairmen of the Symposium. The Twelfth Annual Symposium is scheduled for 30 September-1 October 1980 at the National Bureau of Standards, Boulder, Colorado. *These proceedings include the following papers (indented):*

**Press forging and optical properties of lithium fluoride**, J. F. Ready and H. Vora, *SP568*, pp. 39-46 (July 1980).

**Key words:** fluorides; forging; laser windows; lithium fluoride; mechanical properties; optical properties; ultraviolet transmission.

Lithium fluoride is an important candidate material for windows on high-power, short-pulse ultraviolet and visible lasers. Lithium fluoride crystals have been press forged in one step over the temperature range 300-600 °C to obtain fine-grained polycrystalline material with improved mechanical properties. The deformation that can be given to a lithium fluoride crystal during forging is limited by the formation of internal cloudiness (veiling) with the deformation limit increasing with increasing forging temperature from about 40% at 400 °C to 65% at 600 °C. To suppress veiling, lithium fluoride crystals were forged in two steps over the temperature range 300-600 °C, to total deformations of 69-76%, with intermediate annealing at 700 °C. This technique yields a material which has lower scattering with more homogeneous microstructure than that obtained in one-step forging. The paper will describe the results of characterization of various optical and mechanical properties of single-crystal and forged lithium fluoride, including scattering, optical homogeneity, residual absorption, damage thresholds, environmental stability, and thresholds for microyield.

**Optical properties of forged  $\text{CaF}_2$** , A. K. Hopkins, R. H. Anderson, J. F. Ready, J. M. Bennett, P. C. Archibald, and D. K. Burge, *SP568*, pp. 47-63 (July 1980).

**Key words:** calcium fluoride; hot isostatic forging; hot isostatic pressing; laser windows; optical absorption; optical homogeneity; optical scattering; stress birefringence.

To satisfy the dimensional requirements for large  $\text{CaF}_2$  optical components while reducing the sensitivity of this material to thermal and mechanical damage, some form of deformation processing is likely. Strengthened, fine grain polycrystalline  $\text{CaF}_2$  can be routinely obtained by isostatic forging. When the deformation of the single crystal exceeds 50%, "veiling" appears within the bulk of the forging and increases with increasing deformation.

To assess the effects of forging and the resultant "veiling" on the optical properties of  $\text{CaF}_2$ , forgings of  $\langle 111 \rangle$ ,  $\langle 100 \rangle$  and  $\langle 113 \rangle$  orientations were prepared. Scattering measurements were made in the visible and at 3.39  $\mu\text{m}$ . Then these forgings were isostatically hot pressed (HIP) in an effort to eliminate the veiling. The scattering levels in the visible and at 3.39  $\mu\text{m}$  were remeasured. Homogeneity measurements were obtained using two different methods for single crystal, forged and forged plus HIP  $\text{CaF}_2$ . Photographs of the stress birefringence in the same three conditions were also taken. These optical data are presented and discussed.

**Mechanical and optical properties of forged NaCl**, G. A. Graves, J. A. Detrio, D. McCullum, and D. A. Dempsey, *SP568*, pp. 65-72 (July 1980).

**Key words:** hardness; homogeneity; infrared laser absorption properties; mechanical properties; specific heat; thermal expansion.

The mechanical and infrared laser absorption properties were determined on test specimens cut from a 32-cm diameter forging of Polytran NaCl produced by Harshaw. The homogeneity of the mechanical and optical properties statistically showed a significant dependence of the ultimate strength on azimuthal position in the forging. The absorption of the specimens at  $\text{CO}_2$ , CO, HF/DF, and Nd:YAG laser wavelengths were measured and no significant dependence on specimen location was observed. The absorption variations were less than 10 percent for all of the laser wavelengths studied except at 3.8  $\mu\text{m}$  (40%). Other proper-



ties examined include specific heat, thermal expansion, and hardness. Strength measurements were made with both uniaxial flexural bars and biaxial disc test specimens.

**Optical, thermal, and mechanical measurements on CO<sub>2</sub> laser-irradiated ZnSe,** J. A. Detrio, J. A. Fox, and J. M. O'Hare, *SP568*, pp. 73-89 (July 1980).

**Key words:** absorption; calculated performance; CO<sub>2</sub> laser; holographic interferometry; measured performance; optical path difference; temperature profile; thermal distortion; thermal lensing; ZnSe.

The laser power dependence of the temperature distribution, optical distortion, and strain have been measured for specimens of ZnSe with absorption values between 0.006 and 0.020. For a well behaved Gaussian beam profile we observe a thermal lensing effect which changes the location of the beam waist but which does not significantly increase the minimum beam diameter. The predicted and measured temperature rise agree for laser powers of 230 and 705 watts and beam diameters of 2.1 mm and 4.2 mm, respectively. The identification of factors which influence the departure of predicted from measured response are discussed. The precision of the model is also examined.

**Electronic, nuclear and total nonlinear indices of liquids,** D. C. Brown, J. M. Rinefield, S. D. Jacobs, and J. A. Abate, *SP568*, pp. 91-98 (July 1980).

**Key words:** Abbé value; coolant; index-matching liquids; nonlinear refractive index; self-focusing.

We have extended the work previously reported to this conference on the nonlinear indices of a wide variety of liquids. Based upon measurement of linear indices and calculation of the Abbé value, we obtained the electronic contribution to the total nonlinear index. Using measurements tabulated recently by Hellwarth we are then able to calculate the nuclear and total nonlinear indices.

Agreement between the total nonlinear index and measurements reported in the literature will be discussed as will the correlation with Abbé value and linear index.

**Wavelength modulation spectroscopy of highly transparent solids,** R. Braunstein, R. K. Kim, and M. Braunstein, *SP568*, pp. 99-117 (July 1980).

**Key words:** extrinsic infrared absorption; KBr; KCl; laser windows; volume and surface impurities; wavelength modulation spectroscopy.

We have used wavelength modulation spectroscopy to measure the absorption in highly transparent solids at levels of  $10^{-5} \text{ cm}^{-1}$  in the spectral region from 2 to 12.0  $\mu\text{m}$ . For the first time, it is now possible to obtain the continuous spectral distribution at this level of absorption where previously the only measurements have been laser calorimetric measurements at a few discrete wavelengths. We have used wavelength modulation techniques in conjunction with laser calorimetry to study absorption in the ultraviolet and visible regions. In the present work, a new wavelength-modulated spectrometer system was constructed so as to encompass the dominant HF, DF, CO, and CO<sub>2</sub> laser wavelengths. The richness of structure observed throughout this spectral region provides a possible identification of surfaces and volume contaminants as well as intrinsic absorption processes in solids. Results on KBr and other alkali halides are presented that demonstrate the versatility and power of this technique.

**Synchrotron radiation studies of beryllium fluoride glass,** R. T. Williams, D. J. Nagel, P. H. Klein, and M. J. Weber, *SP568*, pp. 119-123 (July 1980).

**Key words:** BeF<sub>2</sub> glass; exciton resonance; photoelectron spectra; reflectance; synchrotron radiation; vacuum ultraviolet.

We report measurements of the reflectance of pure BeF<sub>2</sub> glasses in the range 9 eV to 120 eV, as well as photoelectron spectra in the valence band region. Based on these data, which should be regarded as preliminary, the lowest-energy reflectance peak is at 12.8 eV, implying an exciton resonance at about 13.1 eV, in close correspondence to LiF. Photoelectron spectra for the bulk glass show a valence band which is roughly symmetrical and about 5.8 eV wide (FWHM), with a tail of states extending into the gap.

**The role of Fe in laser-induced damage in ultrapure KBr,** D. F. Edwards, B. E. Newnam, and W. J. Fredericks, *SP568*, p. 125 (July 1980).

**Key words:** Fe; laser-damage; ultrapure KBr.

The laser-damage threshold has been measured for several samples of ultrapure KBr crystals. Induced neutron activation analysis and thermal light scattering measurements indicate the major impurity to be Fe<sup>2+</sup> with concentrations in the range .04-.095 ppm and radii in the 17-20 Å range. Other impurities either do not contribute to the scattering or are in concentrations 100 ppb or less. The measured damage threshold values were found to have the functional dependence on particle radius and pulse width predicted by the theory of Bennett. Oxygen treatment to the KBr during the crystal growth process is observed to effect the damage threshold values. This suggests a damage mechanism that is related to a species derived from carbon. As an example, carbon present in the sample in ppb concentrations might be converted to CO which is covalently bound to the Fe. In this bound state the Fe no longer contributes to the laser damage.

**Properties and fabrication of crystalline fluoride materials for high power laser applications,** T. M. Pollak, R. C. Folweiler, E. P. Chicklis, J. W. Baer, A. Linz, and D. Gabbe, *SP568*, pp. 127-135 (July 1980).

**Key words:** advanced laser materials; crystal growth; crystalline fluorides; Faraday rotator; high power laser materials; optical damage threshold; top-seeded solution technique; two photon absorption; uniaxial crystal; yttrium lithium fluoride.

Crystalline fluoride materials exhibit certain desirable properties for applications in advanced laser technology. Fluorides are characterized by excellent ultraviolet transmission, low values of nonlinear index of refraction ( $n_2$ ) and high optical damage resistance. Crystal growth temperatures of fluorides are relatively low; and scaling of growth to large diameters has been achieved, demonstrating fabrication capabilities of large apertures of high optical quality material.

This paper describes the fabrication and properties of two fluoride crystal families which exhibit a natural rare earth site. Two crystalline fluorides, Yttrium Lithium Fluoride (YLF), or LiYF<sub>4</sub>, and Potassium Yttrium Fluoride (KYF), or KY<sub>3</sub>F<sub>10</sub>, have specific desirable properties for high power laser applications.

The optical performance of materials is very dependent upon the fabrication processes. Advanced material processing techniques have been developed, including feed purification and crystal growth techniques, which have been employed to fabricate fluoride crystals exhibiting excellent transmission, low scattering, and high resistance to laser damage. In addition, recent crystal growth developments have scaled the crystal growth of YLF to 100 mm diameter. Growth parameters were optimized to maintain proper crystal-melt interface to minimize the formation of defects.



In addition, technical problems were addressed in scaling the crystal growth of YLF to 40 cm diameter.

**Laser damage in yttrium orthophosphate**, R. Allen, L. Esterowitz, P. H. Klein, V. O. Nicolai, and W. K. Zwickler, *SP568*, pp. 137-140 (July 1980).

Key words: absorption spectra; calcite; flux growth; laser damage; neodymium:glass; polarizer; pyrophosphate; xenotime; yttrium orthophosphate; yttrium phosphate.

Preliminary laser-damage experiments on single-crystal blades of yttrium orthophosphate (xenotime,  $\text{YPO}_4$ ) have been performed. Crystals, measuring about  $15 \times 3 \times 0.7$  mm were grown at Philips Laboratories by slow cooling of a flux containing lead pyrophosphate ( $\text{Pb}_2\text{P}_2\text{O}_7$ ). Optical absorption is small from about 300 nm to about 3200 nm, approximating the transmission of calcite. A 1.06- $\mu\text{m}$  Nd:glass laser with Q-switched pulse duration of 17 ns was used for damage measurements. The laser beam (0.025 cm FWHM) was focused on the large face of the  $\text{YPO}_4$  crystals. Visible damage was always observed at front and back crystal surfaces following exposure to pulses averaging 3.6  $\text{GW}/\text{cm}^2$  or more. No visible damage was found in  $\text{YPO}_4$  at power densities less than 2.2-2.4  $\text{GW}/\text{cm}^2$ . Calcite crystals showed damage at somewhat smaller power densities.

**Compressive failure in sapphire under  $\text{CO}_2$  laser heating**, P. A. Miles, J. Gallagher, and R. L. Gentilman, *SP568*, pp. 141-149 (July 1980).

Key words: compressive failure; laser damage; plastic flow; sapphire; thermomechanical analysis.

Irreversible changes have been observed in sapphire crystals subjected to surface heating by  $\text{CO}_2$  laser irradiation at levels above 300  $\text{watts}/\text{cm}^2$ . They are interpreted as due to plastic flow under compressive stress at temperatures above 900 °C. The recognition of possible compressive failures in refractory oxides is of importance in defining laser tolerance levels in high power optics, in the design of laser heating experiments to assess the thermal shock resistance of materials, and possibly in the field of laser assisted machining of ceramics.

A detailed thermo-mechanical analysis has been carried out to predict the temperature and stress conditions throughout disk samples as a function of time, heat flux level and flux distribution. These calculations show that compressive stresses in excess of 200,000 psi were generated in our experiments. They also show that compressive failure is likely to precede tensile fracture in most experiments where partially heated disks are used.

**Failure criteria for laser window materials**, J. A. Detrio, G. A. Graves, and J. M. Wimmer, *SP568*, pp. 151-159 (July 1980).

Key words: brittle failure; failure criteria; flaws; fracture;  $K_{IC}$ ; laser windows; Weibull; yield stress.

The brittle mechanical behavior of laser window materials must be considered in the establishment of failure criteria for selecting candidate materials and in the design of window components. The statistical techniques employed in brittle materials design and analysis are reviewed. The influence of the limited plasticity observed for the alkali halides, which exhibit fracture failure, is also discussed.

**Thermomechanical stress degradation of metal mirror surfaces under pulsed laser irradiation**, H. M. Musal, Jr., *SP568*, pp. 159-173 (July 1980).

Key words: Cu mirrors; damage thresholds; laser damage; laser-induced stress-strain; plastic deformation; surface degradation.

Progressive degradation of the optical surface of metal mirrors in pulsed laser applications can result from cumulative plastic deformation under thermomechanical stress caused by relatively small temperature excursions during irradiation. An analysis of the transient stress-strain behavior of the near-surface region shows that elastic response is maintained below a limiting surface temperature rise ( $\Delta T_y$ ), which depends on the yield stress, modulus of elasticity, Poisson's ratio, and coefficient of thermal expansion of the metal. This temperature rise defines the threshold for first-pulse plastic yield at the surface. An elastic-plastic model of metal behavior shows that the increment of plastic strain accumulated during each successive laser pulse will be proportional to the temperature rise above  $2 \Delta T_y$ . This plastic strain will appear at the surface as slip bands and intergranular slip that progressively degrades the optical quality of the surface. The surface temperature rise of metal mirrors under pulsed laser irradiation depends on both the metal optical and thermal properties as well as the laser pulse parameters. The peak temperature excursion produced by a constant-flux (rectangular) pulse is expressed in terms of the optical absorptance, pulse fluence, pulse duration, thermal conductivity, density, and specific heat. Using this relationship, the pulse fluence threshold ( $F_y$ ) for first-pulse plastic yield is derived. The threshold for multipulse accumulation of plastic deformation is  $2 F_y$ . Numerical values of these thresholds are calculated for copper under  $\text{CO}_2$  laser irradiation. The appearance of well-defined slip bands on the surface of copper mirrors after irradiation by a mode-locked  $\text{CO}_2$  laser pulse burst has been experimentally demonstrated. The theoretical quantification of thermomechanical stress degradation presented here is used to calculate the expected behavior of copper under the reported experimental conditions, and these results are correlated with the available experimental data.

**Defect-damage-resistant copper mirrors**, J. O. Porteus, D. L. Decker, D. J. Grandjean, S. C. Seitel, and W. N. Faith, *SP568*, pp. 175-186 (July 1980).

Key words: crystalline disorder; Cu mirrors; diamond turning; laser-induced slip; polishing; ripples; SiC substrates; surface defects; thermal diffusivity; vapor-deposited mirrors.

The calculated threshold for 10.6- $\mu\text{m}$  laser-induced melting of intrinsic crystalline copper is found to be in excellent agreement with the latest experimental value when the 100-nsec pulse shape and temperature-dependent material properties are properly modeled. Melt thresholds of diamond-turned copper mirrors recently produced and tested at the Naval Weapons Center are found to be very nearly intrinsic. However, laser-induced pitting related to surface defects often causes failure at a considerably lower level. Selection of starting material and technique of surface finishing are shown to be important factors influencing laser damage related to surface defects and disorder. A well-defined inverse relationship between the thresholds for laser-induced slip and melting is demonstrated and provides a good indication of surface disorder on polished, as well as diamond-turned mirrors. Mirrors prepared by vapor deposition of copper on polished silicon carbide are found to be remarkably free of defect and visible (thermal) damage but have lower melt thresholds than good bulk copper mirrors. Thermal modeling indicates that the premature melting can be avoided by improving the thermal conductivity of the substrate.

**Laser-damage resistant copper surfaces with high reflectivity after oxidation**, M. Oron, L. G. Svendsen, and G. Sorensen, *SP568*, pp. 187-193 (July 1980).

Key words: corrosion inhibition; ion implantation; laser damage; mirror surfaces.



Ion implantation of aluminum into copper has been used to produce mirror surfaces with improved properties with respect to pulsed-laser damage. Upon oxidation of implanted samples, they show a much higher reflectivity of the laser pulse compared to non-implanted samples. The oxidation has been followed by Rutherford backscattering technique and nuclear reactions, and the improved surface properties are explained by the presence of compound oxide layer beneath the surface, which shows greater stability against decomposition than the pure metal oxide. This novel coating technique, comprising ion implantation and oxidation, may be advantageous in improving surface properties such as reflectivity of metal mirrors.

**Laser-induced breakdown of diamond-machined window surfaces**, M. J. Soileau, J. O. Porteus, and D. L. Decker, *SP568*, pp. 195-197 (July 1980).

Key words: diamond turning; infrared, windows; laser breakdown; polishing; surface damage.

Previous work on diamond-turned KCl at  $10.6\ \mu\text{m}$  has shown that this technique has significant promise for improving the resistance to laser damage over that of polished surfaces. This work examines the particular characteristics of turned surfaces on  $\text{CaF}_2$  and  $\text{SrF}_2$  which influence the pulsed laser damage thresholds at 2.7 and  $3.8\ \mu\text{m}$ . We consider (1) polarization dependence due to the periodic nature of the surface roughness of turned surfaces, (2) damage to the material produced by the turning process, and (3) residual contaminants introduced by machining. The laser source is an HF-DF TE laser which produces plane-polarized, single-mode 120- and 90-nsec pulses at 2.7- and  $3.8\text{-}\mu\text{m}$  wavelengths, respectively. The spatial distribution of intensity on target is Gaussian to the  $1/e^2$  points. Detailed morphology is obtained from Nomarski and dark-field optical microscopy. The effect of laser conditioning is examined by comparing thresholds and surface characteristics on areas of the surface exposed to nondamaging laser pulses (n-on-l effect). The so-called n-on-l effect was found to be wavelength selective with a much larger effect seen at 2.7 than at  $3.8\ \mu\text{m}$ . This result provides information on machining damage and may have important implications for laser processing as a possible means of improving the performance of machined optical surfaces.

**Optical and surface physical characteristics of diamond-machined infrared window materials**, D. L. Decker, D. J. Grandjean, and J. M. Bennett, *SP568*, pp. 199-208 (July 1980).

Key words: diamond single-point machining; dielectrics; infrared optical components; laser damage; optical properties.

This paper presents the results of the diamond turning of surfaces of a wide range of single-crystal and polycrystalline infrared window materials, including Ge,  $\text{CaF}_2$ ,  $\text{MgF}_2$ ,  $\text{SrF}_2$ , KCl, and GaAs. These surfaces were obtained from an advanced air-bearing, diamond-turning machine recently brought to an operational state at the Naval Weapons Center. The surface characterization performed includes a wide range of optical and surface physical examination including an analysis of scattered and absorbed light, and a surface microtopographic examination by diamond profilometry, phase contrast interference (Nomarski), and scanning electron microscopy. These data are compared with earlier results and are related to the characteristics of the Naval Weapons Center diamond-turning machine and to the machining parameters. A companion paper at this conference discusses the laser damage resistance of these surfaces with implications for their use in laser applications.

**Short-pulse  $\text{CO}_2$ -laser damage studies of NaCl and KCl windows**, B. E. Newnam, A. V. Nowak, and D. H. Gill, *SP568*, pp. 209-227 (July 1980).

Key words: alkali halides;  $\text{CO}_2$  laser; KCl; laser damage; laser fusion; NaCl; nanosecond pulse; surface damage.

The damage resistance of bare surfaces and the bulk interior of NaCl and KCl windows was measured with a short-pulse  $\text{CO}_2$  laser at  $10.6\ \mu\text{m}$ . Parametric studies with 1.7-ns pulses indicated that adsorbed water was probably the limiting agent on surface thresholds in agreement with previous studies at long pulsewidths. Rear-surface thresholds up to  $7\ \text{J}/\text{cm}^2$  were measured for polished NaCl windows, whereas KCl surfaces damaged at approximately 60% of this level. The breakdown electric-field thresholds of exit surfaces were only 50% of the value of the bulk materials. The pulsewidth dependence of surface damage from 1 to 65 ns, in terms of incident laser fluence, increased as  $t^{1/3}$ .

**$\text{CO}_2$ -laser polishing of fused silica surfaces for increased laser damage resistance at  $1.06\ \mu\text{m}$** , P. A. Temple, D. Milam, and W. H. Lowdermilk, *SP568*, pp. 229-236 (July 1980).

Key words: fused silica; laser damage; surface finishing; surface polishing.

We have prepared bare fused silica surfaces by subjecting the mechanically polished surface to a rastered cw  $\text{CO}_2$  laser beam. Analysis shows that this processing causes (a) removal of a uniform layer of fused silica and (b) a probable re-fusing or healing of existing subsurface fractures. The fused silica removal rate is found to be a function of the laser intensity and scan rate. These surfaces are seen to have very low scatter and to be very smooth. In addition, they have exhibited entrance surface damage thresholds at  $1.06\ \mu\text{m}$  and 1 nsec, which are substantially above those seen on the mechanically polished surface. When damage does occur, it tends to be at a few isolated points rather than the general uniform damage seen on the mechanically polished part. In addition to the damage results, we will discuss an observational technique used for viewing these surfaces which employs dark-field illumination.

**The relative importance of interface and volume absorption by water in evaporated films**, T. M. Donovan, P. A. Temple, S. C. Wu, and T. A. Tombrello, *SP568*, pp. 237-246 (July 1980).

Key words: absorption; calorimetry; coatings; encapsulation; hydrogen; thin films; water; water absorption.

Previously, a precision adiabatic calorimeter has been used to make single line HF calorimetry measurements of surface, interface, and bulk absorption on wedge-shaped films. In this paper we correlate hydrogen concentrations and profiles measured using a nuclear resonant technique with these previous calorimetric measurements. Results show, for example, that  $\text{H}_2\text{O}$  is uniformly distributed in materials such as NaF and  $\text{ThF}_4$  but occurs at the film-substrate interface in materials such as  $\text{As}_2\text{Se}_3$  and ZnS. The relative effectiveness of encapsulation of NaF and  $\text{ThF}_4$  by ZnS will be discussed. Good agreement is found between measured absorption and that calculated from measured hydrogen profiles.

**Characterization of small absorptions in optical coatings**, W. N. Hansen, L. Pearson, G. Hansen, and W. J. Anderson, *SP568*, pp. 247-256 (July 1980).

Key words: absorption; coatings; internal reflectance spectroscopy; silicon monoxide; thorium fluoride; zinc selenide; zinc sulfide.

Probably the main causes of laser damage in thin films used as optical coatings are impurities and non-stoichiometry, especially at interfaces. This paper considers the problems of identifying absorbing species, locating them in



the optical structure and measuring the amount of absorbing species present. The importance of an absorbing species at a given location in the structure is directly proportional to the relative electromagnetic field squared ( $E^2$ ) at that location. This fact is used both to avoid absorption when it isn't wanted and to enhance absorption when it is wanted, such as during analysis. Versatile and sensitive spectroscopic procedures for locating and characterizing small absorptions are discussed. Our approach makes use of Poynting's theorem, viz., that the rate of conversion of electromagnetic to joule energy at any point in a medium is proportional to  $(E^2)$  at that point.

**Surface microanalysis techniques for characterization of thin films**, T. W. Humpherys, R. L. Lusk, and K. C. Jungling, *SP568*, pp. 257-268 (July 1980).

**Key words:** Auger analysis; dielectric coatings; optical coatings; surface analysis; thin film characterization; thin film impurities.

With the advent of lower wavelength systems, increased sophistication of functional requirements, and higher incident radiation levels, more stringent demands have been placed on coating depositions with complimentary detailed chemical and physical characterizations being required. Scanning Auger Microscopy, X-ray Photoelectron Spectroscopy, and Secondary Ion Mass Spectroscopy techniques have been applied to thin film coatings to detect and identify compositional and structural irregularities. Impurity sites in  $\text{ThF}_4$  and  $\text{ZnS}$  films, principle causes of poor coating performance, have been isolated and analyzed. Point maps, line scans, and depth profiles are shown to provide remarkable clarity with submicron resolution. Abnormal oxygen content in  $\text{ThF}_4$  films indicates the presence of water and may eliminate its use as a coating material for HF systems. Although these surface analysis methods are destructive by nature, the validity of their use in analyzing thin film coatings is demonstrated and establishes a precedent for coating development programs.

**Pyroelectric measurement of absorption in oxide layers and correlation to damage threshold**, H. Küster and J. Ebert, *SP568*, pp. 269-279 (July 1980).

**Key words:** absorption edge; damage temperature; damage threshold; microsecond pulses; temperature depending absorption; unstable resonator.

The absorption of several oxide layers used in HP laser optics was measured by a fast pyroelectric detector in the range from 600 to 2000 °C. The layers of  $\text{Al}_2\text{O}_3$ ,  $\text{BeO}$ ,  $\text{MgO}$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{Nd}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{TiO}_2$  and  $\text{SiO}_2$ —thickness about  $0.5/\mu\text{m}$ —were electron gun evaporated on Suprasil I substrates.

Damage thresholds were obtained with 800 ns—pulses from an unstable resonator type  $\text{Nd}^{3+}$ -glass laser with a Gaussian farfield intensity profile. The occurrence of damage is determined by electronic registration of laser induced scattering.

The results were analyzed to determine relations with layer absorption, absorption edge and thermal conductivity.

**High-temperature optical characterization of thin film reflector and absorber layers**, M. R. Jacobson and R. D. Lamoreaux, *SP568*, pp. 281-286 (July 1980).

**Key words:** high-temperature; infrared; optical instrumentation; reflectometers; spectrophotometers.

We have developed a High Temperature Spectrophotometer (HTS) capable of measuring the temperature-dependent, reversible changes in reflectance and transmittance of thin films. The effective spectral range of the instrument—0.38 to 15 microns—covers 98% of the solar Air Mass 2

spectrum, as well as 94% of the radiation from a 500 C blackbody. A tungsten-halogen, or global source, provides two beams which are recombined before leaving the vacuum chamber. A Leiss sodium chloride monochromator disperses the radiation, which is detected by either a silicon or a thermocouple detector, depending on wavelength range. A microcomputer controlled sample-and-hold data acquisition system compares the two beams, corrects for background, and initiates data analysis. To minimize irreversible chemical changes in the films, a vacuum on the order of  $5 \times 10^{-6}$  Torr is maintained by a diffusion pump in the central chamber. Cartridge heating assemblies raise the sample substrate temperatures to 700 C in reflectance and 500 C in transmittance; chromel-alumel thermocouples embedded and cemented into the substrates monitor temperatures.

**CVD molybdenum thin films for high power laser mirrors**, G. E. Carver and B. O. Seraphin, *SP568*, pp. 287-292 (July 1980).

**Key words:** chemical vapor deposition; composition; crystal structure; grain size; molybdenum thin films; reflectance.

Molybdenum thin films have been prepared by chemical vapor deposition (CVD) from both molybdenum carbonyl ( $\text{Mo}(\text{CO})_6$ ) and molybdenum pentachloride ( $\text{MoCl}_5$ ). The crystal structure, grain size and composition of the films have been determined and related to their infrared reflectance. Post-deposition annealing raises the absolute reflectance of films deposited from the carbonyl to 98.73% at ten micrometers. The fact that these films are prepared without a polishing step may explain why their reflectance is 0.5% higher than that of super smooth polished bulk molybdenum. The higher reflectance and absence of a polish-induced damage layer could increase the damage threshold of uncoated CVD molybdenum mirrors. Films deposited from the chloride have largely reproduced the optical properties of those prepared from the carbonyl, with grain sizes ranging from 0.03 to 0.5 micrometer. Polished bulk molybdenum substrates could be further smoothed by first overcoating them with, and subsequently polishing of, a several micron thick layer of fine grained CVD molybdenum.

**Photoacoustic experimental studies on an AR coated laser window and some related theoretical calculations**, N. C. Ferneli, *SP568*, pp. 293-300 (July 1980).

**Key words:** bulk optical absorption coefficient; optoacoustic spectroscopy; photoacoustic spectroscopy; surface optical absorption coefficient; ZnSe.

Experimental photoacoustic spectroscopy (PAS) amplitude and phase results on an AR coated ZnSe laser window were obtained at  $10.6 \mu\text{m}$  as a function of chopping frequency. The PAS signal amplitude has an  $f^{-n}$  frequency dependence with  $n = 1.04$ . The PAS phase angle varied by  $20^\circ$  between 1000 Hz and 50 Hz;  $7^\circ$  between 1000 Hz and 100 Hz.

Theoretical calculations related to the situation were performed using the Bennett-Forman and Rosencwaig-Gersho PAS theories. The Bennett-Forman theory agreed with the PAS amplitude results for  $r = \beta_{\text{surface}}/\beta_{\text{bulk}} \geq 0.05 \text{ cm}$ . A  $7^\circ$  phase change was obtained from  $r = 0.03 \text{ cm}$ . The homogeneous sample Rosencwaig-Gersho theory did not fit either amplitude or phase angle data, yielding  $n = 1.5$  and a phase angle of  $45.0^\circ$  which varied less than  $0.04^\circ$  over the frequency range measured.

**Calculations using a two-layer Rosencwaig-Gersho photoacoustic spectroscopy theory applied to an anti-reflective coated laser window**, N. C. Ferneli, *SP568*, pp. 301-311 (July 1980).

**Key words:** bulk optical absorption coefficient; optoacoustic spectroscopy; photoacoustic spectroscopy; surface optical absorption coefficient;  $\text{ThF}_4$ ; ZnSe.



The ZnSe laser window studied experimentally had an AR coating consisting of a ZnS outer layer 0.32  $\mu\text{m}$  thick with a  $\text{ThF}_4$  inner layer 0.99  $\mu\text{m}$  thick. Laser calorimetry experiments at 10.6  $\mu\text{m}$  on other samples indicated that  $\text{ThF}_4$  films have an appreciable optical absorption of  $\sim 10 \text{ cm}^{-1}$ .

Calculations were performed using a two-layer modification of the Rosenzweig-Gersho photoacoustic spectroscopy theory. A  $7^\circ$  phase change between 1000 Hz and 100 Hz was obtained for a coating bulk absorption of  $\beta_c = 2.7 \text{ cm}^{-1}$ . Plots of this result along with the best fit using the Bennett-Forman theory in the previous abstract give similar amplitude and phase results. Examples of results for various  $\beta_c$  and coating thickness results are given.

**Pre-pulse identification of localized laser damage sites in thin films using photoacoustic spectroscopy**, R. P. Freese and K. J. Teegarden, *SP568*, pp. 313-332 (July 1980).

Key words: absorption; Ge; laser damage; photoacoustic spectroscopy; photoacoustic spectroscopy; thin films.

Scanning photoacoustic spectroscopy techniques were used to monitor optical absorption and inhomogeneity in thin films and substrates. Samples examined were 25 mm square by 2.5 mm thick germanium substrates which were partially coated with a thin film of germanium. Inter-sample thin film thicknesses varied from .65  $\mu\text{m}$  to 1.23  $\mu\text{m}$ . Raster scans made at 10.6  $\mu\text{m}$  using a 75 mW  $\text{CO}_2$  laser indicate that thin film and substrate inhomogeneities as well as optical absorption may be nondestructively measured at rates in excess of 400 msec per resolution point. Average absorbance results are in good agreement with those obtained by laser calorimetry and transmission techniques. Chopping frequency studies indicate that some of the inhomogeneities are subsurface. Interference effects detected photoacoustically are used to compute the skew angle between the front and back surfaces. When the sample is exposed to a 40 nsec (FWHM)  $\text{CO}_2$  laser pulse focused to a spot size of 3.5 mm, gross laser damage is found to occur where the interference effects were photoacoustically detected. An excellent correlation is also found to exist between the location of structure in the pre-damage photoacoustic mapping of the coated optic, and the location of isolated, low damage threshold "hot spots" found after the high power pulse irradiation.

**Examination of laser damage sites of transparent surfaces and films using total internal reflection microscopy**, P. A. Temple, *SP568*, pp. 333-341 (July 1980).

Key words: fused silica; laser damage; optical microscopy; total internal reflection.

This paper describes total internal reflection microscopy (TIRM), a microscopic inspection technique useful in examining the laser-damaged surfaces of transparent samples. In this technique, the surface is illuminated from within the sample with a well-collimated polarized laser beam at an angle of incidence just greater than the critical angle. Since total reflection occurs, the illuminated region appears to be dark when viewed from outside the sample except for scatter caused by surface defects such as laser damage sites. We will describe two instruments used for TIRM inspection of samples. Finally, various damaged regions will be shown as they appear under TIRM inspection and under Nomarski microscopy. It will be seen that the two techniques are complementary, and that, on highly polished surfaces, TIRM shows somewhat more detail than does Nomarski microscopy. All of the damage sites shown will be the result of 1.06- $\mu\text{m}$ , 1-nsec irradiation of fused silica or BK-7 surfaces.

**Parameters affecting damage threshold in thin film infrared**

**chalcogenide glass for applications in laser optical switching systems**, W. E. Kienzle and N. I. Marzwell, *SP568*, pp. 343-355 (July 1980).

Key words: absorption coefficient; chalcogenide material; deposition parameters; index of refraction.

The study of process control of film deposition can be important in determining the threshold of film damage due to a laser pulse. This paper reports the optical properties of the infrared chalcogenide glass material  $\text{Ti}_2\text{SeAs}_2\text{Te}_3$  as process parameters are varied. Several RF sputtered chalcogenide glass films of thickness varying from 0.6  $\mu\text{m}$  to 8.9  $\mu\text{m}$  were deposited on germanium and sapphire. The index of refraction and absorption coefficient were determined from the measured reflectance and transmittance curves for these samples. Further, these properties were measured for two different sputtering pressures, two sputtering voltages, twelve azimuthal target positions and three different substrate to target distances. The damage due to switching was assessed by subjecting different switches to  $\text{CO}_2$  laser pulses with FWHM of 2 to 4 msec and energies up to 0.16 Joules which were focused on target spot diameter of 0.4 mm on the chalcogenide optical switch.

**Improvements in clarity and environmental stability of TlI-containing antireflective coatings**, W. T. Boord, P. P. Chow, W. B. Harrison, and J. E. Starling, *SP568*, pp. 355-357 (July 1980).

Key words: antireflective coating; deposition technique; environmental stability; masking layer; potassium chloride window; scattering; thallium iodide.

Clarity of TlI films in visible light was improved by masking the textures of polycrystalline KCl substrates with thin  $\text{SrF}_2$  films. Also, the use of more environmentally durable fluoride films as replacements for KCl in the TlI-KCl-TlI 10.6 micron antireflective coating system was investigated.

**Reactively sputtered optical coatings for use at 1064 nm**, W. T. Pawlewicz, R. Busch, D. D. Hays, P. M. Martin, and N. Laegreid, *SP568*, pp. 359-375 (July 1980).

Key words: glassy structure; laser damage resistance; materials properties; oxide coatings; reactive sputtering; transparent-conductive coatings.

Optical coatings of  $\text{TiO}_2$ ,  $\text{In}_{1.9}\text{Sn}_{0.1}\text{O}_3$  (ITO),  $\text{Ta}_2\text{O}_5$ ,  $\text{Nb}_2\text{O}_5$ , a-Si:H and  $\text{SiO}_2$  have been prepared by reactive sputtering for use with lasers operating near 1064 nm. Damage thresholds of 7-10  $\text{J}/\text{cm}^2$  for  $\text{TiO}_2$  and 5-6  $\text{J}/\text{cm}^2$  for transparent-conductive ITO were measured at Lawrence Livermore Laboratory for  $\lambda/2$  coatings on fused silica irradiated with 1 nsec laser pulses. Sputtered  $\text{Ta}_2\text{O}_5$ ,  $\text{Nb}_2\text{O}_5$  and a-Si:H also appear to be promising high-index coating materials, but have not yet been damage tested. The reactive sputtering process is shown to allow precise control of coating crystalline phase and grain size. For  $\text{TiO}_2$  both optical properties and damage threshold have been related to these materials properties, and glassy coatings are shown to be optimal.

**Recent damage results on silica/titania reflectors at 1 micron**, C. K. Carniglia, J. H. Apfel, T. H. Allen, T. A. Tuttle, W. H. Lowdermilk, D. Milam, and F. Rainer, *SP568*, pp. 377-390 (July 1980).

Key words: absorption; calorimetry; damage; electric field; high energy laser; laser damage; reflectors; thin film.

The results of several laser damage experiments involving 15 layer silica/titania high reflectors (HR) are reported. Damage testing was done by Lawrence Livermore Labora-



tory using 1 ns laser pulses at 1.06  $\mu\text{m}$ . The addition of a halfwave silica overcoat leads to a 50% improvement in HR damage threshold. An experiment to modify the electric field intensity distribution within the coating indicates that the determining factor is neither the peak field within the titania layers, nor the average field in the titania layers, but that the field at the titania/silica interface is important. An attempt to correlate damage threshold with absorption met with partial success. For absorptance values above 100 ppm, there is a strong correlation between damage threshold and absorption. However, for absorptance below 100 ppm, it appears that damage threshold is not related to bulk absorption in the coatings. Optical microscopy supports this conclusion.

**Damage to coatings and surfaces by 1.06  $\mu\text{m}$  pulses,** W. H. Lowdermilk, D. Milam, and F. Rainer, *SP568*, pp. 391-403 (July 1980).

**Key words:** absorption; electric-field strength; film materials; impurities; overcoat; polished surfaces; pulsewidth dependence; thin-film coatings; 1 ns; 1.06  $\mu\text{m}$  damage.

Damage thresholds for 1 ns, 1.06  $\mu\text{m}$  laser pulses were measured for bare, polished surfaces and thin-film coatings prepared by several companies and laboratories. We discuss the origin and morphology of damage, review the experiments and summarize conclusions regarding the influence of substrate material, polishing compounds and processes, coating materials and deposition methods and the effects of absorption, electric-field strength, undercoats, overcoats and surface etching techniques.

**Pulsed damage thresholds of fluoride and oxide thin films from 0.26  $\mu\text{m}$  to 1.06  $\mu\text{m}$ ,** T. W. Walker, A. H. Guenther, C. G. Fry, and P. Nielson, *SP568*, pp. 405-416 (July 1980).

**Key words:** avalanche ionization; film thickness dependence; impurity damage; laser damage; multiphoton induced damage; pulse duration dependence of damage; thin films; wavelength dependence of damage.

The pulsed laser-induced damage threshold for  $\text{CaF}_2$ ,  $\text{MgF}_2$ ,  $\text{ThF}_4$ ,  $\text{MgO}$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{SiO}_2$ ,  $\text{HfO}_2$ , and  $\text{ZrO}_2$  thin films was measured. The measurements were made at 1.06  $\mu\text{m}$ , 0.53  $\mu\text{m}$  and 0.26  $\mu\text{m}$  with pulse lengths of  $\sim 5$  and  $\sim 15$  ns (measured at 1.06  $\mu\text{m}$ ). Different film thicknesses of each material were damaged at each wavelength and pulse length. The film thicknesses were 1  $\lambda$ , 1/2  $\lambda$ , 1/4  $\lambda$ , 1/6  $\lambda$ , and 1/8  $\lambda$  at 1.06  $\mu\text{m}$ .

It was found that the pulse length dependence of breakdown fit with a  $[\text{pulse length}]^{1/2}$  curve for most of the materials. Exceptions were found in some oxide coatings at 1.06  $\mu\text{m}$  where the breakdown energy density was essentially independent of the pulse length. The damage threshold of the fluoride and  $\text{SiO}_2$  films increased with a decrease in film thickness. This did not correlate with changes in the E field inside the thin films. (The oxide films did not exhibit as pronounced a thickness dependence.) The breakdown threshold decreased with decreasing wavelength and correlated inversely with the absorption coefficient, although the correlation was not linear.

There was a marked change in the damage morphology of the materials as wavelength was decreased. At 0.26  $\mu\text{m}$  all the oxide material damaged in a uniform region while the fluorides damaged as isolated pits. The morphology, pulse length and film thickness trends are discussed in terms of impurity, avalanche ionization, and multiphoton damage models.

**Laser-induced damage measurements with 266-nm pulses,** T. F. Deaton and W. L. Smith, *SP568*, pp. 417-424 (July 1980).

**Key words:** damage thresholds; laser damage; pico-second pulses; pulsewidth dependence; UV lasers.

The results of a survey of laser-induced damage thresholds for optical components at 266 nm are reported. The thresholds were measured at two pulse durations—0.150 ns and 1.0 ns. The 30 samples tested include four commercial dielectric reflectors, three metallic reflectors, two anti-reflection films, a series of eight half-wave oxide and fluoride films, and twelve bare surfaces (fluoride crystals, silica, sapphire, BK-7 glass, CD\*A and KDP). The 266-nm pulses were obtained by frequency-quadrupling a Nd:YAG, glass laser. Equivalent plane imagery and calorimetry were used to measure the peak fluence of each of the UV pulses with an accuracy of  $\pm 15\%$ ; the uncertainty in the threshold determinations is typically  $\pm 30\%$ .

**High energy laser optical train performance—A reassessment,** C. A. Klein, *SP568*, pp. 425-438 (July 1980).

**Key words:** focal intensity; high-energy laser; irradiance mapping; mirror/window materials; on-target fluence; optical train; phase aberration; power optics; thermal lensing.

This paper addresses problems relating to thermally induced phase aberrations experienced in a power-optics environment. Specifically, it addresses issues of concern in assessing the performance of High-Energy Laser (HEL) systems with regard to focal intensities and on-target fluences, when thermal lensing phenomena do occur in the optical train. Following Holmes and Avizonis [*Appl. Optics* 15, 1075 (1976)], a model has been developed that should allow HEL-system designers to complete an evaluation of the degradation in light intensity, which is caused by irradiance-mapping aberrations in the near-field. Perhaps the most important conclusion that was reached is that theories, calculations, and experiments conducted on a "single-component" basis provide highly unreliable guidelines for passing judgement on the merits of mirror/window material candidates, or their projected performance in an optical train.

**Analysis of an imperfectly coated conical element for high energy laser resonators,** W. P. Latham, Jr., *SP568*, pp. 439-443 (July 1980).

**Key words:** coatings design; polarization effects; resonator analysis.

The scalar field approximation is normally used in the analysis of eigenmodes and eigenvalues for high energy laser resonators. Recently, Dr. D. Fink demonstrated the need to account for the vector nature of the electromagnetic field when conical elements are used in resonators. Dr. G. C. Dente at the AFWL has developed a theory for the analysis of such polarization effects. When polarization effects are included, an unacceptable mode has been shown to exist in a conical-element, annular-gain laser which is currently being studied at the AFWL. A special optical coating placed on a conical resonator mirror would make the resonator mode acceptable by introducing a 90° phase shift between polarization states which are parallel and perpendicular to the plane of incidence upon reflection at a 45° angle of incidence. The study presented here gives the analysis for a related resonator within Dente's theory. The results indicate the tolerance limits of such a coating for a conical element in a high energy device.

**Nonlinear absorption in direct-gap crystals,** A. Vaidyanathan, T. W. Walker, A. H. Guenther, S. S. Mitra, and L. M. Narducci, *SP568*, pp. 445-455 (July 1980).

**Key words:** multiphoton absorption; nonlinear absorption; two-photon absorption coefficients.

A critical review of the Keldysh, Braunstein and Basov formulations of the nonlinear absorption process in direct-gap crystalline solids is presented. The two-photon absorp-



tion coefficients in several alkali halides and semiconductors are calculated by means of the above three models and compared with available experimental data. It is concluded that the Keldysh formula offers a sufficiently accurate description of the multiphoton absorption process, even when the photon multiplicity is small. This is in contrast to the frequently expressed view that the Keldysh formula is incorrect for small photon multiplicities. It is found that the Keldysh formula is closely related to Braunstein's formula for allowed-allowed transitions, while Basov's formula corresponds to the allowed-forbidden case. It is also shown that the predictive accuracy of the Braunstein formulas can be increased by the use of nonparabolic energy bands and excitonic intermediate states. Finally, the Basov formula, which until now was considered to be the most accurate description of the two-photon absorption process, is shown to contain several errors.

**Completing mechanisms in laser-induced damage**, A. Vaidyanathan, T. W. Walker, and A. H. Guenther, *SP568*, pp. 457-465 (July 1980).

**Key words:** avalanche ionization; laser-induced damage; multiphoton ionization.

The thresholds for laser-induced intrinsic damage in several alkali halide crystals are calculated by means of separate avalanche and multiphoton ionization models, as well as by a combination of the two. The appearance of  $10^{18}$  electrons/cm<sup>3</sup> in the conduction band is taken as the criterion for damage. Numerical calculations are performed for nanosecond and picosecond pulse durations, with wavelengths ranging from 1.064 to 0.355  $\mu\text{m}$ . Upon comparing these theoretical predictions with available experimental results, it is found that, in general, the avalanche mechanism yields damaging optoelectric field strengths in good agreement with the experimentally measured values. The field strengths required for damage solely due to multiphoton ionization are substantially higher. However, when the photon multiplicity is less than or equal to four, the damage fields predicted by the multiphoton model are often smaller than those calculated for catastrophic avalanche multiplication, and are in better agreement with the experimentally measured damage thresholds. Furthermore, it is noted that neither the avalanche nor the multiphoton ionization model, when considered alone, can satisfactorily explain the experimentally observed frequency and pulse length dependence of the damage fields over the entire reported range of these parameters. It is thus suggested that it is more appropriate to combine these two mechanisms.

**Theory of electron-avalanche breakdown in solids**, M. Sparks, T. Holstein, R. Warren, D. L. Mills, A. A. Maradudin, L. J. Sham, E. Loh, Jr., and F. King, *SP568*, pp. 467-478 (July 1980).

**Key words:** alkali halides; electron-avalanche breakdown; electron-phonon scattering; Fokker-Planck equation; laser damage; multiphoton absorption; theory.

Electron-avalanche breakdown in solids is explained by a theory that is predictive and agrees with experimental results for the magnitude of the breakdown field and its temperature dependence, pulse-duration dependence, material-to-material variation, and wavelength dependence for  $\lambda \geq 1 \mu\text{m}$ . The good agreement between experiment and theory with no parameters adjusted is obtained by using improved magnitudes and energy dependences of the electron-phonon relaxation frequencies. The contributions of both optical and acoustical phonons to electron loss and diffusion must be included. The breakdown field  $E_B$  is calculated by solving an eigenvalue equation obtained from the diffusion transport equation. Simple models and inter-

pretations of the diffusion equation afford physical insight into breakdown and render the breakdown conditions predictable. Preliminary results indicate that the diffusion approximation fails for wavelengths considerably shorter than 1  $\mu\text{m}$ , but that  $E_B$  decreases with decreasing  $\lambda$  as a result of multiphoton absorption before the diffusion approximation fails.

**Impurity breakdown model in thin films**, T. W. Walker, A. Vaidyanathan, A. H. Guenther, and P. Nielsen, *SP568*, pp. 479-496 (July 1980).

**Key words:** impurity-induced damage; laser damage; Mie absorption coefficient; pulse duration dependence of damage.

The impurity model for breakdown given by Hopper and Uhlmann was examined. The case for nonmetallic impurities was derived from the thermal equations and affords the results of Hopper and Uhlmann when the correct limits are taken. These equations were then compared to an exact solution given by Goldenberg and Tranter, in which it is not assumed that the radial temperature distribution within the particle is a constant. It was found that the exact solution does not agree with the approximate solutions when the thermal conductivity of the impurity is small. In this case, the temperature in the particle is not uniform and the damage threshold can be substantially lower.

The Mie absorption coefficient was then combined with the exact solution. For nonmetallic impurities the results predict a damage threshold which depends on the film thickness. The experimental results for  $\text{CaF}_2$ ,  $\text{ThF}_4$ , and  $\text{MgF}_2$  were found to agree very well with these theoretical predictions. This agreement was found to hold at both the 5 ns and 15 ns pulse lengths and at 1.06  $\mu\text{m}$ , 0.53  $\mu\text{m}$ , and 0.26  $\mu\text{m}$  wavelengths.

Further theoretical calculations show that different size impurities are the most damage sensitive at different pulse lengths (and wavelengths). The calculation of breakdown threshold as a function of pulse length for fused silica surfaces fit very accurately to a  $\sqrt{t}$  curve, in agreement with the results of D. Milam.

**Frequency and focal volume dependence of laser-induced breakdown in wide band gap insulators**, M. J. Soileau, M. Bass, and P. H. Klein, *SP568*, pp. 497-517 (July 1980).

**Key words:** alkali halides; intrinsic damage; IR windows; laser damage; self-focusing; spot size dependence.

The frequency and focal volume dependence of the laser-induced breakdown fields of selected wide band gap insulators were investigated. The breakdown phenomenon that is reported in this work is the same process that has been called "intrinsic" damage by other workers. Measurements were conducted with pulsed (31 to 140 nsec), simple spatial mode lasers at wavelengths of 10.6, 3.8, 2.7, and 1.06  $\mu\text{m}$ . The results indicate that multiphoton-assisted electron avalanche breakdown is a likely mechanism for laser-induced failure in these materials over the wavelength range studied. For small focal volumes, volumes smaller than the inverse of the free electron density, the frequency dependence of breakdown is determined by multiphoton ionization of impurity levels. This initiates an avalanche and leads to the observation that breakdown fields decrease with increased laser frequency. For large focal volumes, the free electrons initially present in the crystal initiate the breakdown, and the frequency dependence is determined by the electron-phonon relaxation time. Thus, for large focal volumes, the laser-induced breakdown fields increase with increasing laser frequency. From these results it is clear that crystal defects and impurities play an important role in what has been called "intrinsic" damage. As this is the case,



breakdown experiments cannot be relied upon for accurate measurements of the nonlinear index of refraction,  $n_2$ .

**SBS influence on laser damage of optical materials**, P. Balkevičius, E. Kosenko, J. Lukošius, and E. Maldutis, *SP568*, pp. 519-527 (July 1980).

**Key words:** damage morphology; damage thresholds; laser bulk damage; laser surface damage; optical materials; self-focusing; stimulated Brillouin scattering (SBS).

The influence of the stimulated Brillouin scattering (SBS) on the damage of optical materials has been experimentally investigated. It is shown that depending on the experimental conditions, the SBS changes the threshold and the bulk damage character. It can decrease or increase the magnitude of the threshold power of the laser beam, which damages the surface of the optical systems. The SBS increases (the increase of more than 100 times has been registered), but not decreases the threshold power of the bulk damage, as it was thought earlier.

It is shown, that the reason of the decrease of the bulk damage threshold and the changes of the damage thresholds of the surface of the optical system is a redistribution of the laser beam intensity caused by the SBS, which decreases the intensity in the focal region of lens.

The influence of the laser beam redistribution on the damage thresholds and self-focusing is also discussed.

**Computer simulation of damage morphology**, P. Kelly, D. Ritchie, A. Schmid, and P. Bräunlich, *SP568*, pp. 529-530 (July 1980).

**Key words:** beam deformation; computer simulation; damage morphology; dielectric function.

Our progress to-date on the computer simulation of the spatio-temporal behavior of a fast, just damaging pulse focused into an optical material is illustrated in the form of a 16 mm movie. The time and space dependent intensity is shown in profile by the assignment of different colours and allows one to follow beam deformation as the pulse propagates through the medium.

Our present code PULSE is a major modification of the work we first reported at last year's damage conference. It is intended to be sufficiently flexible to accommodate any flux, wavelength, material or temperature dependence of the dielectric function and any possible mechanism of electronic excitation of the solid (avalanche, multiphoton generation, etc.), as well as various conceivable mechanisms for converting the energy of the photon field to excited electron and phonon distributions with an ultimate increase in lattice temperature.

In particular, we illustrate the simulation of the experimental arrangement of W. L. Smith et al., who reported the damage morphology of NaCl using 21 psec pulses at  $0.5321 \mu$ , where we have included the nonlinear interaction of the polaron model by A. Schmid et al.

**SP569. Validation and assessment issues of energy models.** Proceedings of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, Jan. 10-11, 1979, S. I. Gass, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 569*, 559 pages (Feb. 1980) SN003-003-02155-5.

**Key words:** assessment; documentation; econometric models; energy modeling forum; energy models; evaluation; mathematical models; model access; model management; sensitivity analysis; validation.

The Workshop on Validation and Assessment Issues of Energy Models, held at the National Bureau of Standards, Gaithersburg, MD, (Jan. 10-11, 1979), was funded by the Energy Information Administration of the Department of Energy (DOE), Washington, DC. Organized by the Bureau's

Operations Research Division, the Workshop was designed to be a forum in which the theoretical and applied state-of-the-art validation and assessment, with emphasis on energy models, could be presented and discussed. Speakers addressed the following areas: DOE's activities in assessment and validation, taxonomy and structure of assessment and validation, the relationship between model assessment and policy research, the Electrical Power Research Institute's Energy Modeling Forum and projects, independent third-party model assessment, the Texas National Energy Modeling Project, management and improvement of the modeling process, complexity of model evaluation, definitions and structure of model assessment approaches, model access and documentation, assessment of specific models by the MIT Energy Laboratory and other groups, energy and econometric models, and sensitivity analysis. This volume documents the Proceedings (papers and discussion) of the Workshop. *These proceedings include the following papers (indented):*

**Model assessment and validation: Issues, structures, and energy information administration program goals**, G. M. Lady, *SP569*, pp. 5-22 (Feb. 1980).

**Model assessment and the policy research process: Current practice and future promise**, D. O. Wood, *SP569*, pp. 23-62 (Feb. 1980).

**The energy modeling forum: An overview**, J. L. Sweeney, *SP569*, pp. 65-96 (Feb. 1980).

**Electric load forecasting: Probing the issues with models**, B. H. Cherry, *SP569*, pp. 97-106 (Feb. 1980).

**Assessing the ICF coal and electric utilities model**, N. L. Goldman and J. Gruhl, *SP569*, pp. 109-140 (Feb. 1980).

**Developing, improving, and assessing the ICF coal and electric utilities model**, C. H. Stauffer, Jr., *SP569*, pp. 141-149 (Feb. 1980).

**Validation: A modern day snipe hunt? Conceptual difficulties of validating models**, P. W. House and R. H. Ball, *SP569*, pp. 153-165 (Feb. 1980).

**Third party model assessment: A sponsor's perspective**, R. Richels, *SP569*, pp. 171-181 (Feb. 1980).

**An approach to independent model assessment**, D. T. Kresge, *SP569*, pp. 183-196 (Feb. 1980).

**Reflections on the model assessment process: A modeler's perspective**, M. L. Baughman, *SP569*, pp. 197-203 (Feb. 1980).

**The Texas national energy modeling project: An evaluation of EIA's midrange energy forecasting system**, M. L. Holloway, *SP569*, pp. 211-234 (Feb. 1980).

**Assessing ways to improve the utility of large-scale models**, S. I. Gass, *SP569*, pp. 237-253 (Feb. 1980).

**Validity as a composite measure of goodness**, H. J. Greenberg and F. Murphy, *SP569*, pp. 255-263 (Feb. 1980).

**The impact of assessment on the modeling process**, D. Nissen, *SP569*, pp. 267-282 (Feb. 1980).

**The energy modeling forum and model assessment: Substitutes or complements**, J. P. Weyant, *SP569*, pp. 285-297 (Feb. 1980).

**A way of thinking about model analysis**, M. Greenberger, *SP569*, pp. 299-313 (Feb. 1980).

**Appropriate assessment**, S. C. Parikh, *SP569*, pp. 315-323 (Feb. 1980).

**A decision analyst's view of model assessment**, E. G. Caza-

let, *SP569*, pp. 325-336 (Feb. 1980).

**Validation issues: A view from the trenches**, W. Marcuse, F. T. Sparrow, and D. A. Pilati, *SP569*, pp. 337-353 (Feb. 1980).

**Model access and documentation**, M. L. Shaw, *SP569*, pp. 355-363 (Feb. 1980).

**Assessment of the READ model**, D. Freedman, *SP569*, pp. 365-395 (Feb. 1980).

**A modeler's view of the READ model assessment process**, F. Hopkins, *SP569*, pp. 397-429 (Feb. 1980).

**Assessment and selection of models for energy and economic analysis**, E. A. Hudson and D. W. Jorgenson, *SP569*, pp. 431-444 (Feb. 1980).

**Econometric models and their assessment for policy: Some new diagnostics applied to translog energy demand in manufacturing**, E. Kuh and R. E. Welsch, *SP569*, pp. 445-475 (Feb. 1980).

**On a perspective for energy model validation**, L. S. Mayer, *SP569*, pp. 477-495 (Feb. 1980).

**Systematic sensitivity analysis using describing functions**, F. C. Schweppe and J. Gruhl, *SP569*, pp. 497-515 (Feb. 1980).

**A new approach to analyze information contained in a model**, H. J. Greenberg, *SP569*, pp. 517-524 (Feb. 1980).

**Validating the Hirst residential energy use/mid-range energy forecasting system interface**, F. Hopkins and L. Rubin, *SP569*, pp. 525-546 (Feb. 1980).

**SP570. Structure shielding against fallout gamma rays from nuclear detonations**, L. V. Spencer, A. B. Chilton, and C. M. Eisenhauer, *Nat. Bur. Stand. (U.S.), Spec. Publ. 570*, 984 pages (Sept. 1980) SN003-003-02246-2.

**Key words:** civil defense; fallout protection; gamma-ray shielding; nuclear detonations; nuclear war; radiation shielding.

This is a summary of theoretical, experimental, and engineering research on the applications of gamma-ray transport and dosimetry to the analysis of structures for the shielding properties against gamma rays from radioactive fallout. The first chapter presents historical background; and chapter II follows the development of detailed quantitative information on fallout spectra and intensities. Chapters III and IV give information on general gamma-ray transport phenomena, as well as properties, theorems, and methods with specific applications to structure shielding. Chapter V presents a wide variety of data types basic to engineering applications. Chapter VI presents experimental results for the fallout radiation environment. Chapter VIII and X then present experimental results for increasingly complex structure types, while chapters VII and IX present related engineering procedures of analysis of the same or similar, structure types. Chapter XI is very short, and gives general guidance to shielding analysts; and chapter XII concludes with a discussion of the implications of the existing technology for national sheltering programs.

**SP571. Organizations engaged in preparing standards for dental materials and therapeutic agents with a list of standards**, G. C. Paffenbarger, R. W. Rupp, and M. Malmstedt, *Nat. Bur. Stand. (U.S.), Spec. Publ. 571*, 55 pages (Apr. 1980) SN003-003-02163-6.

**Key words:** dental agencies; devices; history; materials; programs; specifications.

The first specification for dental materials was prepared by Dr. Wilmer Souder, a physicist at the National Bureau of Stand-

ards, in 1927. From this stemmed the specification and certification programs of the American Dental Association (1930) and all of the similar national and international programs.

The Federation Dentaire Internationale (FDI) was the first in the international field (1953). Today the International Organization for Standardization (ISO) through its Technical Committee 106-Dentistry, organized in 1963, is the prime international agency formulating specifications for dental materials and devices. The FDI role by agreement with ISO/TC106 is the preparation for standards on clinical evaluations, on biological test methodology, on the preparation of informative reports on dental materials and therapeutic agents and on the proper methods of using them.

Today there are 15 international and national agencies that have prepared about 900 specifications for dental materials and devices. These agencies and their addresses are listed, with a brief history of each, together with a list of the specifications and standards that they have promulgated.

**SP572. National Measurement Laboratory 1979—Technical highlights**, J. D. Hoffman, Compiler, *Nat. Bur. Stand. (U.S.), Spec. Publ. 572*, 126 pages (Apr. 1980) SN003-003-02203-7.

**Key words:** absolute and physical quantities; analytical chemistry; chemistry research; environmental measurements; materials science; measurement services; molecular science; National Measurement Laboratory; nondestructive evaluation; nuclear measurement technology; physics research; radiation research; recycled materials; standard reference data; standard reference materials; technical activities; thermodynamics.

This publication gives selected highlights of research and other technical activities in the National Measurement Laboratory of the National Bureau of Standards during calendar year 1979. Comprehensive overviews provide the introductions to the activities in the five centers and seven programs of the Laboratory. Listings of the Professional staff in each of these units are also provided.

**SP573. NBS staff participation in outside standards activities, 1979 highlights**, J. R. Debelius, *Nat. Bur. Stand. (U.S.), Spec. Publ. 573*, 64 pages (Mar. 1980) SN003-003-02176-8.

**Key words:** annual report; standards activities; standards information; standards participation.

NBS uses a decentralized system for managing the participation of NBS representatives in outside standards committees activities. This type of management is governed by NBS policy; coordinated through standards offices in each NBS Major Organizational Unit; and monitored and supported by the Office of Standards Information, Analysis and Development (OSIAD).

This report summarizes NBS' standards activities during calendar year 1979. It contains information on NBS staff participation on standards committees, highlights of significant technical and individual contributions made by NBS staff, a description of NBS standards management activities, and a directory of staff participating on committees.

For further information on NBS standards activities, contact OSIAD, National Bureau of Standards, Technology, B-166, Washington, DC 20234, (301) 921-2092.

**SP574. Basic optical properties of materials—Summaries of papers**, Presented at the Topical Conference on Basic Optical Properties of Materials held at the National Bureau of Standards, Gaithersburg, MD, May 5-7, 1980, A. Feldman, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 574*, 252 pages (May 1980) SN003-003-02173-3.

**Key words:** fiber optics; graded index materials; infrared; magneto-optics; nonlinear optics; piezo-optics; planar waveguides; thermo-optics; thin films; ultraviolet.



This Special Publication contains summaries of papers to be presented at the Topical Conference on Basic Optical Properties of Materials to be held at the National Bureau of Standards in Gaithersburg, Maryland, on May 5-7, 1980. The conference is sponsored by the National Bureau of Standards in cooperation with the Optical Society of America. This publication contains summaries of 62 papers which include 14 invited papers. The principal topical areas are: Nonlinear Optical Properties; Ultra-violet Properties; Infrared Properties; Graded Index Materials; Inhomogeneous Materials; Properties of Thin Films; Optical Fibers, Planar Optical Waveguides; External Influences—Piezo-optics, Thermo-optics, Magneto-optics.

The purpose of the conference is to discuss the state of the art in the measurement of the optical properties of optical materials. The emphasis is primarily on materials properties rather than on optical devices. The primary focus of the conference is on the measurement and theory of basic optical properties of materials in bulk, thin film and fiber form. *These proceedings include the following papers (indented):*

Properties of low-index laser materials, M. J. Weber, *SP574*, pp. 3-8 (May 1980).

Nonlinear optical susceptibilities of semiconductors and optical bistability, H. M. Gibbs, S. L. McCall, T. N. C. Venkatesan, A. Passner, A. C. Gossard, and W. Wiegmann, *SP574*, pp. 9-12 (May 1980).

Band structure calculations of the two-photon absorption coefficients of InP and CdTe, A. Vaidyanathan, A. H. Guenther, and S. S. Mitra, *SP574*, pp. 13-15 (May 1980).

Measurement and interpretation of ultraviolet properties of solids, D. W. Lynch, *SP574*, pp. 16-19 (May 1980).

The optical properties of Kapton: Measurement and applications, L. R. Painter, E. T. Arakawa, M. W. Williams, and J. C. Ashley, *SP574*, pp. 20-23 (May 1980).

Optical properties of  $\text{TiC}_x$  ( $0.64 \leq x \leq 0.90$ ) from 0.1 to 30eV, D. W. Lynch, C. G. Olson, D. J. Peterman, and J. H. Weaver, *SP574*, pp. 24-27 (May 1980).

Superconvergence relations and the analysis of optical data, D. Y. Smith, *SP574*, pp. 28-31 (May 1980).

Measurement of the far infrared optical constants of disordered solids, U. Strom and P. C. Taylor, *SP574*, pp. 32-35 (May 1980).

Infrared impurity absorption spectra of premium—Q quartz, H. G. Lipson, *SP574*, pp. 36-39 (May 1980).

Far infrared study of the reflection spectra of SnS, D. G. Mead and H. R. Chandrasekhar, *SP574*, pp. 40-43 (May 1980).

Infrared absorption in highly transparent cubic zirconia, B. Bendow, H. G. Lipson, R. C. Marshall, and D. Billard, *SP574*, pp. 44-47 (May 1980).

The temperature dependence of the optical absorption of metals, M. Bass, D. Gallant, and S. D. Allen, *SP574*, pp. 48-50 (May 1980).

The statistical description of optical inhomogeneities, E. L. Church, *SP574*, pp. 51-54 (May 1980).

Photoconductivity at 77K in undoped tellurium, N. G. Shyamprasad, C. H. Champness, and I. Shih, *SP574*, pp. 55-58 (May 1980).

Extrinsic states in cinnabar ( $\alpha\text{-HgS}$ ) grown by chemical vapor transport, C. T. Simpson, W. Imano, and W. M. Becker, *SP574*, pp. 59-62 (May 1980).

Differential reflectometry—An optical technique for investi-

gating band structure changes associated with alloying, dealloying, corrosion and ordering, R. J. Nastasi-Andrews, J. B. Andrews, C. W. Shanley, J. Finnegan, and R. E. Hummel, *SP574*, pp. 63-66 (May 1980).

Free carrier absorption in semiconductors in quantizing magnetic fields, H. N. Spector, *SP574*, pp. 67-70 (May 1980).

Multiphoton absorption in direct gap solids, S. S. Mitra, *SP574*, pp. 71-76 (May 1980).

Measurements of two photon absorption, A. F. Stewart and M. Bass, *SP574*, pp. 77-80 (May 1980).

Three-photon absorption in Nd:YAG, R. W. Boyd and M. A. Kramer, *SP574*, pp. 81-84 (May 1980).

Refractive index and thermo-optic coefficients of  $\text{CD}^*\text{A}$ , L. G. DeShazer and K. E. Wilson, *SP574*, pp. 85-86 (May 1980).

On the use of a calorimeter to investigate loss mechanisms in optical fibers, F. T. Stone, *SP574*, pp. 87-90 (May 1980).

Computerized refractive index measurement for fiber optic glasses, D. L. Wood and J. W. Fleming, *SP574*, p. 91 (May 1980).

Stress optic coefficient of optical fibers, N. Lagakos, *SP574*, pp. 92-95 (May 1980).

Chromatic measurements of gradient index materials by multiple wavelength interferometry, D. P. Ryan, *SP574*, pp. 96-99 (May 1980).

Optical coupling coefficients for pulsed  $\text{CO}_2$  laser radiation on bare and painted aluminum surfaces, S. C. Seitel, J. O. Porteus, and W. N. Faith, *SP574*, pp. 100-103 (May 1980).

Thermomodulation spectra of high-energy interband transitions in Cu, Pd, Ag, Pt, and Au, C. G. Olson, D. W. Lynch, and R. Rosei, *SP574*, pp. 104-107 (May 1980).

Ellipsometric observations on thermally grown oxide films on titanium, A. H. Musa and W. E. J. Neal, *SP574*, pp. 108-113 (May 1980).

Optical properties of A-15 thin films and single crystals, R. C. McKee, D. W. Lynch, C. G. Olson, J. W. Osmun, and J. H. Weaver, *SP574*, pp. 114-117 (May 1980).

IR absorption bands in multilayer thin films of some II/VI, V/VI materials, J. S. Seeley, R. Hunneman, and A. Whatley, *SP574*, pp. 118-121 (May 1980).

Multiwavelength laser rate calorimetry on various infrared window materials, G. S. Coble, D. V. Dempsey, J. A. Detrio, N. C. Fernelius, J. A. Fox, P. R. Greason, G. T. Johnson, and D. B. O'Quinn, *SP574*, pp. 122-125 (May 1980).

Optical constants of boron carbide in the infrared, J. L. Lauer and H. Adari, *SP574*, pp. 126-130 (May 1980).

Critical point analysis of multiphonon infrared absorption in zinc selenide, C. A. Klein and R. N. Donadio, *SP574*, pp. 131-134 (May 1980).

Multiphoton absorption in infrared glasses based on zirconium and hafnium fluorides, H. G. Lipson, B. Bendow, and M. G. Drexhage, *SP574*, pp. 135-138 (May 1980).

Optical characterization of bulk graded index materials, D. T. Moore, *SP574*, pp. 139-142 (May 1980).

Measurement of axial, Gaussian index distribution, G. W. Johnson, *SP574*, pp. 143-146 (May 1980).

Graded-index AR surfaces for improved laser-damage resist-

ance, W. H. Lowdermilk and D. Milam, *SP574*, pp. 147-148 (May 1980).

Reflectance properties of pressed tetrafluoroethylene powder, J. J. Hsia and V. R. Weidner, *SP574*, pp. 149-151 (May 1980).

Measurements of large optical absorption coefficients by diffuse reflectance, R. K. Waring, *SP574*, pp. 152-155 (May 1980).

Ellipsometric measurements of the optical properties of compacted powders, F. C. Zumsteg, *SP574*, pp. 156-159 (May 1980).

Material properties by spectroscopic ellipsometry, D. E. Aspnes, *SP574*, pp. 160-163 (May 1980).

Dielectric function of superlattice materials, P. J. Price, *SP574*, pp. 164-166 (May 1980).

Determination of thin film optical dispersion from spectrophotometer data, A. L. Bloom and D. Fischer, *SP574*, pp. 167-170 (May 1980).

Optical properties of doped-silica waveguide glasses in the 0.8-1.8  $\mu\text{m}$  region, R. Olshansky, *SP574*, pp. 171-177 (May 1980).

The use of a scattering cube to characterize the spectral loss of optical fibers, D. L. Philen and F. T. Stone, *SP574*, pp. 178-181 (May 1980).

Transition element absorption in molecularly-doped optical fiber glasses, A. Barkatt, D. C. Tran, and J. H. Simmons, *SP574*, pp. 182-184 (May 1980).

Measured pockels coefficients and predicted static pressure sensitivity for interferometric fiber optic hydrophones, R. Hughes, N. Lagakos, H. Dardy, and J. Bucaro, *SP574*, pp. 185-187 (May 1980).

Absorption and scattering phenomena in thin-film- and bulk-materials, M. S. Sparks, *SP574*, pp. 188-193 (May 1980).

The measurement of interface and bulk absorption in thin films and bare substrates, P. A. Temple, *SP574*, pp. 194-200 (May 1980).

Infrared optical properties of silicon monoxide films: Application to radiative cooling, A. Hjortsberg and C. G. Granqvist, *SP574*, pp. 201-203 (May 1980).

The photoelastic effect in optical materials, A. Feldman and R. M. Waxler, *SP574*, pp. 204-208 (May 1980).

The relation of elasto-optic and electrostrictive tensors, D. F. Nelson, *SP574*, pp. 209-212 (May 1980).

Photoelastic properties of magnesium fluoride, S. Chung and H. R. Carleton, *SP574*, pp. 213-216 (May 1980).

A microscopic approach to predict refractive indices and electro- or strain-optic coefficients, M. D. Ewbank, P. R. Newman, and W. A. Harrison, *SP574*, pp. 217-220 (May 1980).

Dispersion of thermo-optic coefficients of Nd laser materials, K. E. Wilson and L. G. DeShazer, *SP574*, pp. 221-222 (May 1980).

Temperature dependence of the optical properties of some metals at visible and infrared wavelengths, D. L. Decker and V. A. Hodgkin, *SP574*, pp. 223-224 (May 1980).

Optical properties of Ti diffused LiNbO<sub>3</sub> waveguides, W. K. Burns, *SP574*, p. 225 (May 1980).

Optical properties of thin films by guided waves and surface polaritons, J. D. Swalen, *SP574*, pp. 226-229 (May 1980).

Properties of low loss diffused optical waveguides in glass, T. Findakly and E. Garmire, *SP574*, pp. 230-233 (May 1980).

Thickness measurement of very thin-films by observing anomalous light absorption, H. Kitajima, K. Hieda, and Y. Suematsu, *SP574*, pp. 234-237 (May 1980).

Interferometric wavelength measurement of infrared surface waves, Z. Schlesinger and A. J. Sievers, *SP574*, pp. 238-239 (May 1980).

SP575. Design for better window performance (wall chart), S. R. Hastings and P. Driscoll, *Nat. Bur. Stand. (U.S.), Spec. Publ. 575*, wall chart (May 1980) SN003-003-02238-1.

Key words: design elements; energy performance of windows; window attributes; window design; window design elements; window performance.

The wall chart "Design for Better Window Performance" describes window and other design elements and the impact of these design elements singly and in combination on window performance and building attributes. The design elements are grouped into four categories: Exterior—windbreaks, shades, coverings and sun orientation; Frame—insulating frame, opening type, weather strip and hardware; Glazing—multi-glazing, reflective glazing, plastic glazing and glass block; Interior—interior shading, interior coverings, integral lighting and interior mass.

The impacts of these design elements are described in a matrix form and address the following window and building attributes: Airtightness, Water tightness, Natural ventilation, Insulation, Solar admittance, Daylighting, Visual separation, Acoustical isolation, Safety, Access/Egress, Ease of operation, Forced entry resistance, and Durability/Maintenance. The chart is designed for ready reference during the design process.

SP577. Development of a probability based load criterion for American National Standard A58—Building code requirements for minimum design loads in buildings and other structures, B. Ellingwood, T. V. Galambos, J. G. MacGregor, and C. A. Cornell, *Nat. Bur. Stand. (U.S.), Spec. Publ. 577*, 228 pages (June 1980) SN003-003-02200-4.

Key words: aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber.

Recommended load factors and load combinations are presented which are compatible with the loads recommended in the proposed 1980 version of American National Standard A58, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures (ANSI A58.1-1980 D). The load effects considered are due to dead, occupancy live, snow, wind and earthquake loads. The load factors were developed using concepts of probabilistic limit states design which incorporate state-of-the-art load and resistance models and available statistical information. Reliabilities associated with representative structural members and elements designed according to current (1979) structural specifications were calculated for reinforced and prestressed concrete, structural steel, cold-formed steel, aluminum, masonry and glued-laminated timber construction. The report presents the rationale for selecting the criterion format and load factors and describes the methodology to be followed by material specification groups for determining resistance factors consistent with the implied level of reliability and the statistical data. The load factors are intended to apply to all types of structural materials used in building construction.



SP578. A catalog of data compilations on photochemical and photophysical processes in solution, J. G. Brummer, W. P. Helman, and A. B. Ross, *Nat. Bur. Stand. (U.S.), Spec. Publ. 578*, 27 pages (Nov. 1980) SN003-003-02291-8.

Key words: data compilations; photochemistry; photophysics; review; solutions.

References to compilations and reviews of data on photochemical and photophysical processes in solution have been annotated to indicate subject and data content. Indexes are included for data types, keywords, and authors.

SP579. Symposium on International Standards Information and ISONET. Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, MD, Oct. 11-12, 1979, C. B. Phucas, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 579*, 61 pages (June 1980) SN003-003-02202-1.

Key words: ISO; ISONET symposium; proceedings; standards information.

The American National Standards Institute (ANSI) and NBS have been working cooperatively with the International Organization for Standardization (ISO) to provide United States input to the development of an International Standards Information Network called ISONET. Symposium participants had an opportunity to learn more about existing international standards information systems as well as the plans for the further development of ISONET. Through question and answer discussions, participants were able to learn about new developments in U.S. trade policy, especially those policies pertaining to standards and certification systems. *These proceedings include the following papers (indented):*

U.S. implementation of GATT trade policies and the gatt standards code, D. S. Abelson, *SP579*, pp. 1-6 (June 1980).

NATO objectives for standards harmonization, D. Mitchell, *SP579*, p. 7 (June 1980).

Capabilities presentation—Information services for exporters, R. Rutelionis, *SP579*, pp. 9-10 (June 1980).

Providing information services to exporters, B. Roden, *SP579*, pp. 11-12 (June 1980).

To promote international trade by providing rapid access to reliable information, J. Lieblich, *SP579*, pp. 13-16 (June 1980).

Standards and technical regulations—The international solution, E. J. French, *SP579*, pp. 17-21 (June 1980).

Standards and technical regulation—The information problem, E. Kierski, *SP579*, pp. 23-24 (June 1980).

Statement—Presented before the Symposium on International Standards Information and ISONET, C. Mohr, *SP579*, pp. 25-26 (June 1980).

Presentation on the Standards Council of Canada and their role in information exchange, A. A. Tunis, *SP579*, pp. 27-33 (June 1980).

A small country in the world of standards, G. Jenssen, *SP579*, pp. 35-38 (June 1980).

AFNOR and information about standards and related matter, D. Geronimi, *SP579*, pp. 39-40 (June 1980).

SP580. The state-of-the-art of thermal analysis. Proceedings of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, May 21-22, 1979, O. Menis, H. L. Rook, and P. D. Garn, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 580*, 265 pages (Aug. 1980) SN003-003-02219-5.

Key words: adsorbents; chemical processing; coordination compounds; enthalpimetry; glass processing; instrumentation; paper technology; polymer ignition; rubber processing; thermal analysis; thermogravimetry.

A workshop on the State-of-the Art of Thermal Analysis was held at the National Bureau of Standards, May 21-22, 1979. This volume contains the texts of the invited lectures with summaries by the rapporteurs. Topics covered include the variety of uses of thermal analysis in industrial processing, such as the measurement of the temperature coefficients needed for pilot plant design in the chemical industry, quality control and product testing in the rubber industry, a review of instrumental developments, descriptions of enthalpimetry, high pressure thermogravimetry using large samples, reports on polymer ignition, energy conservation in ceramic processing, industrial adsorbents, coordination compounds, and studies of ancient paper technology. Also, a poster session was provided for contributed presentation; these included a dynamic mechanical analysis system, high pressure DTA to study glass transitions, aluminum alloy microstructure, characterization of thermoplastics, and simultaneous thermogravimetry and differential scanning calorimetry. Abstracts of the poster presentations are included. *These proceedings include the following papers (indented):*

Thermal analysis in chemical processing, D. Dollimore, *SP580*, pp. 1-31 (Aug. 1980).

Key words: applications; kinetics; thermal analysis.

The interpretation of the science and technology of chemical processing must be dominated by the simple knowledge that the particular process is kinetically or thermodynamically dominated. This in turn decides how thermal analysis data on the subject is to be treated. The subject is made complicated by the fact that both types of process are described by the same basic equation, namely,  $\log k = A - (C/T)$  where  $k$  is a particular property based upon either thermodynamic or kinetic principles depending upon the process investigated and the environmental conditions of the investigation.

In thermodynamically dominated processes the Vant Hoff equation describes the conditions;  $\log_e K_p = (-\Delta H/RT) + \text{constant}$  where  $K_p$  is the equilibrium constant,  $\Delta H$  is the heat of reaction,  $R$  the gas constant and  $T$  the temperature in degrees kelvin.

For a description of kinetic processes the Arrhenius equation is used in the form,  $\log_e k = (-E/RT) + \text{constant}$ , where  $k$  is the specific reaction rate and  $E$  the activation energy.

It can be demonstrated that rising temperature data can be used to calculate the specific reaction rate in the Arrhenius equation. If, however, the rising temperature data is not a reflection of kinetic changes, then it would be erroneous to apply the kinetic interpretation. It would also be in error to interpret data as representing the equilibrium condition if the data did not comply with thermodynamic principles.

Some simple observations are made indicating the characteristic phenomena if the rising temperature regime applied to a particular system under specified conditions is a reflection of the changing equilibrium conditions or represents kinetic parameters. Further conditions are then laid down to ensure that kinetic parameters calculated under particular experimental restraints actually refer to the chemical reaction itself and not to a diffusion-controlled kinetic process.

Various technological processes drawn from the fields of glass manufacture, ceramics, and catalysis are then discussed with reference to the information provided by thermal analysis methods on these subjects.

Progress in the use of differential thermal analysis-evolved gas analysis (DTA-EGA) for the analysis of second phases in steel, W. R. Bandi, *SP580*, pp. 33-53 (Aug. 1980).

**Key words:** alloys; differential thermal analysis; gas analysis; steel.

For the past 15 years, U.S. Steel Research has applied differential thermal analysis-evolved gas analysis (DTA-EGA) to the identification and quantitative determination of second phases in steels and other alloys. Often existing equipment had to be modified, or special instruments had to be built to attain project objectives.

The procedure has been used for the qualitative identification of at least 35 second-phase compounds which can be chemically or electrochemically isolated from steels and other alloys. Small amounts of a particular phase, or in some instances new phases, have been identified even though they were not detected by other methods. Often phases which have similar diffraction patterns have been easily differentiated using EGA methods. In addition to the progress in identification, the quantitative determination of the precipitated phases has been a valuable aid in studying the rate of precipitation of a phase at a specific temperature; in determining changes in the type of crystal structure of precipitates as a result of heat-treating changes; and in observing the change in physical properties of the steel as a function of phase precipitation.

**Thermal analysis in the rubber industry,** D. W. Brazier, *SP580*, pp. 55-87 (Aug. 1980).

**Key words:** differential scanning calorimetry; elastomers; polymers; rubber; thermal analysis.

In this review an attempt will be made to outline just some of the applications of thermoanalytical procedures (TG, DSC, TMA) in the rubber industry. Despite the extensive use of these procedures in the study of high molecular weight polymers, relatively little has been published on commercial elastomers and complex elastomeric compounds. For ease of presentation, each procedure is considered separately; however, the total characterization of a system by several methods often provides insight not apparent from one procedure.

The major areas considered are:

TG/DTG—basic thermal stability of elastomers; qualitative identification of elastomers and elastomer blends; quantitative analysis of rubber compounds (elastomers, carbon black, fillers, etc.).

DSC—basic features of DSC data on elastomer compounds; the heat of vulcanization and characterization of curative systems.

TMA/DTMA—characteristic feature of TMA curves; low temperature properties of elastomeric products.

The above is by no means exhaustive and it is hoped that the areas chosen will illustrate the versatility and usefulness of thermal analysis in all aspects of the industry.

**Thermogravimetry at high heating rates: Studies on polymer ignition,** B. Miller and J. R. Martin, *SP580*, pp. 89-97 (Aug. 1980).

**Key words:** decomposition temperatures; polymeric solids; thermogravimetry.

A commercial thermogravimetric analyzer has been used to monitor the behavior of polymeric solids brought to ignition by exposure to preheated air. Samples were inserted into the TG oven and weight loss and sample temperature monitored simultaneously as a function of time. By using a series of oven temperatures and measuring times to ignition, it was possible to establish the minimum heating rate required for ignition and the initial decomposition temperature at that rate. Critical rates for 14 polymers ranged from 380 to 3380 °C/min and the decomposition temperatures were considerably higher than what is observed at lower heating rates. The two measured parameters have

been combined to give a single value which seems to be a good indicator of a material's ignitability hazard potential.

**Ceramic processes and energy conservation,** W. R. Ott, *SP580*, pp. 99-130 (Aug. 1980).

**Key words:** cements; ceramics; glasses; industrial processes; thermal analysis.

Ceramics, including glass and cements, are reviewed for their use of thermal analysis. Processing is considered to include the mining of the raw materials, batch preparation, forming, drying, and firing. Energy conservation considerations include methods used to lower process temperatures or shortening process time as well as reducing energy consumption through greater process efficiency.

Examples include the use of DTA/TG/TMA/EGA in studies of solid state reactions, sintering, drying, etc. The use of the data as applied to pollution control and energy conservation in ceramics is discussed.

Thermal analysis is shown to be a critical tool in ceramics for material and process improvement. Substantial energy reductions have been realized through effective use of thermal analysis on a wide variety of materials.

**Current contributions of thermal analysis to the study of technological adsorbents,** J. Rouquerol, *SP580*, pp. 133-147 (Aug. 1980).

**Key words:** adsorbents; gas exchange; surface areas; thermal analysis.

The adsorbents considered here are mainly those used in gas adsorption (either physical or chemical) and in heterogeneous catalysis. A number of specific features of this class of material and the corresponding problems raised in thermal analysis are examined (problems of atmosphere control, temperature and pressure gradients, spurting out under vacuum, sampling, re-adsorption from air, high sensitivity for the detection of desorption).

The use of thermal analysis is considered throughout the life of an adsorbent: a) Production of porous adsorbents by thermolysis and achieving of a reproducible standard state of the surface; b) Characterization of the adsorption properties (through a study of gas adsorption, gas desorption, and gas exchange); c) Thermal destruction of adsorbents (sintering and also destructive characterization).

Among the thermal analysis techniques examined here are TG, DTA, DTG, EGD, EGA, and also Temperature Programmed Desorption and Controlled Decomposition Rate Thermal Analysis (including Quasi-Isothermal Thermogravimetry).

**Enthalpimetric analysis: Thermochemical titrations and related methods,** J. Jordan, J. D. Stutts, and W. J. Brattlie, *SP580*, pp. 149-181 (Aug. 1980).

**Key words:** kinetics; thermal analysis; thermochemical titrations.

Conventional methods of thermal analysis involve generally the characterization of *solid samples*. In contradistinction, enthalpimetric analysis relies on measuring temperature changes in *dilute solutions*, under effectively adiabatic conditions. The basic principle of enthalpimetric analysis is a linear correlation between the heat evolved (or absorbed) in a chemical reaction and the amounts reacted. The relevant proportionality constant is  $\Delta H^\circ$ . However, experimental conditions must be judiciously adjusted to minimize extraneous caloric effects, heats of dilution and maintain invariant heat capacity. These crucial requirements mandate reliance on highly sensitive temperature transducers which have a fast response. Thermistor circuits and novel curie-point sensors will be discussed in this context, focussing on ultimate limitations in signal-to-noise ratios. The state-of-



the-art of thermometric enthalpy titrations (TET), direct injection enthalpimetry (DIE), and flow enthalpimetry will be outlined. Significant areas of applications will be reviewed, including quantitative analysis and determination of thermodynamic and kinetic parameters. The salient feature of enthalpimetric methods is their universal applicability, predicted by the fact that  $\Delta H$  is the most general property of chemical processes. Paradoxically though, this—*per se*—imposes severe restrictions due to lack of specificity. The difficulty has been circumvented by reliance on chemical processes which are highly specific by their very nature, e.g., immunological and enzymatic reactions. Recent progress will be described. Capabilities and limitations of enthalpimetric analysis will be assessed, focussing on contemporary national needs, ranging from clinical chemistry to monitoring of contaminants in the new coal conversion technologies.

**Chemical complexes**, P. D. Garn, *SP580*, pp. 183-198 (Aug. 1980).

Key words: chemical complexes; chemical equilibrium; kinetics; thermal analysis.

**Paper technology from Egyptian, Chinese, and Mayan cultures**, H. G. Wiedemann, *SP580*, pp. 201-217 (Aug. 1980).

Key words: Aztec paper; Egyptian papyrus; paper technology; thermal analysis.

**Recent instrumental developments**, W. W. Wendlandt, *SP580*, pp. 219-233 (Aug. 1980).

Key words: instrumentation review; methods; thermal analysis.

A survey was made of the thermal analysis (TA) techniques that were used in the six latest volumes of *Thermochemica Acta* and the *Journal of Thermal Analysis*. The most widely used techniques are thermogravimetry (TG), differential thermal analysis (DTA), and differential scanning calorimetry (DSC); these techniques account for over 50 percent of the experimental data in a total of 465 technical articles. Rather surprisingly, high temperature x-ray diffraction accounted for about 4 percent of the experimental techniques. New TA techniques discussed include concurrent DTA, EC, and TG using commercial equipment, and the thermophotometry of coordination compounds.

**Thermogravimetric measurements at high pressures**, N. C. Gardner, J. J. Leto, S. Lee, and J. C. Angus, *SP580*, pp. 235-250 (Aug. 1980).

Key words: high pressure methods; kinetics; thermogravimetry.

Significant advances have been made in the last decade in vacuum microbalance technology, particularly with regard to ultra-high vacuum and nanogram capabilities. However, thermogravimetric measurements at high pressures and temperatures, in regimes of importance to commercial processes, have received much less attention. In this paper, we review the principal techniques that have been used at these conditions and discuss their inherent problems.

Most prior thermobalances for use at high pressure have employed a hanging sample basket within a pressure containment vessel. The devices differed principally in the means of heating and the mass transducer used.

We have employed a novel means for obtaining thermogravimetric kinetic data, viz., the entire reactor plus contents are weighed during the course of a run. A 130 kg reactor (300 lb) with thin-walled flexible gas lines and thermocouples attached is suspended from a large balance. The balance has a sample capacity of 0.5 kg (1 lb) and an inherent sensitivity of 10 mg which is diminished by about

50 mg per attached line. The experimental design permits the entire reacting gas stream to be passed through the sample bed. Control over the fluid mechanical regime is therefore possible allowing elimination of external mass transfer effects, operation as a true differential bed reactor and permitting measurement of meaningful product gas compositions.

The thermobalance has been designed to operate at temperatures to 1370 °K (2000 °F) at pressures as high as 100 atm. This covers the operating range of many practical chemical processes.

**SP581. Radon in buildings**. Proceedings of a Roundtable Discussion of Radon in Buildings held at the National Bureau of Standards, Gaithersburg, MD, June 15, 1979, R. Collé and P. E. McNall, Jr., Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 581*, 84 pages (June 1980) SN003-003-02196-2.

Key words: buildings; environment; health; measurements; radiation; radon; radon daughters; ventilation.

This is the proceedings of a Roundtable Discussion of Radon in Buildings held June 15, 1979 at the National Bureau of Standards in Gaithersburg, Maryland. The meeting brought together a number of participants with diverse interdisciplinary interest in radiation protection, radiation measurement and building technology, provided a forum to exchange information, and drew attention to some of the problems and research needs associated with radiation exposure due to radon in buildings. Emphasis was placed on (1) the characterization of the sources and pathways of radon in buildings; (2) the biological and health effects; (3) measurement considerations; and (4) strategies and control technologies to minimize indoor radiation exposure. *These proceedings include the following papers (indented):*

**The physics and interaction properties of radon and its progeny**, R. Collé. *SP581*, pp. 1-21 (June 1980).

**The biological and health effects of radon: A review**, D. A. Morken, *SP581*, pp. 21-26 (June 1980).

**Techniques for measuring radon in buildings**, A. J. Breslin, *SP581*, pp. 27-35 (June 1980).

**Radon and radon daughters in buildings: A survey of past experience**, C. R. Phillips, S. T. Windham, and J. A. Broadway, *SP581*, pp. 37-44 (June 1980).

**Residential building technology trends and indoor radon and radon daughter concentrations**, P. E. McNall, Jr., and S. Silberstein, *SP581*, pp. 45-51 (June 1980).

**SP582. Measurement technology for safeguards and materials control**. Proceedings from American Nuclear Society Topical Meeting held at Kiawah Island, SC, Nov. 26-30, T. R. Canada and B. S. Carpenter, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 582*, 769 pages (June 1980) SN003-003-02207-1.

Key words: accountability; accuracy; gamma spectrometry; mass spectrometry; nondestructive assay; nuclear safeguards; precision; reference materials; special nuclear materials; x-ray fluorescence.

This publication contains the proceedings of the American Nuclear Society's Topical Conference entitled, Measurement Technology for Safeguards and Materials Control. The meeting, co-sponsored by the Office of Measurements for Nuclear Technology of the National Bureau of Standards and the Institute of Nuclear Materials Management, was held at Kiawah Island, South Carolina, on November 26-30, 1979. The objective of the conference was to provide a forum for reports of current work and for information exchanges on technical subjects that are relevant to measurement technology for nuclear safeguards and material control.



The presentations were applications oriented and offered a good balance between chemical analysis, nondestructive assay techniques, bulk measurement techniques, inspection techniques, and integrated systems for material measurements and control. Reports discussing preparation and use of reference materials and measurement traceability were included. Examples of measurement requirements and techniques used for both national and international safeguards are given. Approaches to various analysis of materials throughout the fuel cycle from enrichment and fuel fabrication to spent fuel and reprocessing are considered. *These proceedings include the following papers (indented):*

**Reference materials and measurement traceability—Fact vs. fiction,** C. D. Bingham, *SP582*, pp. 1-14 (June 1980).

Key words: destructive; nondestructive measurements; nuclear materials; reference materials; traceability.

Nuclear materials safeguards within the U.S.A. are accomplished by the integration of activities involving physical protection, material control and material accountability. Material accountability requires both sound measurement technology and well-defined accounting procedures to provide final evidence that physical protection and materials control have achieved their purpose.

The quantities of nuclear materials received, shipped, stored or in process must be verified by accurate and precise physical and/or chemical measurements of the materials themselves and of their bulk properties. Measurements of concentration (both elemental and isotopic) are combined with measurements of bulk properties (mass or volume) to verify the total quantities of materials being protected.

When safeguards measurements are performed, the ability to demonstrate and document the *accuracy* of the measurement system being utilized is of ultimate importance. This importance is more apparent when the consequences of inaccurate measurements are considered. The inaccuracy of measurements or the incompatibility of measurement systems can contribute to inventory differences (ID) within a material balance area (MBA) or to shipper-receiver (SR) differences between MBAs, between plants, between countries, and/or between a facility and its safeguards authority and could, in reality, mask a diversion.

Private nuclear plant operators in the U.S.A. are required by license conditions to demonstrate through a measurement assurance program that safeguards measurements are compatible with, i.e., traceable to, a nationally accepted reference base. A similar requirement exists for U.S. Government facilities.

Reference materials are one means by which measurement technology may be transferred to users in that measurement methods or measurement systems can be calibrated to produce and reproduce the value assigned to the reference. Reference materials are also a means for relating measurements made at different sites, within or between countries, to each other.

This paper discusses some facts vs. some fallacies regarding the use of reference materials and the establishment of traceability of destructive and nondestructive measurements.

**The role of standard reference materials in achieving measurement traceability,** W. P. Reed, *SP582*, pp. 15-24 (June 1980).

Key words: definitive methods; measurement compatibility; protocol; reference methods; SI units; standard reference materials; traceability.

This paper will discuss the general concept of a measurement system and the various components of that system as applied to analytical measurements. It will emphasize the

relationship of the components of the system including the SI base units, standard reference materials, and reference methods and how these components contribute to making accurate and thus compatible measurements. The concept of compatibility of measurements is a key to understanding traceability requirements and one reason for the use of Standard Reference Materials. In addition, the status of current NBS projects for the preparation and certification of new Standard Reference Materials for nuclear measurement systems is discussed.

**Preparation of prototype NDA reference materials: A progress report,** A. M. Voeks and N. M. Trahey, *SP582*, pp. 25-33 (June 1980).

Key words: interlaboratory evaluation program; nondestructive assay; uranium reference material.

Three prototype NDA reference materials for scrap and waste have been developed at the New Brunswick Laboratory for use in an interlaboratory evaluation program. They are ion exchange resin, cellulose fiber and synthetic calcined ash. A total of 19 reference materials containing varying amounts of enriched uranium were prepared. Details of the preparation, packaging and characterization are described.

**Mass spectrometric measurements to determine the half-life of  $^{241}\text{Pu}$ ,** E. L. Garner and L. A. Machlan, *SP582*, pp. 34-41 (June 1980).

Key words: half-life; mass spectrometry; plutonium-241; thermal ionization.

The isotopic abundance ratios of a group of plutonium reference samples and Standard Reference Materials were precisely determined by thermal ionization mass spectrometry. The procedure was based upon the well developed methodology for uranium, making appropriate allowances for relative differences in the ionization efficiencies of the elements. The  $^{241}\text{Pu}$  half-life results for independent decay curves for the samples involved in the study varied from 14.32 to 14.36 years and were independent of  $^{241}\text{Pu}$  atom composition.

**Analytical data for practical safeguards: Performance and evaluation of international intercomparison programs,** W. Beyrich and G. Spannagel, *SP582*, pp. 42-54 (June 1980).

Key words: alpha spectrometry; intercomparison programs; mass spectrometry; plutonium; safeguards; statistical evaluation; uranium.

During the past decade, a number of international analytical intercomparison programs have been organized by the Karlsruhe Nuclear Research Center in order to investigate the capability of measuring methods used in safeguards when applied under routine conditions. A survey is given of the main results of these experiments which have been directed specifically to analyzing materials from reprocessing and enrichment facilities. Based on the experience gained, general design problems of the experiments are discussed. Furthermore, an empirical method of evaluation is described briefly which proved to be effective in handling the data material which, as obtained during such programs, was mostly statistically inhomogeneous. Examples are given for using this evaluation method.

**Computer-aided in-line and off-line analytical control system for an experimental thorium-uranium reprocessing facility,** B. G. Brodda, *SP582*, pp. 55-65 (June 1980).

Key words: automation; data processing; HTGR spent fuel reprocessing; in-line measurements; off-line measurements; process control; remote pipetters; remote sample preparation; SNM accountancy; x-ray fluorescence.



The paper discusses in brief the technological background and specific obstacles of general process control and nuclear material assay in reprocessing facilities. It also describes essential parts of an analytical control system designed to service an experimental reprocessing plant for spent thorium-uranium fuel. The features displayed are the data processing system, sample identification applying bar coded labels, remote pipetter and sample lock systems as well as a remote XRF sample preparation device.

**Nuclear materials analysis using plasma desorption mass spectrometry**, W. H. Ulbricht, Jr., *SP582*, pp. 66-78 (June 1980).

Key words: fission fragment desorption; isotope ratio measurement; plasma desorption; time-of-flight mass spectrometer.

A unique time-of-flight mass spectrometer has been built to make use of a process referred to as plasma desorption to measure isotope ratios of materials which contain fissionable material. Plasma desorption is the very rapid and energetic process by which a fission fragment may desorb and ionize minute portions of the sample. It is so rapid that fractionation is thought not to occur, and the amount of material removed from the sample is extremely small. The mass spectrometer construction is discussed and a description of the timing electronics is given.

**Quadrupole mass spectrometry for isotopic analysis of uranium hexafluoride**, H. S. Kusahara and C. Rodrigues, *SP582*, pp. 79-85 (June 1980).

Key words: nuclear safeguards; precision; quadrupole mass spectrometer; uranium hexafluoride; uranium isotope analysis.

This paper describes the procedures for isotopic analysis of uranium in  $UF_6$  using a quadrupole mass spectrometer/computer system in a closed loop mode. The results of a series of measurements on natural uranium samples are discussed. A typical internal precision of about  $10^{-4}\%$  for the  $^{235}U/^{238}U$  ratio was obtained.

**Safeguards reference measurement system utilizing resonance neutron radiography**, R. A. Schrack, J. W. Behrens, C. D. Bowman, and A. D. Carlson, *SP582*, pp. 86-92 (June 1980).

Key words: epithermal neutron energy; neutron radiography; nondestructive assay; position-sensitive proportional counter; uranium.

A resonance neutron radiograph system is being developed to provide a reference method for nondestructive assay (NDA) measurements for the safeguards program. Initial tests have produced radiographs of 5 mm and 1 mm resolution and determined the uranium content of commercial reactor fuel pellets.

**Accurate in-situ assay of total fissile isotopes in inputs of reprocessing plants: A reference method or a "definitive" method?**, W. Lycke, M. Gallet, F. Peetermans, R. Damen, E. Bouwmeester, P. De Bievre, and J. Van Audenhove, *SP582*, pp. 93-102 (June 1980).

Key words: alloys; blend; input concentration; isotope dilution; neodymium; plutonium; safeguards; spike; total mass; uranium.

The solid spike method previously established and used by this laboratory to assay fissile isotope concentrations in-situ in undiluted input samples from reprocessing plants, has been improved considerably for Pu by replacing previously used  $^{235}U/^{239}Pu$  solid spikes by  $^{235}U/^{242}Pu$ . Results of plant tests are given indicating a same 0.3% standard deviation on a single determination for both U and Pu. Comparison

with the former method is made.

Also presented are the results of the first laboratory tests of an extension of the above-mentioned method to include the determination of the total mass of a solution using again isotope dilution mass spectrometry.

The combination of both methods, concentration and total mass determination, allows the in-situ assay of total U and total Pu in any input batch of a reprocessing plant.

**Gamma-ray measurements for uranium enrichment standards**, T. D. Reilly, *SP582*, pp. 103-110 (June 1980).

Key words: accuracy; gamma-ray spectroscopy; mass spectrometry; precision; uranium enrichment measurement.

The gamma-ray spectroscopic measurement of uranium enrichment is one of the most widely used nondestructive analysis techniques. A study has been started of the precision and accuracy achievable with this technique and the physical parameters which affect it. The study was prompted by questions raised during the ongoing ESARDA-NBS experiment to produce uranium oxide reference counting materials for the technique. Results reported here using a high-quality Ge(Li) spectrometer system show reproducibility comparable to that attainable with mass spectrometry (approximately 0.1% for low enrichment uranium).

**New advances in alpha spectrometry by liquid scintillation methods**, W. J. McDowell and G. N. Case, *SP582*, pp. 111-120 (June 1980).

Key words: alpha counting; alpha particle; liquid scintillation; solvent extraction; spectrometer.

Although the ability to count alpha particles by liquid scintillation methods has been long recognized, limited use has been made of the method because of problems of high background and alpha energy identification. In recent years some new developments in methods of introducing the alpha-emitting nuclide to the scintillator, in detector construction, and in electronics for processing the energy analog and time analog signals from the detector have allowed significant alleviation of the problems of alpha spectrometry by liquid scintillation. Energy resolutions of 200 to 300 keV full peak width at half maximum and background counts of  $< 0.01$  counts/min with rejection of  $> 99\%$  of all beta plus gamma interference is now possible.

Alpha liquid scintillation spectrometry is now suitable for a wide range of applications, from the accurate quantitative determination of relatively large amounts of known nuclides in laboratory-generated samples to the detection and identification of very small, subpicocurie amounts of alpha emitters in environmental-type samples. Suitable nuclide separation procedures, sample preparation methods, and instrument configurations are available for a variety of analyses.

**Acid-compensated multiwavelength determination of uranium in process streams**, D. T. Bostick, *SP582*, pp. 121-128 (June 1980).

Key words: determination; dual wavelength; nitric acid; spectrophotometric; uranium.

Uranyl absorbance was measured in the presence of 0.02-5M  $HNO_3$  to determine the effect of nitric acid concentration on the absorbance of uranium in the concentration range of 20-200 g/l. The uranyl absorbance was found to be primarily the result of three uranyl species:  $UO_2^{2+}$ ,  $UO_2NO_3^+$  and a uranyl dimer. The concentration of  $HNO_3$  determines the relative concentration of each of these uranyl cations and, hence, their contribution to the total absorbance. Because  $UO_2^{2+}$  and  $UO_2NO_3^+$  are the major uranyl species in streams containing excess acid (0.5-5M  $HNO_3$ ), the absorbance at 416 and 426 nm is used to simul-



taneously calculate the total uranium and nitrate concentration in a stream to within 5% and 0.5 molar units, respectively. The uranyl absorbance in acid deficient aqueous streams (0.02-0.5M  $\text{HNO}_3$ ) is due primarily to the absorbance of  $\text{UO}_2^{2+}$  and the uranyl dimer. As a result the absorbance at 416 and 426 nm can be used to simultaneously calculate the total uranium and hydrogen ion concentration in samples to within 3% and 0.2 molar units, respectively.

**LASL analytical chemistry program for fissionable materials safeguards**, D. D. Jackson and S. F. Marsh, *SP582*, pp. 129-139 (June 1980).

Key words: assay of uranium; automated controlled-potential analyzer; automated spectrophotometer; complexometric titration of uranium and thorium; dissolution of nuclear fuel-cycle materials; half lives plutonium isotopes; plutonium and thorium; plutonium reference materials.

Major tasks in this program are (1) development of dissolution techniques for refractory nuclear materials, (2) development of methods and automated analyzers for determining plutonium, uranium, and thorium, (3) preparation of plutonium reference materials distributed as certified reference materials by the National Bureau of Standards, used in the Safeguards Analytical Laboratory Evaluation (SALE) program administered by the New Brunswick Laboratory, and used to calibrate nondestructive analysis apparatus at LASL, and (4) preparation and characterization of plutonium isotope materials and participation in an intralaboratory program to measure longer-lived plutonium isotope half lives. More recent and significant achievements are reported. Gas-solid reactions at elevated temperature, used previously to convert uranium in refractory forms to species readily soluble in acid, are being applied to thorium materials. A microgram-sensitive spectrophotometric method was developed for determining uranium and the LASL Automated Spectrophotometer has been modified to use it. The instrument now is functional for determining milligram amounts of plutonium, and milligram and microgram amounts of uranium. Construction of an automated controlled-potential-coulometric analyzer has just been completed. It is giving design performance of 0.1% relative standard deviation for the determination of plutonium using a method developed especially for the instrument. A method has been developed for the microcomplexometric titration of uranium in its stable (VI) oxidation state. A color probe analyzer assembled for this titration also has been used for microcomplexometric titration of thorium. The present status of reference materials prepared for NBS and for the SALE program, as well as examples of working reference materials prepared for use with nondestructive analyzers, is given. The interlaboratory measured value of the  $^{239}\text{Pu}$  half-life is 24,119 yr. Our just completed measurement of the half life of  $^{241}\text{Pu}$  is 14.38 yr. Measurement of the  $^{240}\text{Pu}$  half life is in progress.

**Low level uranium determination by constant current coulometry**, W. G. Mitchell and K. Lewis, *SP582*, pp. 140-146 (June 1980).

Key words: constant current coulometry; low level titration; uranium titration; vanadium (V) titrant.

A scaled-down version of the titration of uranium by electrogenerated V(V) has been studied at the New Brunswick Laboratory. The full-scale method, automated by the Lawrence Livermore Laboratory, was based on a modification by Goldbeck and Lerner of the titrimetric method for uranium by Davies and Gray. A 1/4 scale-down of the coulometric method has resulted in precise and accurate titrations of 5-40 mg levels of uranium. Modifications were

made in the approach to the end point of the titration and in the treatment of the indicator electrodes.

**Application of a direct method for the determination of trace uranium in safeguards samples by pulsed laser fluorometry**, A. C. Zook and L. H. Collins, *SP582*, pp. 147-155 (June 1980).

Key words: analyses; fluorometry; laser-induced fluorescence; low-level analysis; nuclear safeguards; trace levels; uranium determination; waste solution analysis.

A direct method for the fluorometric determination of trace amounts of uranium in solution has been developed. Precision and accuracy are better than 5% with a sensitivity of 0.005 ng U. The method employs a pulsed nitrogen laser to excite uranium atoms in solution containing a pyrophosphate fluorescence reagent. The resulting fluorescence is filtered, electronically gated, and integrated. A standard addition technique is used to overcome sample matrix effects.

**An automated ion-exchange system for the rapid separation of plutonium from impurities in safeguards analyses**, B. P. Freeman, J. R. Weiss, and C. E. Pietri, *SP582*, pp. 156-163 (June 1980).

Key words: automated ion-exchange; automated plutonium separation; AUTOSEP; impurity separation; ion-exchange separation; plutonium.

Many plutonium samples cannot be analyzed directly after dissolution because of their high impurity content. Even when relatively interference-free methods such as controlled-potential coulometry are used, dissolved organic matter and high salt content from sample dissolution fusion treatments may require separation for highly reliable results. The anion-exchange separation of these interferences from plutonium (IV) in the Dowex-1 8N  $\text{HNO}_3$  system has been successfully used at the New Brunswick Laboratory (NBL) for many years. However, the demand to increase sample analysis output, to decrease sample turnaround time, and to reduce operating costs, has prompted the development of an automated system, AUTOSEP, based on the manual ion-exchange method. Application of this automated system to the analysis of safeguards inventory verification samples should have significant positive impact on those goals.

The AUTOSEP system is designed as a batch-type operation in which ten sample aliquots are simultaneously passed through mini ion-exchange columns in a pattern nearly imitating NBL's manual procedure for this same process. Weighed aliquots of dissolved sample, each containing 5-10 mg of plutonium, are added to each of ten reservoirs in the mini anion-exchange separator. The volume of liquid in each reservoir is adjusted uniformly by reagent addition, and all subsequent steps in the separation are performed automatically. The system incorporates a means of programming reagent delivery, adjustment of the sample to the plutonium (IV) oxidation state via Fe(II) reduction/ $\text{HNO}_3$  oxidation, plutonium sorption on the resin in 8N  $\text{HNO}_3$ , washing of the resin bed with 8N  $\text{HNO}_3$  to remove impurities, elution of the purified plutonium with 0.36N  $\text{HCl}$ -0.01N  $\text{HF}$ , and waste effluent disposal. The reagents are delivered by gravity from a module whose only moving parts are rotary valves. The eluted plutonium solutions are collected in glass coulometer cells in stainless steel holders for subsequent automated coulometric analysis.

**Computer-assisted controlled-potential coulometric determination of plutonium for safeguards measurements**, M. K. Holland, T. L. Frazzini, J. R. Weiss, and C. E. Pietri, *SP582*, pp. 164-168 (June 1980).



**Key words:** computer-assisted coulometry; controlled-potential coulometry; control-potential adjustment; electrical calibration; plutonium; plutonium determination.

A computer-assisted coulometric system, based on the New Brunswick Laboratory (NBL) manual controlled-potential coulometric method for plutonium determination has been developed. This system reduces the costs and operating time for plutonium measurements without loss in reliability in the analysis nuclear safeguards materials.

The computer-assisted system employs the same features as the manual method: 1) electrical calibration of the integration system is used to relate the coulombs produced during sample electrolysis to the quantity of plutonium electrolyzed, 2) corrections for the nonelectrolyzed fraction of the sample and for the coulombs resulting from background current (faradaic, charging, and constant currents) are applied, and 3) the control-potential adjustment technique developed at NBL is used for endpoint location.

**Measurement requirements and experience in international safeguards,** A. J. G. Ramalho and L. W. Thorne, *SP582*, pp. 169-177 (June 1980).

**Key words:** equipment; International Atomic Energy Agency; international safeguards.

This report describes IAEA experience in the application of NDA techniques in international safeguards. It refers to the main pieces of equipment and their use, placing emphasis on high resolution gamma spectrometry and neutron coincidence counting. Some recent experience, problems found and improvements needed are also touched upon.

**Inventory verification methods in DOE safeguards inspections,** C. S. Smith and R. O. Inlow, *SP582*, pp. 178-188 (June 1980).

**Key words:** inventory verification; measurement of inventory; nuclear materials; safeguards.

The most difficult and complex activity of a nuclear materials safeguards survey involves measurements review and inventory testing. At the Albuquerque Operations Office, we have relied on remeasurements as the key to inventory verification. Measurement of inventory items is accomplished by weighing, non-destructive assay (using contractor instruments and our assay meter), sampling/chemistry, and the use of off-site laboratories. The emphasis on each of these methods shifts from one contractor facility to another depending on processing history during the survey period and measurement capabilities required for proper safeguards accountability. ALO surveys five major facilities and we use five completely different approaches to measurement verification.

The goal of inventory verification is to assure that the contractor has all the nuclear materials reported to be in his possession. Verification is complete when it has been demonstrated that items purported to be in the inventory are present and easy to locate, that SNM items in the inventory are on the inventory listing, and that items contain the purported amounts of SNM. Ideally, an independent verification of inventory holdings would require a 100% remeasurement. This is not possible for facilities with large inventories. An alternate method is to remeasure items randomly selected through an attribute sampling plan. In our experience, this is unworkable for large, throughput-dominated facilities. By subdividing the inventory holdings into categories depending on the nature of the material, process characteristics, and measurement methods, the inspector can logically design a remeasurement campaign. This method is the most efficient means for examination of measurement performance during the entire accountability period.

Inspector remeasurement activities may be categorized under bulk properties determination, sampling and chemical assay, or NDA measurements. When possible, measurements are performed by the inspector or done under direct observation of the inspector. Samples are selected for each measurement method and material category such that the entire calibrated range of an instrument is tested. These measurements provide verification of random errors only. Off-site independent assays are provided by reference laboratories such as NBL or Mound Facility. This facet of our program has been very successful in improving contractor measurement systems and identifying or reducing significant biases. Samples returned after calorimetry at Mound are especially valuable in that they may be used as working standards for calibration of NDA instruments with actual process materials. When a facility possesses NDA and calorimetry capabilities, a dynamic calibration program may be established with process stream samples, reducing the need for extensive stocks of prepared standards.

ALO plans to field test a transportable calorimeter being designed and built by Mound for the Office of Safeguards and Security, DOE. This instrument has potential to be a valuable addition to our measurement capabilities by providing a rapid, inspector-operated assay system.

**Safeguards independent measurements program,** W. G. Martin, *SP582*, pp. 189-191 (June 1980).

**Key words:** analyses; destructive; nondestructive assay; NRC Safeguards; special nuclear material.

The special nuclear material (SNM) control and accountability inspection program of the U.S. Nuclear Regulatory Commission (NRC) stresses independent verification of their inventories of SNM. In addition, independent assessments of the licensee's measurement systems are also performed by NRC Safeguards inspectors. The independent measurements program consists of two major areas; one being nondestructive assay and the other being destructive analyses. Both areas employ the use of NRC and NBL prepared standards to independently assess a licensee's capability in performing NDA and DA measurements.

**Instrumentation development for the enhanced utilization of calorimetry for nuclear material assay,** C. L. Fellers, W. W. Rodenburg, J. H. Birden, M. F. Duff, and J. R. Wetzel, *SP582*, pp. 192-200 (June 1980).

**Key words:** calorimetric assay; calorimetry; plutonium assay; plutonium safeguards.

Calorimetric assay is an accurate and reliable technique for safeguards measurements. It is used extensively in DOE laboratories for SNM accountability and quality assurance measurements. To enhance the usefulness of calorimetric assay, an instrumentation and operating method development program is conducted at Mound. Recent development efforts have been directed at reducing analysis time, providing transportable instrumentation and relating calorimetric assay to chemistry.

**Experimental comparison of the active well coincidence counter with the random driver,** H. O. Menlove, N. Ensslin, and T. E. Sampson, *SP582*, pp. 201-220 (June 1980).

**Key words:** calibration; coincidence counter; neutron; non-destructive assay; precision; random driver; stability; uranium.

A direct comparison has been made between the IAEA Active Well Coincidence Counter (AWCC) and the LASL Random Driver at CMB-8. The comparison included an experimental evaluation of precision, counting rate, accuracy, penetrability, stability, and the effect of sample inhomogeneity.



Samples used in the evaluation included highly enriched  $U_3O_8$ ,  $U_3O_8$  mixed with graphite, highly enriched uranium metal discs, and depleted uranium metal. These materials are typical of the samples of interest to the IAEA inspectors.

We concluded from these investigations that the two instruments had very similar performance characteristics with the Random Driver giving better penetrability and the AWCC giving better stability.

**A rapid inventory taking system**, P. S. S. F. Marsden, *SP582*, pp. 221-233 (June 1980).

Key words: inventory taking; nuclear material; physical inventory.

A data processing system designed to facilitate inventory taking is described. The process depends upon the earliest possible application of computer techniques and the elimination of manual operations. Data is recorded in optical character recognition (OCR) 'A' form and read by a hand held wand reader. Limited validation checks are applied before recording on mini-tape cassettes. The data is read from the cassette directly into a computer system. A software package has been developed to validate the data, collate it with verification data, compare the physical and book inventories, and output the data in the form required to satisfy Regulation 3227/76. The system depends critically on label security and aspects of this problem are considered.

**Evaluation of reactor track-etch power monitor**, B. S. Carpenter, I. G. Schroder, L. J. Pilione, J. W. Roe, and S. Sanatani, *SP582*, pp. 234-238 (June 1980).

**Irradiated fuel monitoring by Cerenkov glow intensity measurements**, E. J. Dowdy, N. Nicholson, and J. T. Caldwell, *SP582*, pp. 239-256 (June 1980).

Key words: Cerenkov glow; inventory verification; irradiated fuel.

Attribute measurement techniques for confirmation of declared irradiated fuel inventories at nuclear installations under safeguards surveillance are being investigated. High-gain measurements of the intensity of the Cerenkov glow from exposed assemblies in water-filled storage ponds are promising for this purpose. Such measurements have been made of Materials Testing Reactor plate-type fuel assemblies and Pressurized Water Reactor pin-type fuel assemblies. The measured intensities depend on cooling times as calculations predict.

**A tamper recorder for unattended safeguards instruments**, D. C. Smathers, *SP582*, pp. 257-260 (June 1980).

Key words: safeguards instrument; seal; tamper; unattended safeguards system.

The Secure Counter Panel is an electro-mechanical module which records attempts to tamper with instruments of an unattended safeguards system in a way which cannot be sabotaged or bypassed without leaving obvious evidence of tampering. A number of novel tamper-safing techniques are included in the design, some of which are widely applicable to other safeguards instruments.

**International safeguards at the feed and withdrawal area of a gas centrifuge uranium enrichment plant**, D. M. Gordon and J. B. Sanborn, *SP582*, pp. 261-275 (June 1980).

Key words: gas centrifuges; IAEA safeguards; isotope separation; material balance; material unaccounted for; nondestructive analysis; safeguards; uranium; uranium hexafluoride; uranium 235.

This paper discusses the application of International Atomic Energy Agency (IAEA) safeguards at a model gas centrifuge uranium enrichment plant designed for the production of low-enriched uranium; particular emphasis is placed upon the verification by the IAEA of the facility material balance accounting. After reviewing the IAEA safeguards objectives and concerns at such a plant, the paper describes the material accountancy performed by the facility operator, and discusses strategies by which the operator might attempt to divert a portion of the declared nuclear materials. Finally, the paper discusses the verification of the declared material balance, including sampling strategies, attributes and variables measurements, and non-destructive measurements to improve the efficiency of the inspection measures.

**NDA for the SRP fuel fabrication process**, R. V. Studley, *SP582*, pp. 276-307 (June 1980).

Key words: accountability in fabrication of reactor fuel; active neutron interrogation; material control; neutron activation analysis; nondestructive assay (NDA); safeguards.

The Savannah River Plant fuel fabrication process is described to illustrate requirements for a variety of assay techniques. Criteria and design of some NDA systems for this process are discussed. Initial performance of a neutron activation analysis system (californium shuffler) as an assay method for several varieties of material is reported.

**An in-line monitor of plutonium holdup in glovebox filters**, T. K. Li and R. S. Marshall, *SP582*, pp. 308-312 (June 1980).

Key words: glovebox filter; in-line holdup monitor; NaI detector; nondestructive assay; real-time accountability.

An in-line filter holdup monitoring system has been designed and installed in the Los Alamos Scientific Laboratory (LASL) Plutonium Processing Facility to detect plutonium buildup in a glovebox exhaust filter. The filter is located on top of a glovebox in which  $PuO_2$ ,  $UO_2$ , and carbon are blended, milled, and prepared for making advanced fast breeder reactor (FBR) fuel. The system uses a 5- by 5-cm NaI detector for the gamma-ray nondestructive assay of plutonium in the filter. The system is simple and inexpensive, and is able to automatically and continuously collect data on plutonium buildup. The system is capable of measuring less than 0.1 g of plutonium in the filter.

**Integrated quality status and inventory tracking system for FFTF driver fuel pins**, G. P. Gottschalk, *SP582*, pp. 313-323 (June 1980).

Key words: fuel pin identification system; fuel pins; inventory tracking system; manufacturing information system; quality status tracking system.

An integrated system for quality status and inventory tracking of Fast Flux Test Facility (FFTF) driver fuel pins has been developed. Automated fuel pin identification systems, a distributed computer network, and a data base are used to implement the tracking system.

**The in-plant evaluation of a uranium NDA system**, J. K. Sprinkle, Jr., H. R. Baxman, D. G. Langner, T. R. Canada, and T. E. Sampson, *SP582*, pp. 324-341 (June 1980).

Key words: densitometry; uranium assay.

The Los Alamos Scientific Laboratory has an unirradiated enriched uranium reprocessing facility.

Various types of solutions are generated in this facility, including distillates and raffinates containing ppm of uranium and concentrated solutions with up to 400 grams U/l. In addition to uranyl nitrate and  $HNO_3$ , the solutions may also contain zirconium, niobium, fluoride, and small



amounts of many metals.

A uranium solution assay system (USAS) has been installed to allow accurate and more timely process control, accountability, and criticality data to be obtained. The USAS assays are made by a variety of techniques that depend upon state-of-the-art high-resolution Ge(Li) gamma-ray spectroscopy integrated with an interactive, user-oriented computer software package.

Tight control of the system's performance is maintained by constantly monitoring the USAS status. Daily measurement control sequences are required, and the user is forced by the software to perform these sequences.

Routine assays require 400 or 1000 seconds for a precision of 0.5% over the concentration range of 5-400 g/l.

A comparison of the USAS precision and accuracy with that obtained by traditional destructive analytical chemistry techniques (colorimetric and volumetric) is presented.

**Automated in-line measurement of nuclear fuel pellets**, D. R. McLemore and D. H. Nyman, *SP582*, pp. 342-364 (June 1980).

Key words: automated fuel fabrication equipment; nuclear fuel pellets; safeguards/accountability.

The Hanford Engineering Development Laboratory (HEDL) operated by the Westinghouse Hanford Company for the United States Department of Energy is currently developing, fabricating, and evaluating automated fuel fabrication equipment. This program has as its major goals: reduced personnel exposure, improved safeguards/accountability and improved fuel performance.

One of the automated equipment items which has been fabricated is a fuel pellet inspection system. This system inspects fuel pellets for surface flaws and measures pellets for length, diameter, and weight at a rate of one pellet per second. The inspected pellets are sorted automatically and the results of the inspection are transmitted to a central computer for trend analysis and verification of accountability data.

**Passive nuclear material detection in a personnel portal**, P. E. Fehlau and M. J. Eaton, *SP582*, pp. 365-371 (June 1980).

Key words: IAEA safeguards; neutron detectors; portal monitors; radiation detectors; SNM monitors; ZPPR.

The concepts employed in the development of gamma-ray and neutron detection systems for a special nuclear materials booth portal monitor are described. The portal is designed for unattended use in detecting diversion by a technically sophisticated adversary and has possible application to International Atomic Energy Agency safeguards of a fast critical assembly facility. Preliminary evaluation results are given and plans for further parameter studies are noted.

**An active neutron technique for detecting attempted special nuclear material diversion**, G. W. Smith and L. G. Rice, III, *SP582*, pp. 372-390 (June 1980).

Key words: inventory control; neutron interrogation; special nuclear material.

The identification of special nuclear material (SNM) diversion is necessary if SNM inventory control is to be maintained at nuclear facilities. (Special nuclear materials are defined for this purpose as either  $^{235}\text{U}$  or  $^{239}\text{Pu}$ .) Direct SNM identification by the detection of natural decay or fission radiation is inadequate if the SNM is concealed by appropriate shielding. The active neutron interrogation technique described combines direct SNM identification by delayed fission neutron (DFN) detection with implied SNM detection by the identification of materials capable of shielding SNM from direct detection.

This technique is being developed for application in an unattended material/equipment portal through which items such as electronic instruments, packages, tool boxes, etc., will pass. The volume of this portal will be 41-cm wide, 53-cm high and 76-cm deep. The objective of this technique is to identify an attempted diversion of at least 20 grams of SNM with a measurement time of 30 seconds.

**In-situ verification techniques for fast critical assembly cores**, S. B. Brumbach, P. I. Amundson, and C. T. Roche, *SP582*, pp. 391-424 (June 1980).

Key words: autoradiography; fast critical assemblies; non-destructive assay; plutonium; reactivity; spectral index; uranium.

Active and passive autoradiographic techniques were used to obtain piece counts of fuel plates in fast critical assembly drawers and to verify the assembly loading pattern. Active autoradiography using prompt-fission and fission-product radiation was more successful with uranium fuel while passive autoradiography was more successful with plutonium fuel. A source multiplication technique was used to measure changes in reactivity when small quantities (2-2.5 kg) of fissile material were removed from a subcritical reference core of the Zero Power Plutonium Reactor. Efforts to compensate for the loss of reactivity by substituting polyethylene for fuel were largely unsuccessful. Some compensation was achieved by replacing U-238 with polyethylene. The sensitivity for detection of partially compensated fuel removed from minimum worth regions was approximately 2.5 kg (fissile) for a core containing 2600 kg (fissile). Substitution of polyethylene was detected with a spectral index which was the ratio of the rate of the In-115 (n, $\gamma$ ) reaction to the rate of the In-115 (n,n') reaction. This spectral index was sensitive to the presence of an 0.64-cm-thick, 5.08-cm-high polyethylene column 10-15 cm away from the indium foil. The reactivity worth of Pu-239 was also obtained as a function of location in the reactor core with the use of an inverse kinetics technique. Reactivity worths for Pu-239 varied from a maximum of 58.67 lh/kg near the core center to a minimum of 14.86 lh/kg at the core edge.

**New developments in nondestructive measurement and verification of irradiated LWR fuels**, D. M. Lee, J. R. Phillips, J. K. Halbig, S. T. Hsue, L. O. Lindquist, E. M. Ortega, J. C. Caine, J. Swansen, K. Kaieda, and E. Dermendjiev, *SP582*, pp. 426-446 (June 1980).

Key words: axial profiles; fission chamber; instrumentation; ion chamber; irradiated (spent) fuel; nondestructive assay.

Nondestructive techniques for characterizing irradiated LWR fuel assemblies are discussed. This includes detection systems that measure the axial activity profile, neutron yield and gamma yield. A multielement profile monitor has been developed that offers a significant improvement in speed and complexity over existing mechanical scanning systems. New portable detectors and electronics, applicable to safeguard inspection, are presented and results of gamma-ray and neutron measurements at commercial reactor facilities are given.

**System for nondestructive assay of spent fuel subassemblies—Comparison of calculations and measurements**, G. L. Ragan, C. W. Ricker, M. M. Chiles, D. T. Ingersoll, G. G. Slaughter, and L. R. Williams, *SP582*, pp. 447-456 (June 1980).

Key words: assay accuracy; calculations; criticality control; material accountability; measurements; neutron interrogation; nondestructive assay; nuclear fuel subassembly; nuclear safeguards; process control; spent nuclear fuel.



A nondestructive assay system was developed for determining the total fissile content of spent fuel subassemblies at the head of a reprocessing plant. The system can perform an assay in 20 min with an uncertainty of  $< 5\%$ . An antineutrino-neutron (23 keV) interrogate the subassemblies, and proton recoil counters detect the resulting fission neutrons. Pulse-height discrimination differentiates between the low-energy interrogation neutrons and the higher-energy fission neutrons.

To optimize the performance of the system, 51-energy-group neutron-transport calculations were made, first with a one-dimensional (1-D) computer model, followed by a 2-D computer model. The performance of the as-built system was calculated using a 2-D model. The cross-sections were from the ENDF/B-IV data file and were processed for use in liquid-metal-cooled fast breeder reactor (LMFBR) calculations.

Calculated and measured results were compared for (1) interrogation-neutron penetrability, (2) fission-neutron detectability, (3) radial variation of assay sensitivity, (4) axial variation of assay sensitivity, and (5) the variation of detector count rate as a function of the number of fuel rods in a special 61-rod, LMFBR-type subassembly.

The calculational procedures were validated by comparison with experimental measurements, thus permitting further exploration of system performance by means of additional calculations. In this manner, the following system characteristics were investigated: the relative assay sensitivities of various fissile nuclides; the applicability of the system to a wide variety of fuels, either fresh or spent; the effect on assay accuracy of uncertainties in the isotopic abundances in the fuel; and the efficacy of possible methods of determining isotopic abundances in the sample.

**A study of gamma-ray spectroscopy for spent fuel verification at the Bruce CANDU reactors,** J. J. Lipsett, J. C. Irvine, and W. J. Williams, *SP582*, pp. 457-471 (June 1980).

Key words: bonded storage; Bruce reactors; gamma-ray spectroscopy; nuclear safeguards; spent fuel; verification.

A test program was undertaken to establish whether gamma-ray spectroscopy could be used to verify that fuel bundles from the Bruce NGS reactors have been irradiated before they are placed in long-term bonded storage. The verification would be done while the fuel bundles are in transit, and in motion. The fuel-transfer conditions were simulated in the storage bay of the NRU reactor at the Chalk River Nuclear Laboratories, with irradiated test fuel bundles, and the results, as reported in the paper, demonstrated feasibility of this concept.

**Monte Carlo calculational design of an NDA instrument for the assay of waste products from high enriched uranium spent fuels,** G. W. Eccleston, R. G. Schrandt, J. L. Macdonald, and F. H. Cverna, *SP582*, pp. 472-496 (June 1980).

Key words: assay; contaminated waste; delayed neutrons; Monte Carlo; spent fuel.

The Monte Carlo design of the waste assay region of a dual assay system, to be installed at the Fluorinel and Storage Facility, is described. The instrument will be used by the facility operator to assay high-enriched spent fuel packages and waste solids produced from dissolution of the fuels. The fissile content discharged in the waste is expected to vary between 0 and 400 g of  $^{235}\text{U}$ . Material accountability measurements of the waste must be obtained in the presence of large neutron ( $0.5 \times 10^6$  n/s) and gamma (50 000 R/hr) backgrounds. The assay system employs fast-neutron irradiation of the sample, using a 5 mg  $^{252}\text{Cf}$  source, followed by delayed neutron counting after the source is transferred to storage. Calculations indicate a  $\pm 4$ -

g ( $2\sigma$ ) assay for a waste canister containing 300 g of  $^{235}\text{U}$  is achievable with an end-of-life (1 mg)  $^{252}\text{Cf}$  source and a background rate of  $0.5 \times 10^6$  n/s.

**Spectrophotometric determination of plutonium in irradiated fuels solutions procedures and shielding facilities,** M. C. Bouzou and A. A. Brutus, *SP582*, pp. 497-508 (June 1980).

Key words: irradiated fuels; plutonium; spectrophotometric.

The Cogema Laboratory of Marcoule has developed and widely used a spectrophotometric determination of plutonium in the industrial solutions of the Purex process.

This determination based upon the plutonium VI specific absorption is made according to two variants: direct method and internal standard method (with neodymium nitrate as internal standard).

The two methods are routinely employed throughout the irradiated fuel reprocessing control, whatever the solution's activity, the amount of plutonium and the nature of analysed phase may be.

The performances obtained are given and a description of the "hot equipment" used is made.

**Gamma spectrometric measurements of pressurized water power reactor spent fuel,** V. Kupryashkin, T. Haginoya, V. Poroykov, T. Dragnev, and B. Damjanov, *SP582*, pp. 509-516 (June 1980).

Key words: burn-up; cooling time; Cs-134/Cs-137 ratios; Pu/U; spent fuel; Zr-95/Cs-137.

This report presents the results of gamma spectrometric measurements on spent fuel bundles carried out during a routine inspection at Kozlodui Nuclear Power Station in Bulgaria (PWR-Novovorenezh type) by using portable IAEA equipment. A Ge spectrometer was used to measure gamma spectra in the energy region from 500 to 900 keV. The cooling time was determined from the Zr-95/Cs-137 ratio, and the average burn-up and Pu/U fraction was calculated from Cs-134/Cs-137 ratio.

**Automated tank calibrator,** G. P. Baumgarten, V. Brame, D. G. Cooper, and B. Robertson, *SP582*, pp. 517-533 (June 1980).

Key words: accountability tanks; automated system; diverter correction; turbine meters; volume calibration.

An automated system for remotely calibrating nuclear fuel accountability tanks is described. It uses two turbine meters to measure a quantity of water introduced at up to 40 liters/minute into the tank to be calibrated and records the quantity and the resulting pressure in the tank. A diverter valve, controlled by the computer, directs the flow either into the tank or down a drain. The method of calibrating the turbine meters and determining the correction for the error introduced by the diverter valve is described, and representative data are presented. The turbine and diverter calibration data are referenced by the computer when the system is used to calibrate a tank. The short-term uncertainty in the water volume is  $\pm .02$  percent, which is almost entirely due to the nonrepeatability of the turbine meters. Confidence in the uncertainty figure is retained by measuring the ratio of the two turbine meter frequencies. If the ratio changes by more than .02 percent, the turbine meters can be recalibrated in one day.

**In-tank measurement of solution density,** F. E. Jones, R. M. Schoonover, and J. F. Houser, *SP582*, pp. 534-537 (June 1980).

Key words: accountability tanks; differential pressure; in-tank density determination; nuclear process solutions; solution density.

This paper presents the results of an experiment which



established the feasibility of in-tank determination of the density of nuclear process solutions in the field with an accuracy competitive with the precision claimed for laboratory determinations. The work also provided a calibration factor, with a precision (estimate of the relative standard deviation of the mean) of 2.2 parts in 10,000, which can be used to infer density from differential pressure measurements in the particular accountability tank. The technique eliminates one error in the laboratory determination of density and minimizes another. It also can be used to indicate the homogeneity of the tank solution and thus determine when a sample should be taken for determination of the concentration of nuclear material in the solution.

**Analysis of plutonium and uranium by the resin bead-mass spectrometric method,** R. L. Walker and D. H. Smith, *SP582*, pp. 538-546 (June 1980).

Key words: isotope dilution; mass spectrometry; plutonium; resin bead; safeguards; uranium.

The development of the resin bead method and the techniques employed in its application to isotopic analysis of Pu and U in highly radioactive solutions of spent reactor fuel will be described. The method, developed primarily for safeguards analyses, may also be applied to isotopic measurements for assessing nuclear fuel cycle technology. Satisfactory analyses of both elements can be obtained from a single resin bead when the initial dissolver solution has a U/Pu ratio in the range of 50 to 300. Optimum bead loadings are 1-3 ng Pu and U; these loadings are obtained if the concentration of the solution is adjusted to about 1  $\mu\text{g}$  U per bead before the beads are introduced. Isotopic composition measurements of NBS standards using this technique indicate a precision of  $\pm 0.5\%$  for minor isotopes in the 1% concentration range and  $\pm 0.1\%$  for major isotopes in the 50% range. Analyses of a synthetic dissolver solution give an accuracy for the isotope dilution measurement of Pu and U of  $\leq 0.5\%$  with an internal precision of 0.9% and 0.6% for Pu and U, respectively.

**Demonstration of totally sampled wavelength dispersive XRF for use in the assay of the SNM content of dissolver solutions,** C. R. Hudgens and B. D. Craft, *SP582*, pp. 547-554 (June 1980).

Key words: dissolver solution; slurry analysis; SNM assay; solution analysis; total sampling; x-ray fluorescence analysis.

X-ray fluorescence analysis of simulated SNM in solution was demonstrated, using totally sampled, continuously recirculated solutions, some of which contained slurried analyt and dense matrix. The total sampling system contributed no identifiable variation to the data, and the slurried matter, at particle sizes of 20 micrometers or less, contributed no systematic error. Continuous recirculation also removes photolytically produced gas, and maintains homogeneity of the solution or slurry.

**Study of a two-detector method for measuring plutonium isotopes,** J. G. Fleissner, J. F. Lemming, and J. Y. Jarvis, *SP582*, pp. 555-567 (June 1980).

Key words: gamma-ray spectrometry; nondestructive isotopic analysis; plutonium safeguards.

A technique to improve the timeliness and accuracy of Pu isotopic measurements for bulk samples has been studied. The technique utilizes two Ge detectors to simultaneously assay different energy regions of the Pu gamma-ray spectrum. Isotopic ratios are determined from the areas of close lying peak pairs. Factors determining the choice of these peak pairs for the total isotopic measurement are discussed. The technique has been tested on samples of varying mass, burnup, isotopic content, age, and chemical

composition.

**Gamma ray NDA assay system for total plutonium and isotopes in plutonium product solutions,** L. R. Cowder, S. T. Hsue, S. S. Johnson, J. L. Parker, P. A. Russo, J. K. Sprinkle, Y. Asakura, T. Fukuda, and I. Kondo, *SP582*, pp. 568-583 (June 1980).

Key words: densitometry; gamma-ray NDA; product solutions; reprocessing; transmission-corrected gamma-ray assay.

A LASL-designed gamma-ray NDA instrument for assay of total plutonium and isotopes of product solutions at Tokai-Mura is currently installed and operating. The instrument is, optimally, a densitometer that uses radioisotopic sources for total plutonium measurements at the K absorption edge. The measured transmissions of additional gamma-ray lines from the same radioisotopic sources are used to correct for self-attenuation of passive gamma rays from plutonium. The corrected passive data give the plutonium isotopic content of freshly separated to moderately aged solutions. This off-line instrument is fully automated under computer control, with the exception of sample positioning, and operates routinely in a mode designed for measurement control. A one-half percent precision in total plutonium concentration is achieved with a 15-minute measurement.

**Nondestructive, energy-dispersive, x-ray fluorescence analysis of product stream concentrations from reprocessed nuclear fuels,** D. C. Camp and W. D. Ruhter, *SP582*, pp. 584-601 (June 1980).

Key words: accountability; computer-based system; dynamic concentration measurements; inventory control; nondestructive measurements; on-line real-time measurements; plutonium concentration and isotopes determinations; reprocessing plant process control; uranium; x-ray fluorescence analysis.

Energy-dispersive x-ray fluorescence analysis (XRFA) can be used to measure nondestructively pure and mixed U/Pu concentrations in process streams and hold tank solutions. The 122-keV gamma ray from  $^{57}\text{Co}$  excites the actinide K x rays which are detected by a HPGe detector. A computer- and disk-based analyzer system provides capability for making on-stream analyses, and the noninvasive measurement is easily adapted directly to appropriate sized pipes used in a chemical reprocessing plant. Measurement times depend on concentration and purpose but vary from 100s to 500s for process control of strong to weak solutions. Accountability measurements require better accuracy thus more time; and for solutions containing plutonium, require a measurement of the solution radioactivity made with an automatic shutter that eclipses the two exciting sources. Plutonium isotopic abundances can also be obtained. Concentrations in single or dual element solutions from less than 1 g/l to over 200 g/l are determined to an accuracy of 0.2% after calibration of the system. For mixed solutions the unknown ratio of U to Pu is linearly related to the net U/Pu K x-ray intensities. Concentrating values for ratios different than the calibration ratio require only small corrections to the values derived from a calibration polynomial. Minor fission product contamination does not prevent concentration determinations by XRFA. The computer-based system also allows real-time dynamic concentration measurements to be made.

**Experimental U-233 nondestructive assay with a random driver,** P. Goris, *SP582*, pp. 602-616 (June 1980).

Key words: random coincidence corrections; U-233 decay chain.



Nondestructive assay (NDA) of U-233 in quantities up to 15 grams containing 7 ppm U-232 age 2 years was investigated with a random driver. A passive singles counting technique showed a reproducibility within 0.2% at the 95% confidence level. This technique would be applicable throughout a process in which all of the U-233 had the same U-232 content at the same age. Where the U-232 content varies, determination of U-233 fissile content would require active NDA. Active coincidence counting utilizing a Pu-238, Li neutron source and a plastic scintillator detector system showed a reproducibility limit within 15% at the 95% confidence limit. The active technique was found to be very dependent on the detector system resolving time in order to make proper random coincidence corrections associated with the high gamma activity from the U-232 decay chain.

**Measurement of plutonium and americium in molten salt residues,** F. X. Haas, J. L. Lawless, W. E. Herren, and M. E. Hughes, *SP582*, pp. 617-621 (June 1980).

**Key words:** americium; nondestructive assay; nuclear safeguards; plutonium; waste assay.

The measurement of plutonium and americium in molten salt residues using a segmented gamma-ray scanning device is described. This system was calibrated using artificially fabricated as well as process generated samples. All samples were calorimetered and the americium to plutonium content of the samples determined by gamma-ray spectroscopy. For the nine samples calorimetered thus far, no significant biases are present in the comparison of the segmented gamma-ray assay and the calorimetric assay. Estimated errors are of the 10 percent and is dependent on the americium to plutonium ratio determination.

**Uranium and plutonium assay of crated waste by gamma ray, singles neutron, and slow neutron coincidence counting,** R. A. Harlan, *SP582*, pp. 622-632 (June 1980).

**Key words:** counter; estimates; gamma rays; neutrons; non-destructive assay; plutonium waste; safeguards; uranium waste; verification.

Nuclear counting techniques were applied to plutonium contaminated waste in 4-ft by 4-ft by 7-ft wooden crates sealed with a fire retardant polyester plus fiberglass overcoat. The counting systems were proven to be useful for safeguards verification measurements and to some extent for accountability measurements. Neutron and gamma ray measurements both are recommended. The latter serve to double check the neutron results and provide a capability for estimating uranium and other radionuclides that may be in the waste but that do not emit usable amounts of neutrons. About 5 grams (g) of plutonium or uranium can be detected in 20 minutes.

**Evaluation of an LIII x-ray absorption-edge densitometer for assay of mixed uranium-plutonium solutions,** W. C. Mosley, M. C. Thompson, and L. W. Reynolds, *SP582*, pp. 633-650 (June 1980).

**Key words:** densitometer evaluation; uranium and plutonium solutions assay; x-ray absorption-edge densitometry.

An LIII x-ray absorption-edge densitometer (XRAED), designed and built at Los Alamos Scientific Laboratory, has been evaluated at Savannah River Laboratory for the assay of uranium and plutonium in process solutions. For 2000-second data collection, the precisions (95% confidence level) for uranium assays varied  $\pm 1.04\%$  at 10 g of uranium per liter to  $0.34\%$  at 45 g/L, and plutonium assays varied from  $\pm 6.7\%$  at 2 g of plutonium per liter to  $\pm 2.2\%$  at 10 g/L. Hydroxylamine nitrate, a reducing agent used in solvent extraction tests, affect the accuracies of

both uranium and plutonium assay by densitometry, and plutonium analysis by coulometry. It appears that the XRAED could be used to control the SRL miniature mixer-settlers, but additional testing will be needed to demonstrate that XRAED accuracy is sufficient for accountability of special nuclear materials.

**The goals of measurement systems for international safeguards,** J. M. de Montmollin and E. V. Weinstock, *SP582*, pp. 651-669 (June 1980).

**Key words:** International Atomic Energy Agency; international safeguards; safeguards objective; safeguards performance criteria.

The safeguards applied by the International Atomic Energy Agency are based on technical performance goals and criteria that have been developed, but not officially adopted by the Agency. The goals derive in part from the external consequences that safeguards are intended to prevent and in some cases on internal considerations of feasibility. To the extent that these goals may not be attainable, as may be the case with large-throughput bulk reprocessing plants, the Agency is placed in a difficult position. In this paper safeguards goals and criteria and their underlying rationales are critically examined. Suggestions for a more rational and workable structure of performance goals are offered.

**The evolution of safeguards systems design,** J. P. Shipley, E. L. Christensen, and R. J. Dietz, *SP582*, pp. 670-676 (June 1980).

**Key words:** detection; deterrence; diversion of nuclear energy; evolution; safeguards performance criteria; safeguards systems; safeguards technology.

Safeguards systems play a vital detection and deterrence role in current nonproliferation policy. These safeguards systems have developed over the past three decades through the evolution of three essential components: the safeguards/process interface, safeguards performance criteria, and the technology necessary to support effective safeguards. This paper discusses the background and history of this evolutionary process, its major developments and status, and the future direction of safeguards system design.

**Monte Carlo simulation of MUF distribution for application to Euratom safeguards,** F. Argentesi and M. Franklin, *SP582*, pp. 677-689 (June 1980).

**Key words:** Euratom safeguards; MUF simulation; MUF statistical inference.

A statistical material accountancy system (NUMSAS) has been developed by the Joint Research Centre. This system is designed for implementation within the framework of Euratom Safeguards. As well as developing NUMSAS, the J.R.C. has developed a computer code to provide a Monte Carlo simulation of the activity of NUMSAS. This simulation code is being used to study the statistical properties of MUF and MUF variance as estimated by NUMSAS. This paper presents simulation results describing the propagation of skewness through a set of plant accounts. It also illustrates the effect of skewness on detection and false alarm probabilities.

**Sensitivity analysis of a material balance declaration with respect to measurement error sources,** F. Argentesi and G. R. Cullington, *SP582*, pp. 690-701 (June 1980).

**Key words:** material balance declaration; measurement error sources; sensitivity analysis.

A sensitivity analysis of the variance of MUF, with respect to the basic statistical properties, in terms of variances



for random and systematic errors of the measurement system's components, has been performed for an actual material balance of a high enriched uranium fabrication plant. The material balance considered in this study contains several thousand batches.

**Deviations from mass transfer equilibrium and mathematical modeling of mixer-settler contactors,** A. L. Beyerlein, J. F. Geldard, H. F. Chung, and J. E. Bennett, *SP582*, pp. 702-711 (June 1980).

Key words: chemical contactors; mass transfer equilibrium; mass transfer rates; mathematical models; mixer-settlers; plutonium holdup; uranium holdup.

This paper presents the mathematical basis for the computer model PUBG of mixer-settler contactors which accounts for deviations from mass transfer equilibrium. This is accomplished by formulating the mass balance equations for the mixers such that the mass transfer rate of nuclear materials between the aqueous and organic phases is accounted for. Mass transfer equilibrium or SEPHIS limit can be achieved with this model in the limit of a large mass transfer area between the two phases. Concentration profiles calculated with PUBG in the SEPHIS limit agree with those calculated using SEPHIS-MOD3 or -MOD4. (For a description of SEPHIS models see S. B. Watson and R. H. Rainey, "Modifications of the SEPHIS Computer Code for Calculating the Purex Solvent Extraction System," ORNL-TM-5123, Dec. 1975 and A. D. Mitchell, "A Comparison Between SEPHIS-MOD4 and Previous Models for the Purex Solvent Extraction System," ORNL-TM-6565, Feb. 1979). Comparisons with Thompson and Shankle's measured uranium concentration profiles (M. C. Thompson and R. L. Shankle, "Calculation of Uranium Inventories in Mixer-Settlers During Solvent Extraction with 7.5% TBP," Savannah River Laboratory, DP 1357, August 1974) on the 1D and 1E contactors indicated good agreement between PUBG calculations and measured data is obtained by adjustment of the mass transfer area to values which indicate there are significant deviations from mass transfer equilibrium. PUBG calculations in the SEPHIS limit on the 1D and 1E contactors predict a steady state uranium holdup that is 10.8% and 16.3% lower, respectively, than the experimental values. This is consistent with the expectation that deviations from equilibrium will lower the efficiency of the contactor and increase its nuclear material holdup.

**Dynamic materials accounting for solvent-extraction systems,** D. D. Cobb and C. A. Ostenak, *SP582*, pp. 712-717 (June 1980).

Key words: chemical modeling; dynamic materials accounting; in-process inventory; solvent-extraction contactors.

Methods for estimating nuclear materials inventories in solvent-extraction contactors are being developed. These methods employ chemical models and available process measurements. Comparisons of model calculations and experimental data for mixer-settlers and pulsed columns indicate that this approach should be adequate for effective near-real-time materials accounting in nuclear fuels reprocessing plants.

**Materials accounting considerations for international safeguards in a light-water reactor fuels reprocessing plant,** E. A. Hakkila, D. D. Cobb, H. A. Dayem, R. J. Dietz, E. A. Kern, and J. P. Shipley, *SP582*, pp. 718-729 (June 1980).

Key words: dynamic accounting; fuel reprocessing; nuclear safeguards.

This paper summarizes the requirements and functions of materials measurement and accounting systems applicable to large (1500 metric tonnes heavy metal per year—

MTHM/yr) future reprocessing facilities as well as small (210 MTHM/yr) plants that are presently under IAEA safeguards. The effectiveness of conventional and proposed improved measurement and accounting systems were compared using modeling, simulation, and analysis procedures. The study showed that conventional accountability can meet IAEA goal quantities and detection times in these reference facilities only for low-enriched uranium. Dynamic materials accounting may meet IAEA goals for detecting abrupt (1-3 wks) diversion of 8 kg of plutonium. Current or projected techniques cannot meet the one year protracted diversion goal for plutonium if this goal is based on an absolute 8 kg quantity.

**Study of the application of semi-dynamic material control concept to safeguarding spent fuel reprocessing plants,** K. Ikawa, H. Ihara, H. Nishimura, M. Hirata, H. Sakuragi, M. Iwanaga, N. Suyama, and K. I. Matsumoto, *SP582*, pp. 730-739 (June 1980).

Key words: diversion sensitivity; reprocessing facilities; semi-dynamic material control.

This report presents a result of the feasibility study of the application of the dynamic material control concept to existing small spent fuel reprocessing facilities, using the Tokai Reprocessing Plant as a model. A semi-dynamic material accounting and control system was examined corresponding to the detection time of ten days. This accounting system would be achieved by weekly measured material balances with a maximum delay of three days for analyses. Comparative studies of diversion sensitivity suggest that such a system could be meet control objectives currently discussed relating to the quantitative sensitivity and timeliness. The proposed system uses existing plant instrumentations and capabilities of the laboratory, and therefore it could be back-fitted to the existing small facilities.

**Safeguards system of backend facilities with emphasis on waste management,** Y. Akimoto, T. Ishii, S. Yamagami, and T. Shibata, *SP582*, pp. 740-749 (June 1980).

Key words: backend facilities; containment and surveillance; detection probability; evaluation of safeguards effectiveness; waste management.

Safeguards system for the collocated backend facilities is discussed. According to the assessment using evaluation function for CS (containment and surveillance) and MA (material accountancy), proposed here, CS should play a very important role to increase the safeguards effectiveness for the industrial scale facilities. Diversion of nuclear material through an abnormal route can be avoided by multiple devices of CS, installed to every possible diversion path along the nuclear material flows. Nuclear materials, shipped or received at each facility, should be itemized as much as possible, so that CS may effectively complement the function of MA. For a section recovering plutonium from dirty scrap and  $\alpha$  waste, an independent MBA is recommended to be set up with enhanced safeguards system.

**SP583. Hydraulic research in the United States and Canada,** 1978, P. H. Gurewitz, *Nat. Bur. Stand. (U.S.), Spec. Publ. 583*, 397 pages (Oct. 1980) SN003-003-02247-1.

Key words: fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1977-1978 are summarized. Projects from more than 200 university, industrial, state and Federal Government laboratories in the United States and Canada are reported.

**SP584. Joint Conference on Measurements and Standards for Recycled Oil/Systems Performance and Durability.** Proceedings of a Conference held at the National Bureau of Standards, Gaithersburg, MD, Oct. 23-26, 1979, D. A. Becker, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 584*, 333 pages (Nov. 1980) SN003-003-02272-1.

Key words: engine oil; hydraulic oil; industrial oil; lubricating oil; oil specifications; petroleum standards; petroleum test methods; recycled oil; re-refined oil; used oil; waste oil.

This publication is a formal report of the Joint Conference on Measurements and Standards for Recycled Oil/Systems Performance and Durability held at the National Bureau of Standards on October 23 through 26, 1979. There were seven sessions on specific subject areas, with a total of 32 technical presentations. The subject areas were as follows: (I) Recent Developments in Recycled Oil, (II) Engine Oil Evaluation, (III) Lube Oil Basestock Characterization, (IV) Oil Analysis for Engine Condition Monitoring, (V) Bench Tests for Oil Evaluation—I, (VI) Bench Tests for Oil Evaluation—II, (VII) Systems Performance and Durability. Included in this report are the entire texts of the various presentations, including figures and tables. *These proceedings include the following papers (indented):*

**Activities of the National Association of Oil Recovery Coordinators,** D. Eastep, *SP584*, pp. 15-16 (Nov. 1980).

**The Maryland Oil Recycling Legislation,** C. Wiley and D. Phillips, *SP584*, pp. 17-23 (Nov. 1980).

**Re-refining oil in India,** M. Bhargava, *SP584*, pp. 25-33 (Nov. 1980).

**Re-refining waste oils: Improving acid/clay treatment by using acid sludges as an additional fuel in cement kilns,** A. Rollin and L. Estaque, *SP584*, pp. 35-48 (Nov. 1980).

**Status of the MIL-L-46152A engine oil specification,** T. Bowen, *SP584*, pp. 51-54 (Nov. 1980).

**Field test of re-refined automobile engine oil in RCMP vehicles,** J. Armstrong, *SP584*, pp. 55-67 (Nov. 1980).

**PROP re-refined oil engine test performance,** R. Linnard, *SP584*, pp. 69-74 (Nov. 1980).

**Historical perspective of lubricant deposit evaluations at Southwest Research Institute,** J. Bowden and S. J. Lestz, *SP584*, pp. 75-95 (Nov. 1980).

**Current activities of the National Bureau of Standards recycled oil program,** D. Becker, *SP584*, pp. 97-102 (Nov. 1980).

**ASTM/NBS base stock consistency study,** K. Frassa, *SP584*, pp. 105-107 (Nov. 1980).

**Properties of Canadian re-refined base oils,** P. Strigner, *SP584*, pp. 109-122 (Nov. 1980).

**Association of petroleum re-refiners standards for re-refined base oils,** R. Pedall, *SP584*, pp. 123-125 (Nov. 1980).

**The viscometric requirements for re-refined engine oils,** T. Selby, *SP584*, pp. 127-138 (Nov. 1980).

**Comments from a producer of virgin base oil,** D. Espey, *SP584*, pp. 139-140 (Nov. 1980).

**Characterization of lubricating base stocks for automotive crankcase oils,** S. Hsu, *SP584*, pp. 141-155 (Nov. 1980).

**Wear particle equilibrium measurements and their significance,** R. D. Driver and E. R. Bowen, *SP584*, pp. 159-165 (Nov. 1980).

**Used oil analysis: Past, present, and future,** C. Schwarz,

*SP584*, pp. 167-171 (Nov. 1980).

**Wear particle analysis from grease-lubricated bearings,** W. Rosenlieb, *SP584*, pp. 173-182 (Nov. 1980).

**Engine condition defined by oil analysis,** C. Salvesen, *SP584*, pp. 183-189 (Nov. 1980).

**Engine oil evaluation through bench testing,** S. Hsu, *SP584*, pp. 191-204 (Nov. 1980).

**Development of the Army thermal oxidation lube oil tester,** M. Valtierra and S. Lestz, *SP584*, pp. 205-219 (Nov. 1980).

**Predictive test method for coking and fouling tendency of used lubricating oil,** G. Steele, D. Brinkman, and M. Whisman, *SP584*, pp. 221-225 (Nov. 1980).

**Antioxidant consumption and oxidative degradation of lubricants,** S. Korcek, L. Mahoney, M. Johnson, and K. Otto, *SP584*, pp. 227-235 (Nov. 1980).

**Application of the antioxidant capacity test to re-refined and virgin base stock oils,** R. Rebbert, *SP584*, pp. 237-242 (Nov. 1980).

**Pin-and-V-block and ring-and-block bench wear tests for engine oil evaluation,** L. Ives and P. Boyer, *SP584*, pp. 245-259 (Nov. 1980).

**The four-ball wear test for engine oil evaluation,** R. Gates and S. Hsu, *SP584*, pp. 261-270 (Nov. 1980).

**Application of differential scanning calorimetry to the characterization of lube oils,** J. Walker and W. Tsang, *SP584*, pp. 271-284 (Nov. 1980).

**Evaluation of basestock and formulated lubes using the Penn State microoxidation test,** E. Klaus, V. Krishnamachar, and H. Dang, *SP584*, pp. 285-294 (Nov. 1980).

**Determination of polychlorinated biphenyls in waste and lubricating oils,** S. Chesler, W. May, P. White, R. Parris, and F. Guenther, *SP584*, pp. 295-299 (Nov. 1980).

**Lubricant factors in rolling contact fatigue,** C. Rowe, *SP584*, pp. 301-312 (Nov. 1980).

**The relationship between viscometric laboratory measurements and field performance and service,** T. Selby, *SP584*, pp. 313-328 (Nov. 1980).

**System health monitoring through wear particle analysis,** P. Senholzi, *SP584*, pp. 329-338 (Nov. 1980).

**Mechanical failures and lubrication performance,** M. Peterson, *SP584*, pp. 339-343 (Nov. 1980).

**SP585. Fire and life safety for the handicapped.** Reports of the Conference on Fire Safety for the Handicapped held at the National Bureau of Standards, Nov. 26-29, 1979, B. M. Levin, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 585*, 154 pages (July 1980) SN003-003-02210-1.

Key words: building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge.

On November 26-29, 1979, the National Bureau of Standards hosted a Conference on Fire Safety for the Handicapped where 80 experts discussed the problems of the handicapped in fire emergencies, safety procedures, and hardware that upgrades their safety. The major work of the conference was conducted by seven panels that met in parallel: overview, alarm systems, refuge, egress, self-protection, management actions, and emergency service actions.



Six workshops were held in preparation for the conference during August and September 1979 in the area of life safety for the handicapped in emergencies. The workshops were: codes and standards, emergency preparedness planning, building design, education, consumer interests, and products. Each of the 13 panels and workshops prepared a report containing background information and the recommendations of the panels. This document contains the 13 reports, the speeches at plenary sessions and supplementary comments by some of the participants.

**SP586. Research and innovation in the building regulatory process.** Proceedings of the Fourth NBS/NCSBCS Joint Conference held in St. Louis, MO, on Sept. 11, 1979, in conjunction with the Twelfth Annual Meeting of the National Conference of States on Building Codes and Standards (NCSBCS), Inc., S. A. Berry, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 586*, 261 pages (June 1980) SN003-003-02212-8.

**Key words:** building code enforcement; buildings; design; energy conservation; housing codes; regulatory approaches.

The Proceedings of the 4th Annual NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process contain nineteen technical papers, the opening remarks and Keynote Address. The subject matter covered in these Proceedings includes: Issues in Building Code Enforcement; Legal, Political and Educational Aspects of Code Enforcement; Studies Dealing with Housing Codes; Energy Conservation and the Built Environment; Design Considerations and Their Impact on Code Enforcement; and, Innovative Regulatory Approaches for Metrication, Insulation Standards, and Climatic Conditions. *These proceedings include the following papers (indented):*

**Development fee schedule survey**, D. D. Fontaine and D. M. Coffey, *SP586*, pp. 13-16 (June 1980).

**Key words:** affordable housing; development fee; planning cost; Proposition 13.

**Criterion for the thermal insulation quality of a building**, J. Uyttenbroeck, *SP586*, pp. 19-31 (June 1980).

**Key words:** heat loss; standard; thermal insulation; U-value.

In an effort to conserve energy in Belgium, the Belgian Standardization Institute has published a draft of a proposed standard for thermal insulation of a building. The concept and methodology is described in this paper.

The global thermal insulation value,  $U_m$ , varies as a function of the ratio of volume of the building to the exposed area of the building ( $V/A$ ). The relationships are simple and the implementation, through legislation and enforcement, is relatively straight-forward.

**A report—Indiana building code enforcement survey 1979**, D. L. Bills, *SP586*, pp. 33-42 (June 1980).

**Key words:** building departments; building inspection; code administration; Indiana building code enforcement; local government; political appointments; survey of local building departments.

This survey of Indiana cities, towns, and counties was undertaken by the Division of Code Enforcement of the Indiana Administrative Building Council. Its purpose was to determine the status and effectiveness of local building code administration and enforcement agencies. Its findings will be used to provide guidance and priority to state level programs to encourage the development and advancement of local building regulatory agencies, which is a statutory mission of the Division.

The survey measured manpower resources and productivity; inspection frequency; building permit fees; inspector

training, and the status of local ordinances pertaining to adoption of the statewide building code, establishment of building departments, and regulation of unsafe buildings.

The survey results depict the condition of statewide building regulation in a rural, small community environment with traditional political influence on local governmental operations and services.

**Legal relations and considerations for code officials and design professionals**, J. R. Groves, Jr., *SP586*, pp. 45-57 (June 1980).

**Key words:** appeals process; architect; certification; checklists; code official; consultant; engineer; equivalent life safety; municipal attorney; product endorsement; professional liability; variances.

In the last several years, the number of statutes, ordinances, and the volume of case law affecting architects and engineers has increased dramatically. The changing legal responsibilities of architects and engineers has been a matter of great concern to individuals in those professions. Professional liability insurance, negligence, statutes of limitation, reasonable care, duty, contract relationships, and numerous other subjects have moved to the forefront of continuing education efforts for registered design professionals. During this process, code officials as well have found themselves increasingly involved with sometimes complex legal considerations. Code officials, in particular, have moved out of the shelter of freedom from liability based on government immunity into a legal posture in some ways similar to that of design professionals. This has been intensified by the often overlapping relationship between registered design professionals and code officials in the administration of a variety of codes.

In the past, programs and articles on this subject have often taken an approach of admonishment rather than education. Code officials and design professionals have been told that caution and self-protection are emerging as the basis for the conduct of day-to-day affairs. This concept has been further supported with numerous cases and incidents involving property damage, personal injury or death and resulting in the legal determination of extremely large monetary judgments. While this process may have a dramatic impact, it often ignores the need to continue a normal professional relationship placing basic competency as the fundamental principle directing those concerned. Certainly lawsuits illustrating a variety of problems confronting both design professionals and building officials will continue. The notion, however, the judgment, common sense and risk can or should be eliminated from the construction and code administration process is in practice unrealistic. The legal education of parties to the process cannot seek to eliminate every possible misfortune which could befall those involved. To attempt to do so would cause the entire process to grind to a halt.

Based on the premise that scare tactics are not the appropriate vehicle for the legal education of code officials and design professionals, this paper will proceed to discuss a number of current legal developments of interest to both. The goal will be to help in establishing prudent but sensible ways of discharging professional obligations and enforcing laws, codes and ordinances in a manageable and professional manner. Inherent in the process will be the translation of basic legal concepts into workable professional practice techniques and procedures.

**The effects of civil service, unions, statutory law and economics on systems development in municipal regulatory agencies**, N. S. Remmer, *SP586*, pp. 59-70 (June 1980).

**Key words:** civil service; code administration agencies; idealized system; reorganization.



In 1973, the City Council of Worcester, Massachusetts voted to create a new Department of Code Inspection which would incorporate all the responsibilities for administration and enforcement of code and regulatory activities in the City in one Department under one administrative head.

The initial concept was to include building and trade inspection, construction inspection, zoning, housing, fire prevention, weights and measures, environmental inspection, subdivision, license board and license commission inspections.

The plan was to proceed forward in three phases: 1. The immediate incorporation of building, zoning and housing responsibilities into the new department from the department of public works and department of public health, respectively. 2. The integration of administrative processes for the building, housing and zoning responsibilities and the development of necessary procedures for the incorporation of the additional functions and responsibilities. 3. The incorporation of the additional functions and responsibilities over a period of time and systematic development of the administrative programs for integrating the functions.

It became apparent early in the process that the ability to pass home rule ordinances had no relationship with the ability to implement the ordinance due to union considerations, civil service requirements and over-riding statutory requirements. The attempted implementation of an idealized system of management and organization required many modifications and trade-offs to try to accommodate the constraints of law, budget and time which developed. Even the determination of the sequence of many of the steps became a crucial factor in trying to organize such an integrated regulatory system.

While the process is still continuing, the lessons already learned about the limitations imposed on the creation of an idealized system are important, and the questions for the future of such efforts, especially in Massachusetts and states with similar situations are important to consider.

**Licensing of building code officials: The educational requirements,** K. Albert, *SP586*, pp. 71-83 (June 1980).

Key words: building codes; building inspectors; code enforcement; course development; educational requirements; inspection; licensing; testing; training code officials.

The State of New Jersey has recently adopted a statewide body of regulations known as the "New Jersey Uniform Construction Code." The code is designed to achieve innovation and economy in building construction and uniformity of standards throughout the State.

A unique set of standards and procedures for licensing code enforcement officials has been established along with the adoption of existing recognized standards as subcodes. The first part of this paper focuses on the problems associated with the development and the regulation of the specialized courses for building inspectors and code administrators which have been developed and implemented to meet the educational standards established by the code. The broader issues of licensing code officials and the establishment of educational criteria are discussed.

The second part of the paper proposes a model program for the implementation of the education component of the certification process.

**Housing standards: Objectives and agendas,** D. L. Schodek, *SP586*, pp. 87-102 (June 1980).

Key words: building regulations; housing policies; housing standards; minimum property standards.

Housing standards imply a set of values and objectives that are rarely made explicit. In addition to stated goals of health and safety, standards also implement certain national

policies and agendas relating to social planning. The nature of these objectives and their influence on the formulation of housing standards form the subject of this paper.

The paper traces the general development of national housing policies in the United States and briefly highlights those in other countries. It is argued that space and usability standards promote housing types responsive only to a limited set of biased objectives and mitigate against the development of housing responses to a broader range of lifestyles, cultural values and climatic conditions.

**Housing standards: Their derivation and rationale,** U. P. Gauchat, *SP586*, pp. 103-115 (June 1980).

Key words: equivalency; housing standards; minimum standards; space standards.

The quality of housing is mandated by minimum standards. The standards are based on egalitarian principles and on the assumption that housing anywhere in the United States would meet certain norms. Space standards, in particular, imply social planning objectives which apply throughout the country regardless of location, climate, or user group. These standards, perhaps unwittingly, promote the notion of an "American House."

Although fair in the sense of providing equality, the present system does not allow an adequate range of responses to different lifestyles and cultural backgrounds. It is the purpose of this paper to propose housing solutions that more adequately reflect regional characteristics and personal predilections. The proposals are based on the premise that housing standards should be based on the notion of equivalency rather than equality.

This paper first examines the key determinants of quality in housing; then analyzes the effects of current property standards; and finally, suggests modifications that would render housing standards more responsive and flexible.

**Comparative analysis of provisions in housing codes and rehabilitation guides,** P. W. Cooke, *SP586*, pp. 117-133 (June 1980).

Key words: code provisions; comparison; existing buildings; housing codes; model codes; performance levels; regulations; rehabilitation.

The performance levels of existing buildings generally do not comply with the standards for safety or function that are required of new buildings. To have a solid base for regulatory authorities and others to use in establishing minimum requirements pertaining to life safety and health issues pertinent to the reuse of existing buildings and to assure an adequate level of acceptance in terms of the traditional intent of codes, it is essential to have a good understanding of the regulatory provisions for codes currently in place that address occupancy, maintenance and rehabilitation.

This paper highlights some of the more explicit comparisons that were available from a comprehensive analysis of the content of seven code documents that relate exclusively to the occupancy, maintenance or rehabilitation of existing residential buildings. This sampling of detailed comparisons indicates some of the inconsistencies among code documents with respect to uniformity as well as non-scientific approaches taken in the development of code provisions.

**Problems in housing code enforcement: A focus on the budget,** C. B. Meeks, *SP586*, pp. 135-148 (June 1980).

Key words: budgets; economic analysis; enforcement; housing codes; personnel.

A housing code is one option available to communities concerned with maintenance of housing quality. Housing code administrators in New York State identified lack of financial and human resources as two key problems in code



enforcement.

Primary attention in this paper is given to analysis of community housing code budgets which varied considerably among communities.

In a log-log regression equation, the size of per capita housing code budgets was significantly influenced by the number of housing code inspections conducted, the percent of revenues obtained from property taxes and the percent of owner occupied housing.

Practitioners can compare the results with their own situation.

**Development and evaluation of solar standards and criteria, R. D. Dikkers, *SP586*, pp. 151-160 (June 1980).**

**Key words:** buildings; cooling; durability/reliability; performance criteria; safety; solar collectors; solar energy; standards; thermal performance.

Many organizations, including the National Bureau of Standards (NBS), American Society of Heating, Refrigerating and Air-Conditioning Engineers and the American Society for Testing and Materials, have been very active during the past several years carrying out activities relating to the development of standards and performance criteria for solar heating and cooling applications. This paper, which describes various activities and accomplishments to date pertaining to the development and evaluation of solar heating and cooling standards and criteria, updates previous information presented by the author at the First NBS/NCSBCS Joint Conference held in 1976.

**Thermal mass effects in log homes, W. Magruder and S. Winter, *SP586*, pp. 161-179 (June 1980).**

**Key words:** BLAST; effective U-value; heat capacity; log home; mass factor; thermal mass;  $\Delta R$  effect.

To improve thermal standards for log homes, certain adjustment factors must be established to account for the effects of thermal mass. Alternative definitions for these factors are presented as the "mass factor" and the " $\Delta R$  effect." These factors will be a function of at least six parameters, which are discussed here in terms of their relevance to log homes. The six parameters of concern are wall mass, wall color, location of mass, air infiltration, HVAC set-point schedule, and climate. The paper concludes with a summary of the results of a BLAST computer analysis of a log home in Des Moines.

**Analysis of code related responses from the solar demonstration program, J. Greenberg, *SP586*, pp. 181-185 (June 1980).**

**Key words:** building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy.

This paper is based on a report prepared jointly for the Department of Housing and Urban Development (HUD) and the Department of Energy (DoE) under activities carried out by the National Bureau of Standards (NBS) relative to the Solar Heating and Cooling Demonstration Program. The report documents and analyzes building regulatory information gathered by HUD Contractor personnel during the course of the Solar Residential Demonstration Program—from inception of the program (late 1975) through September 30, 1978.

Although not all builders and local code officials participating in the demonstration program were interviewed for the study, the total number of participants interviewed was of sufficient size to postulate trends and draw reasonable conclusions regarding the building regulatory aspects of the program. The report concludes that existing codes do not present a barrier to the installation and acceptance of solar systems; however, code officials need additional training

and better back-up material to properly evaluate solar systems.

This paper summarizes and presents the major findings included in the report.

**Contracting for value management during design, D. E. Parker, *SP586*, pp. 189-196 (June 1980).**

**Key words:** economic analysis; life cycle cost; value management; value study.

This paper describes the content and application of the General Services Administration (GSA) Value Management (VM) Program requirements incorporated by regulation in all architect-engineer (A-E) contracts.

The objective of this VM Program is to control the cost of construction by performing VM studies at various points in the design process with the objective of recommending changes to design work in progress.

The VM process requires the understanding and agreement of two parties—the client and the designer. VM study forces the enhancement of communication between these two parties. It provides the freedom to challenge codes, criteria, needs, desires, and specifications in a professional atmosphere.

Because the economic measure of value is life cycle cost, the program controls life cycle cost as well as initial cost. Thus, it has been effective in reducing maintenance and energy cost in addition to ensuring the project budget is met.

Required VM service design contracts can be expected to provide an average \$10 return for every dollar invested in cost of the service.

**Building recertification and Dade County, Florida, R. Warburton, *SP586*, pp. 197-203 (June 1980).**

**Key words:** architects; codes; earthquake; engineers; Florida; inspection; legislation; recertification.

One of the major problems in maintaining environmental quality is the need for continual routine monitoring of existing private-sector construction to ensure structural integrity over time. Dade County, Florida has an operating ordinance which provides a model deserving significant consideration in this regard, so that extensive loss of life and property can be minimized.

On May 21, 1975, the Dade County, Florida Commission adopted Ordinance 75-34, providing for routine examination by private-sector architects and engineers of structures over 40 years old (and re-examination at 10 year intervals thereafter) to verify their continued eligibility for a Certificate of Occupancy. The ordinance covers all private-sector buildings providing facilities for over 10 persons and having over 2,000 sq. ft. of floor area, except for 1 and 2 family residential structures.

At present, about 6,000 buildings have felt the effects of this ordinance, with about 75% receiving immediate recertification and about 10% requiring enforcement measures. Buildings are currently coming under the ordinance provisions at the rate of about 700 per year.

Evaluation of potential generic issues, considering the program development to date, indicates no serious defects in the program and the immense benefits to the public from such an ordinance covering private-sector buildings.

In fact, the Dade County Ordinance presents a model worthy of national attention and adoption as appropriate as part of new state/local building code legislation as well as through revisions to professional established standards and policies.

**Computer-aided design review: Predicting the emergency egress potential of proposed buildings, F. I. Stahl, *SP586*, pp. 205-224 (June 1980).**



**Key words:** building codes; building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation.

This paper discusses the potential use of computer simulation techniques by building code officials, as tools which aid in the prediction of building performance. As a case in point, the BFIRE program for simulating emergency egress during building fires, developed at NBS, is presented. The program is described from the user's viewpoint, and a specific example of its application in assessing building design is treated.

**Metrication—An opportunity for the harmonization of American building codes,** H. J. Milton, *SP586*, pp. 227-251 (June 1980).

**Key words:** building codes; conversion strategies; harmonization; metrication; metric transition.

The merits of more harmonious building codes have been debated for many years, receiving support from professional groups, manufacturers, contractors, and other sectors of the construction community. But it has always been difficult to make drastic changes to the status quo, although the variety of building and associated codes has been narrowed gradually by the model codes movement and regulatory activities of the States.

The inevitable change to metric (SI) units of measurement in the U.S. construction community, proposed for the 1980's, will pose some problems as well as a unique opportunity for harmonization and rationalization. At one end of the spectrum, unilateral activity by the private model code groups and, subsequently, the state and local administering authorities, could lead to short-term confusion of sizeable magnitude, especially if further divergency in measurement references is introduced. Not only would code compliance be complicated for professionals, manufacturers and contractors, but diversity would make it difficult to familiarize building code officials and inspectors with metric usage and application in plan approval and site inspection. At the other extreme, metrication provides a once-only opportunity to resolve many of the differences in code formats, approaches, and required acceptance levels at the same time as new and rationalized metric values (hard conversions) are introduced. Such harmonization would make it possible to develop a national approach to metric familiarization and training for code officials by means of explanatory metric reference manuals, which could also be used by designers and other groups to ensure maximum compliance.

There are a number of possible approaches between these extremes, such as the partial harmonization of model and State building codes in all areas of national significance, technologically and economically; for example, in the provisions relating to energy conservation, fire safety, access and egress, structural factors, seismic considerations, etc.

This paper discusses the issue of metrication as an opportunity to take a positive approach to building code harmonization, and suggests some basic guidelines to minimize problems during the transitional period. It deals with soft conversion to equivalent values and hard conversion to metric alternatives which would no longer be interchangeable. Practical examples are used to illustrate possibilities of code harmonization.

**Setting formaldehyde standards,** R. L. Meyer, *SP586*, pp. 253-258 (June 1980).

**Key words:** committee; concentration; department; formaldehyde; formaldehyde-based chemicals; formaldehyde level; standards; urea-formaldehyde resins.

Formaldehyde is utilized in the manufacture of a variety of products. The most significant use is in the production of

phenolic, melamine and urea formaldehyde resins. It is also used in agriculture, for chemical analysis, concrete and plaster, cosmetics and deodorants, disinfectants and fumigants, dyes, hydrocarbon products, for leather tanning, paper manufacture, photography, rubber production, solvents and plasticizers, starch, wood, textiles, and embalming fluid. It is also a byproduct of combustion found in automotive exhaust and cigarette smoke.

There are an increasing number of complaints received from persons residing in mobile homes caused from the emission of formaldehyde vapor.

The department is developing standards for formaldehyde vapor.

While formaldehyde standards have been established to protect the worker from formaldehyde vapor, no standards have been set for formaldehyde in non-working environments.

The paper will deal with Wisconsin's experience in developing standards for formaldehyde vapor.

**Snow—Wind—Ice, its changing effect on building construction,** C. V. Opdyke, *SP586*, pp. 259-270 (June 1980).

**Key words:** building collapse; ice; snow; wind.

The impacts of the effects of "Weather" is being experienced across the nation as it relates to the destructive forces of snow, wind and ice on building construction.

In an effort to deal with these problems individually or collectively, we must re-evaluate all of our engineering principles, practices and theories that have been used through the years and have been accepted as gospel.

This paper deals with new and innovative design principles and methods of construction to overcome, wind loads, snow loads, icing conditions, freeze-thaw cycles, ventilation problems, roof leaks and structural failure. It also covers new types of roof designs and how to deal with them.

The report speaks to the many types of freezes, the wind pattern effect, the snow effect and the general combined effects of all three.

Finally, the paper speaks to a general lack of accurate local climatology recording on a uniform basis.

**SP587. Lighting issues in the 1980's. Summary and Proceedings of a Lighting Roundtable held at the Sheraton Center, New York, NY, June 14-15, 1979, A. I. Rubin, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 587*, 175 pages (July 1980) SN003-003-02218-7.**

**Key words:** biological effects of lighting; energy conservation; illumination levels; lighting; lighting design; lighting education; lighting research; post-occupancy evaluation; power budget; task lighting; visual performance.

The Lighting Roundtable described in this report was conducted to foster an open discussion of the goals, issues, and responsibilities of the lighting community. It was not a problem-solving session, but rather a time to examine the long-term aspirations and objectives of lighting and barriers that may stand in the way of achieving them. Eight major issues were addressed by nine panelists and a number of invited auditors. The issues are as follows: 1. The Public Image of the Lighting Community; 2. U.S. Role in the Worldwide Lighting Community; 3. Factors Affecting Human Activities in the Built Environment; 4. Effect of Lighting on Environmental Quality; 5. Effects of Barriers; 6. Establishment of Illuminance Levels; 7. Integration of Subsystems; and 8. Professional Development and Lighting Education.

The present publication consists of two parts; (1) A summary of the proceedings and (2) a complete transcript.

**SP588. Critical materials and fabrication issues for pressure vessels, piping, pumps, and valves. Preview of an ASME SYMPOSIUM Co-Sponsored by the National Bureau of Standards,**



held at the St. Francis Hotel, San Francisco, CA, Aug. 14-15, 1980, J. T. Fong, R. C. Dobbyn, and L. Mordfin, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 588*, 112 pages (June 1980) SN003-003-02215-2.

**Key words:** ASME Boiler Code; data; fabrication; failure analysis; fatigue; fracture; materials science; nondestructive evaluation; piping; pressure vessels; product liability; pumps and valves; standards; statistical modeling; welding.

As part of its centennial observances in August 1980, the American Society of Mechanical Engineers (ASME) will co-sponsor with the National Bureau of Standards and others a unique symposium entitled "Critical Issues." Through an intensive two-year series of debates, meetings, presentations, and reviews, a total of twelve issues on the materials and fabrication aspects of technical problems in the pressure vessels and piping industry were identified for discussion at the August 1980 meeting. The twelve issues are: (1) The role of engineering judgment and the computer in the management of material property data; (2) Curve-fitting vs. modeling for formulating design rules; (3) New material property data: Terminal vs. incremental tests; (4) Variability of data: Standards for applications; (5) On-line monitoring of critical components to improve reliability; (6) Upgrading welders' skill and educational level: How and why; (7) Reliability of nondestructive evaluation; (8) Characterization of the subjective component of inservice data; (9) Should there be a methodology for failure analysis? (10) Accelerated development of a more rational basis for nonlinear fracture mechanics; (11) Safety factors in Fatigue Design: Arbitrary or Rational? (12) The ASME Code and product liability: Should compliance create a rebuttable presumption of proper design? This report contains extended abstracts of the twelve issue papers and summaries of reviewers' comments for distribution to all symposium pre-registrants to stimulate and guide an orderly debate at the August 1980 meeting. *These proceedings include the following papers (indented):*

**The role of engineering judgment and the computer in the management of material property data**, A. O. Schaefer and P. M. Brister, *SP588*, pp. 9-14 (June 1980).

**Curve-fitting vs. modeling for formulating design rules**, S. Y. Zamrik, *SP588*, pp. 17-20 (June 1980).

**New material property data: Terminal vs. incremental tests**, E. P. Esztergar, *SP588*, pp. 23-28 (June 1980).

**Variability of Data: Standards for applications**, R. W. Swindeman, *SP588*, pp. 31-36 (June 1980).

**On-line monitoring of critical components to improve reliability**, G. R. Egan, *SP588*, pp. 43-46 (June 1980).

**Upgrading welders' skill and educational level: How and why**, W. P. Webb, *SP588*, pp. 49-52 (June 1980).

**Reliability of nondestructive evaluation**, L. Mordfin, *SP588*, pp. 55-59 (June 1980).

**Characterization of the subjective component of inservice data**, B. M. Tashjian, *SP588*, pp. 63-67 (June 1980).

**Should there be a methodology for failure analysis?**, R. Roberts, *SP588*, pp. 75-78 (June 1980).

**Accelerated development of a more rational basis for nonlinear fracture mechanics**, M. F. Kanninen, *SP588*, pp. 81-85 (June 1980).

**Safety factors in fatigue design: Arbitrary or rational?**, J. T. Fong and J. H. Smith, *SP588*, pp. 89-94 (June 1980).

**The ASME code and product liability: Should compliance create a rebuttable presumption of proper design?**, M. S. Selt-

zer, *SP588*, pp. 97-100 (June 1980).

**SP590. The technological importance of accurate thermophysical property information.** Proceedings of a Session of the Winter Annual Meeting of the American Society of Mechanical Engineers held in New York, NY, December 6, 1979, J. V. Sengers and M. Klein, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 590*, 56 pages (Oct. 1980) SN003-003-02244-6.

**Key words:** aeroscience; data accuracy; design; geothermal; process; thermodynamics; transport properties.

These papers were presented at a meeting of the American Society of Mechanical Engineers. The meeting session addressed the role of the accuracy of thermophysical properties data in a number of applications areas. The areas covered included aerospace sciences where such data have played a central role for a number of years, geosciences where first steps are being taken toward using accuracy in describing systems in terms of thermophysical properties. Also included were a discussion of the economic value of accuracy in the chemical process industry, a description of the role of data centers, and a description of several high quality data compilations. An example of a specific problem in the design of a heat exchanger for geothermal applications was also presented with the design uncertainties produced by data in accuracies illustrated. *These proceedings include the following papers (indented):*

**The role of data accuracy in application of thermophysics: An introduction and overview**, M. Klein, *SP590*, pp. 1-9 (Oct. 1980).

**Present and future sources of fluid property data**, N. A. Olien, *SP590*, pp. 11-17 (Oct. 1980).

**The influence of thermophysical properties on the design and sizing of geothermal power plant components**, H. E. Khalifa and J. Kestin, *SP590*, pp. 18-25 (Oct. 1980).

**Thermophysical properties of rocks: A perspective on data needs, sources, and accuracy**, H. P. Stephens and S. Sinnock, *SP590*, pp. 27-32 (Oct. 1980).

**Thermophysical property data: Who needs them?**, R. C. Hendricks, *SP590*, pp. 33-41 (Oct. 1980).

**Problems and procedures in providing values of thermophysical properties of fluids**, P. E. Liley, *SP590*, pp. 43-53 (Oct. 1980).

**SP591. Testing laboratory performance: Evaluation and accreditation.** Proceedings of a National Conference held at the National Bureau of Standards, Gaithersburg, MD, Sept. 25-26, 1979, G. A. Berman, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 591*, 179 pages (Aug. 1980) SN003-003-02229-2.

**Key words:** accreditation; audit certification; laboratory accreditation; laboratory performance evaluation; quality control; testing laboratories.

Proceedings of a National Conference on Testing Laboratory Performance: Evaluation and Accreditation held at the National Bureau of Standards on September 25-26, 1979. Twenty-nine papers address various techniques for evaluating the performance of testing laboratories, quality control aspects of the testing function, existing and proposed accreditation programs and systems, and international coordination. *These proceedings include the following papers (indented):*

**User experiences with laboratory accreditation**, J. E. French, *SP591*, pp. 3-5 (Aug. 1980).

**Key words:** accreditation; certification; colleges; confidence; criteria; evaluation; hospitals; inspectors; marketing; qualification; re-examination; technicians.



Laboratory accreditation serves a two-fold purpose in the marketplace. This relatively new technical function can provide increased confidence in the capability and reliability of testing laboratories by customers of their services. The function can also serve as a marketing tool for laboratory managers. In this sense there is an analogy with product certification. Although laboratory accreditation may eventually become a leveling force, much as accreditation of hospitals and academic departments within colleges has become, the enterprising laboratory manager should not regard accreditation as a least common denominator activity at this time. Experience of testing laboratories in several disciplines where accreditation has been available or required are reviewed. Long range roles for the accrediting function are discussed.

**Laboratory accreditation—State-of-the-art in 1979**, J. W. Locke, *SP59I*, pp. 6-10 (Aug. 1980).

**Key words:** laboratory accreditation; state-of-the-art in 1979.

Laboratory accreditation systems which formally determine and recognize that a laboratory has the capability to carry out specific tests or types of tests are increasing both in number and in the number of laboratories examined and accredited. The need for such systems can be traced to the growing need for laboratory testing in general. These systems are being developed normally to facilitate both national and international trade. Fifty-six laboratory accreditation systems were recently examined in a Department of Commerce study. Only 2 of the systems existed in 1947. By 1970 the number had grown to 33, and by 1978 the number was 56 with a significant portion of this increase occurring in 1977 and 1978. Over 5,500 laboratories are formally recognized by these systems and, since many of the systems are new, this number should increase substantially in the 80's. There is also a growing interest in the international recognition of national accreditation systems. Public and private sector coordination to promote acceptance of accreditation criteria and consolidation of accreditation systems is a growing need.

**Generic standard basis for laboratory accreditation**, H. E. Schock, Jr., *SP59I*, pp. 11-14 (Aug. 1980).

**Key words:** accreditation systems; certification; evaluation of inspection organizations; evaluation of testing organizations; inspection standards; laboratory accreditation; laboratory evaluation; regulatory liability; test standards; voluntary consensus standards.

The paper provides an overview of generic criteria for laboratory capability evaluation. The new American National Standard, ANSI/ASTM E 548-79, Standard Practice for Use in the Evaluation of Testing and Inspection Agencies, is reviewed. It provides generic criteria for evaluation of an agency for intended purpose, agency organization, human resources, material resources, and quality systems. New work is also reviewed relating to generic criteria development for accreditation systems and accreditors. Examples are provided of voluntary standards for specific disciplines and product areas. Discussion is provided of work in similar national and international areas, including mandatory use. Additional opportunities are given of appropriate survey and audit techniques for use in evaluation and accreditation.

**Laboratory performance evaluation services of the U.S. National Bureau of Standards**, J. O. Bryson, B. C. Belanger, and R. K. Kirby, *SP59I*, pp. 15-22 (Aug. 1980).

**Key words:** calibrations; collaborative reference programs; laboratory performance; measurement assurance; measure-

ment evaluation technology; measurement services; physical standards; proficiency testing; standard reference materials; testing; traceability.

This paper describes the principal services provided by the U.S. National Bureau of Standards that allow laboratories to assess and maintain at a high level the quality of their measurements. The NBS programs described in some detail in this paper include: Standard Reference Materials, Calibration Services, Measurement Assurance Program Services, and Collaborative Reference Programs. The paper deals with the basic aims and objectives of these services. A brief description of each service is provided, along with indications of how these services have improved the performance of laboratories. Also discussed are general concepts regarding the assurance of measurement accuracy and compatibility among laboratories on a national and/or international scale.

**The measuring process and laboratory evaluation**, T. W. Lashof, *SP59I*, pp. 25-30 (Aug. 1980).

**Key words:** collaborative reference program, test method; interlaboratory testing; laboratory evaluation; linear model; measuring process; proficiency testing; Youden two-sample analysis.

Graphical review of the theory of the measuring process. In view of the theory, what should be examined in the evaluation of laboratories? What might questionnaires and inspection reveal? How good are various types of proficiency tests?

**Inter-laboratory round robins for determination of routine precision of methods**, C. A. Bicking, *SP59I*, pp. 31-40 (Aug. 1980).

**Key words:** accuracy; between-laboratory precision; components of variance; duplicity; ideal conditions; measurement process; omnifariousness; precision; round robin; routine conditions; variance model; within-laboratory precision.

Attention is directed to the importance of determining precision of test methods under routine conditions of use. Comparisons of precision values obtained under very limited conditions have a very narrow range of usefulness. Such "ideal" precision values lead to incorrect use of "checking limits" in attempts to control performance of operators and of laboratories and of statistically invalid rules for retesting, rejection of results, and initiation of third-party referee testing. Measures of precision under routine conditions, both within-laboratory and between-laboratories, are necessary to identify the contribution of the test method to the total variability of measurement in research, manufacturing, and in exchange of materials and goods in commerce.

**Laboratory evaluation techniques—U.S. Army calibration program**, C. B. Coulter, *SP59I*, pp. 41-44 (Aug. 1980).

**Key words:** audit; calibration; calibration laboratory; certification; evaluation; inspection.

The U.S. Army utilizes three principal techniques in the evaluation of its calibration laboratories: Technical Measurement Audits, Technical Inspections and Certification of Technicians. Each major calibration laboratory is subject to each of the above techniques or a combination thereof contingent upon its mission and location within the Department of Army logistical complex. Each of the techniques is administered or managed by the U.S. Army Metrology and Calibration Center (USAMCC) at Redstone Arsenal, Alabama.

Technical Measurement Audits are objective in nature while Technical Inspections and Certification of Technicians rely heavily on subjective considerations. The combi-



nation establishes a comprehensive quality assurance program for calibration.

**The value of split sample programs for contractual acceptance of in-house laboratory procedures**, R. A. Mullins, *SP591*, pp. 45-49 (Aug. 1980).

**Key words:** heterogeneous; in-house; laboratory; preparation; riffle; sample; standards.

Because coal is heterogeneous, special procedures are necessary for the determination of the quality. Commercially, the amount of coal to be sampled in a year for a contract may be a million tons. Both the seller and the buyer need a proven system for contractual acceptance of the determined quality. The necessity for including both the automatic sampler and the laboratory in such a system is discussed and the resulting split sample program is shown to be a natural development. The program serves the primary purpose of determining the quality but it also serves as a continuous evaluating system of the in-house laboratory procedures.

**Summary of evaluations of clinical laboratories participating in the Center for Disease Control evaluation program**, L. C. Lamotte, Jr., *SP591*, pp. 53-62 (Aug. 1980).

**Key words:** checklist; CLIA '67; Clinical Laboratories Improvement Act of 1967; clinical laboratory evaluation; evaluation, internal quality control; evaluation, performance; evaluation, qualifications of laboratory personnel; improvement; proficiency testing.

During the period from 1969 to 1979, the Center for Disease Control has provided for the evaluation of about 1,000 interstate clinical laboratories for licensure purposes, and has provided a performance evaluation program to an additional 1,700 clinical laboratories that were not required to participate by the CLIA '67 law. Licensed laboratories are required to use personnel who meet personnel standards, to meet applicable standards for internal quality control of tests, and to perform satisfactorily in various proficiency testing programs. In most cases the personnel and internal quality control were not evaluated for nonlicensed participants. A review of the data suggests that some laboratories meet or exceed most of the standards, but that a disturbing number of laboratories do not. The demonstration of specific poor performance is often a sufficient stimulus to improvement; in some cases regulatory authority seems necessary to bring about improvement. This paper will provide data based on the CDC program.

**Evaluation and approval of laboratories in Connecticut—Importance of voluntary standards**, J. S. Tucker, *SP591*, pp. 63-66 (Aug. 1980).

**Key words:** clinical laboratories; cost effectiveness; environmental laboratories; licensure; performance evaluation; physician's office laboratories; proficiency testing; public health; recombinant DNA; registration and approval; voluntary standards.

The Laboratory Division of the Connecticut Department of Health Services is responsible for licensure, registration, performance evaluation and approval of hospital, independent clinical, water, waste water, food, dairy, air and a variety of other laboratories which perform tests of public health significance. Of the almost 400 facilities, more than three-quarters of these participate in proficiency testing and are inspected yearly.

The philosophy of performance evaluation and approval in Connecticut has evolved from one of complete authority and control by the state to one which is based increasingly upon cost effectiveness, consistency, enforceability and participant input. Dependence on voluntary standards now ex-

tends from granting equivalence for inspections conducted by qualified professional groups to accepting proficiency testing results from well conceived programs. Most success in acceptance of equivalent programs has been attained with clinical laboratories and least progress has been made with environmental laboratories. This difference probably is attributable to the newness of environmental as opposed to clinical laboratory legislation and the availability of acceptable programs.

Using the evaluation and approval of recombinant DNA laboratories in Connecticut as an example, the advantages of using existing regulations and voluntary standards are discussed as a model of efficiency.

**The laboratory accreditation program of the American Industrial Hygiene Association**, F. I. Grunder, *SP591*, pp. 67-70 (Aug. 1980).

**Key words:** accreditation; accreditation committee; American Industrial Hygiene Association; coordinator; industrial hygiene laboratories; laboratory; PAT; performance; personnel; proficient; quality control; reaccreditation; site visit.

The accreditation program for laboratories will be described along with the program to assist accredited laboratories to maintain their accreditation through continued demonstration of competence and performance. An Industrial Hygiene Laboratory is a laboratory that analyzes samples taken to assist in the recognition, evaluation and control of the workplace environment. The factors which are used to determine whether a laboratory qualifies for accreditation as an industrial hygiene laboratory will be described in detail. Such factors include personnel qualifications, quality control and proficiency testing, facilities, recordkeeping, analyses performed, safety and analytical procedures. A description of the accreditation process will be provided along with steps that are taken to assist laboratories not maintaining acceptable standards of performance. The role of the coordinator, the site visitor, the accreditation committee and the AIHA Board of Directors will be outlined and possible changes in the program will be discussed. The effectiveness of the program in improving industrial hygiene laboratories will be reviewed.

**College of American Pathologists Inspection and Accreditation Program**, F. Ryan, *SP591*, pp. 71-74 (Aug. 1980).

**Key words:** accreditation; College of American Pathologists; criteria; inspection; inspector's manual; pathology; proficiency testing; standards.

The College of American Pathologists Inspection and Accreditation Program is a professional, voluntary, peer-review program of laboratory improvement. The standards are developed by a Commission of volunteer pathologists and the program is operated by this Commission, with support from the College's central office and computer center. Biennial inspections are conducted by volunteer pathologists. Each pathologist is assisted by a team of his choosing, representative of the size and complexity of the laboratory to be inspected. The standards include requirements on quality control, safety, environment, instrument maintenance and personnel. An inspection checklist is used to assure that all areas are examined. Proficiency testing is a prerequisite and results are an integral part of the accreditation decision. Emphasis is placed on the educational aspects of the program. CAP accreditation is accepted by the Joint Commission on Accreditation of Hospitals, the Center for Disease Control, and some states. Accreditation by CAP assures the physician and patient that test results are reliable.

**Laboratory accreditation for toxicology facilities**, H. W. Hays, *SP591*, pp. 75-76 (Aug. 1980).



**Key words:** accreditation; certification criteria; evaluation; toxicology laboratories.

Certification of toxicologists and accreditation of toxicology laboratories have been the subject of concern to the Society of Toxicology since 1973. Numerous committees have studied the problem and all came to the conclusion that such programs would greatly enhance the science of toxicology. This paper describes certification and accreditation programs for toxicologists and toxicology laboratories.

**Laboratory performance evaluation and accreditation—It's all in the implementation,** W. J. Smith and G. T. Castino, *SP591*, pp. 79-84 (Aug. 1980).

**Key words:** countercheck reference tests; critical control features; feedback; implementation; inspections; laboratory accreditation; laboratory performance evaluation; noncompliance; proficiency.

Based on many years of experience in the development of product evaluation information under Federal, State and local Codes and Standards and related in-house studies of associated accreditation programs, the critical features of these programs have been identified in terms of the degree to which they are likely to achieve their objectives. Most accreditation programs place heavy emphasis on written documentation of conformance to established criteria and in-house quality assurance programs, stressing test equipment calibration and maintenance, with limited attention to the critical control features and measures of the extent of in-house implementation. A review of the critical features of laboratory accreditation programs indicates that these programs must include: (1) "hands-on" proficiency of personnel, (2) feedback mechanisms for program improvement, (3) procedures-in-case-of non-compliance and/or errors, (4) random unannounced inspections of test facilities and (5) independent countercheck reference testing. Accreditation programs lacking in one or more of these critical features can drift to a "least common denominator" modus operandi and fall short of original objectives.

**Laboratory accreditation by disciplines,** R. J. Amorosi, *SP591*, pp. 85-87 (Aug. 1980).

**Key words:** classes of tests; directory of accredited laboratories; discipline; laboratory accreditation.

In Laboratory Accreditation Programs by Discipline—the laboratories are accredited for performance of groups of tests or specific tests within a discipline of testing. Individual laboratories may be accredited in more than one discipline and for one or more classes within each discipline. The evaluation process for discipline accreditation covers the technical and ethical competence of the personnel, and the equipment and quality control procedures for the discipline/groups of tests that are enumerated in the laboratory's application for accreditation.

**Accreditation program for Canadian testing organizations,** R. E. MacNintch, *SP591*, pp. 88-91 (Aug. 1980).

**Key words:** accreditation; Canada; laboratories; standards; Standards Council of Canada; testing.

The paper briefly describes the constitution, role and responsibilities of the Standards Council of Canada, which is the accrediting authority for the national voluntary accreditation program for testing organizations in Canada. It also touches on the composition of the National Standards System (NSS), a federation of independent autonomous organizations working towards the further development and improvement of voluntary standardization in the national interest. This system, which is under the aegis of the Standards Council, will include accredited testing organizations

as one component.

The document, "Criteria and Procedures for Accreditation of Testing Organizations" (CAN-P-4) was approved and published by Council in 1978. A limited (pilot) accreditation program is being conducted this year (1979) in order to evaluate implementation procedures and estimate costs for a national program. It is hoped that this limited program will provide sufficient information for Council to make decisions in 1980 concerning a national program.

**Economic effect of laboratory accreditation,** D. Krashes, *SP591*, pp. 92-96 (Aug. 1980).

**Key words:** accreditation; costs; economic; prices; testing.

A fear of some commercial laboratory owners about national accreditation is that laboratories remaining unaccredited will be able to charge lower prices and, thus, garner the majority of the testing business. This study determined average prices for tensile tests of metals, relative amounts of these tensile tests performed in "well-accredited" and "poorly-accredited" laboratories; and determined the effect of being accredited, under today's systems of accreditation, on the quantities of tensile testing business obtained by commercial laboratories. In geographic regions where being "accredited" is recognized as important by a major segment of manufacturing industry, most of the tensile testing, regardless of price, is performed in "well-accredited" laboratories. In geographic regions where no strong segment of consuming industry requires "accreditation," most of the tensile testing is done in laboratories "poorly accredited" by today's systems. Thus, if the consuming industry recognizes the value of accreditation, there will be an economic advantage for accredited laboratories: they will be able to charge more and also may gain more testing business. In regions where no strong segment of industry recognizes the value of accreditation, accredited laboratories will suffer economically. The economic effect of any proposed laboratory accreditation program should be studied prior to initiating the program.

**The role of the quality control manual in the inspection and testing laboratory,** R. J. Wening, *SP591*, pp. 99-103 (Aug. 1980).

**Key words:** calibration; equipment; evaluation; laboratory; manual; personnel; quality assurance; quality control; systems.

An indispensable tool for every testing laboratory is an adequate quality control manual. Such a document is a cornerstone of the laboratory's credibility and an important ingredient in its assessment for accreditation.

Several years ago, the American Council of Independent Laboratories (ACIL), an organization with a long history of interest in laboratory accreditation, made a significant contribution in this area. ACIL commissioned its Laboratory Accreditation Committee to develop a guidebook on laboratory quality control. The committee's product was published by ACIL in 1976; its title is "Manual of Practice: Quality Control System: Requirements for a Testing and Inspection Laboratory."

In this paper, ACIL will review the development of the manual and its contents. Included in it are sections on Organization; Operational Procedures; Personnel; Equipment and Calibration; Reference Samples; Recommended Personnel Basic Requirements; Inventory of Standards and Equipment Requiring Calibration; and Sources of Reference Samples.

The paper will also assess the impact of this manual on the laboratory community. Samples of adaptations of the manual's guidelines by individual laboratories in various disciplines will be presented. Also, reference to the manual



by other bodies, such as Government agencies, will be discussed.

Finally, the paper will estimate the importance of quality control manuals and programs in the day-to-day operation of a laboratory and in relation to the broader issues of evaluating and accrediting testing laboratories.

**Laboratory quality program requirements**, T. A. Ratliff, Jr., *SP591*, pp. 104-108 (Aug. 1980).

Key words: accuracy; control chart; control limits; corrective action; data validation; precision; proficiency analytical testing; quality control; statistical quality control.

The need for quality control of laboratory results was identified early by The National Institute for Occupational Safety and Health when a great disparity of analytical results was noted among 14 industrial hygiene laboratories. The result was a four pronged attempt to improve performance: 1) An educational program was developed; 2) An interlaboratory proficiency program, PAT, was started; 3) A laboratory quality control manual and a standard for laboratory control were developed; 4) A laboratory accreditation program was developed by AIHA under contract.

The Environmental Protection Agency, the Occupational Safety and Health Administration, the Food and Drug Administration, the American Society for Testing Materials and others have described similar programs in various standards and regulations. Finally the American National Standards Institute (ANSI) Z-1 Committee on Quality Assurance and its Systems and Procedures Sub-Committee have agreed that there is a need for a generic Quality Control Standard for laboratories which will differ from a manufacturing quality control standard. A laboratory quality control standard is being drafted by a writing committee under the aegis of the Biomedical Division of the American Society for Quality Control.

**Quality control procedures in a laboratory—Testing cement for compressive strength**, R. D. Gaynor and R. C. Meininger, *SP591*, pp. 109-123 (Aug. 1980).

Key words: cement and concrete reference laboratory; cement and concrete testing; compressive strength; control charts; in-house quality control; quality control system.

This paper describes an in-house quality control system used by the Joint Research Laboratory (JRL) of the National Ready Mixed Concrete Association and the National Sand and Gravel Association (NRMCA-NSGA). The system is used to control the quality of the results of compressive strength tests of portland or blended cements by ASTM Method C109 but can also be used for other physical and chemical tests of cement and concrete.

**Standard thermal performance testing procedures**, J. D. Verschoor, *SP591*, pp. 124-130 (Aug. 1980).

Key words: laboratory test procedures; quality assurance lab test; standard test methods; thermal performance test.

Formal standardized procedures for thermal performance tests were established at the Johns-Manville R&D Center as part of a program to assure reliability of test data. A number of requirements had to be met by the procedures. While the tests are based on ASTM and other similar recognized standard methods, the procedures had to be sufficiently detailed to insure consistently reliable results by all operators, some of whom may not have had long-term experience in thermal testing. Likewise, the procedures has to cover a wide variety of types and forms of materials, test equipment and temperature ranges. A complicating factor was the inter-relation between general lab procedures applicable to all activities, procedures for checking general pur-

pose equipment and specific thermal test equipment, thermal test methods, and test specimen preparation procedures for specific types of materials.

This paper describes the formats for a series of formal cross-referenced standardized procedures for thermal performance tests. The paper also details some of our experiences in preparing and implementing these test procedures.

**Laboratory performance evaluation—A new look at quality assurance in the testing laboratory**, D. J. McClain, *SP591*, pp. 131-134 (Aug. 1980).

Key words: consumer awareness and legality; customer and laboratory responsibilities; Institute of Electrical and Electronic Engineers Specifications; laboratory capabilities; laboratory performance evaluation; manufacturers response to laws and consumers; pretest quality planning.

Safety and liability laws, consumer awareness and Federal laws governing test requirements necessary to qualify a component for use in Nuclear reactors has caused a new look at laboratory performance. The independent laboratory is preferred by legal departments since it avoids the connotation of conflict of interest in any litigation which might result if a component fails. Quality Assurance organizations have revised their methods of audits and approach to the control requirements needed by independent test laboratories. This reexamination has shown that in many cases laboratory performance has not been what the laboratory customer expected. This paper presents not only the requirements for nuclear qualification but assesses those performance standards currently found in test laboratories. Further and most important, it presents several solutions to the problems. These are solutions that have been used successfully. They require, as most human endeavors, understanding and cooperation as well as acceptance of certain responsibilities on both the laboratory and the laboratory customer.

**A measurement assurance program—Thermometer calibration**, G. T. Furukawa and W. R. Bigge, *SP591*, pp. 137-145 (Aug. 1980).

Key words: calibration; check thermometers; fixed points; International Practical Temperature Scale of 1968; measurement assurance program; platinum resistance thermometer; reference thermometer; thermometer.

The platinum resistance thermometer (SPRT), calibrated in accordance with the specifications of the International Practical Temperature Scale of 1968 (IPTS-68), is the international standard for temperature measurement in the range 13.81 K ( $-259.34^{\circ}\text{C}$ ) to 903.89 K ( $630.74^{\circ}\text{C}$ ) to which the United States subscribes. Such SPRT's are used to calibrate other SPRT's, "industrial resistance thermometers," or other types of thermometers, or used directly where highly accurate temperature measurement is desired. There are many laboratories in the United States that calibrate SPRT's and other resistance thermometers at various levels of accuracy. A measurement assurance program (MAP) on the calibration of SPRT's has been developed at the National Bureau of Standards. In the program, three pre-calibrated SPRT's are shipped to a participating laboratory for calibration. Upon return, the SPRT's are recalibrated at the NBS and shipped to the next laboratory. The two NBS calibrations (before and after) are compared with those of the participant. This paper describes the results of the MAP measurements on the SPRT's.

**The certification of building products in the United States**, L. H. Breden and L. K. Snell, *SP591*, pp. 146-155 (Aug. 1980).

Key words: building products; certification; laboratory accreditation.



Based on a survey of certification for building products United States, HUD has developed qualifications and procedures for administrators in carrying out certification programs. In addition, a glossary of terms, used in the HUD Certification of Building Products Program, has been developed. In the United States, manufacturers provide certification of a product to a particular standard while administrators provide a validation of the manufacturer's certification. Several examples of certifications will be discussed. As an adjunct to certification, HUD and specific program administrators, have developed basic criteria to be used by administrators in approving laboratories. An example of the use of these criteria in the carpet program will be extensively discussed. It is anticipated that a NVLAP for the testing of carpet will be developed. Finally, HUD's view on administrators, building products, future certification and laboratory accreditation programs in the United States and international certification will be presented.

**Licensing programs for field technicians and concrete laboratories in Massachusetts,** G. H. Brattin and C. G. Hanafin, *SP591*, pp. 156-163 (Aug. 1980).

Key words: accreditation; concrete testing laboratories; field concrete licensing; prequalifying agency; testing agency.

The state-wide licensing of field concrete technicians and concrete testing laboratories has been in effect in Massachusetts since January, 1975. As of this date there are twenty licensed concrete testing laboratories and approximately 1250 licensed field concrete technicians. Prequalifying agencies were designated by the State Building Code Commission to insure a proper mechanism to license technicians and laboratories. Proven test methods, procedures, and standards were adopted, wherever possible, to give the programs credence and to ease their implementation. The need, development, operation, rules and regulations, and evaluation of the programs are set forth.

**The crime laboratory accreditation program of the American Society of Crime Laboratory Directors (ASCLD),** A. Longhetti, *SP591*, pp. 164-168 (Aug. 1980).

Key words: accreditation; American Society of Crime Laboratory Directors (ASCLD); certification; management; on-site visit; personnel qualifications; physical evidence; proficiency testing; standards.

The American Society of Crime Laboratory Directors (ASCLD) has formulated a crime laboratory accreditation program with the following objectives: 1) to improve the quality of laboratory services provided to the criminal justice system, 2) to offer to the general public and to users of laboratory services a means of identifying throughout the nation those laboratory facilities which satisfy accreditation criteria, 3) to develop and maintain criteria which can be used by a laboratory to assess its level of performance and strengthen its operation, and 4) to provide an independent, impartial and objective system by which laboratory facilities can benefit from a total organizational review.

A significant part of the program is the Standards Manual, which identifies the principles and standards, discusses them and lists evaluation criteria for each of the following areas: 1) laboratory management and operation, 2) personnel qualifications, 3) procedures and instruments/equipment, and 4) physical plant and security.

A pilot program is currently under way to test the on-site evaluation aspect of the accreditation program. Four crime laboratories of varying size, geographic location, and organizational placement have volunteered to serve as "test sites" for this phase of the program.

**Certified laboratory performance evaluation,** H. J. Barth,

*SP591*, pp. 169-170 (Aug. 1980).

Key words: accuracy and precision of the checking authority; laboratory procedures; reliability of the sample collection; tools for laboratory evaluation.

The USDA-FSQS-Science Certified Laboratory Program commenced in late 1962 in response to the meat food industry for more rapid analytical results on official samples. Initially, non-government Chemistry laboratories that requested certification and that met our requirements were certified for moisture, protein, and salt determinations. In 1969, with the advent of the cooked sausage regulations, the Certified Laboratory Program was extended to cover fat determinations in addition to the previously mentioned determinations.

Presently, the Certified Laboratory performance evaluation is an ongoing program. Analytical results are compared between the Certified Laboratories and the USDA Laboratories. These analyses are monitored using computer generated reports. Each USDA Certified Laboratory Reviewer is responsible for verifying these reports for accuracy and following up on unacceptable analytical variations. In addition, the Certified Laboratory Reviewer makes an unannounced on-site review of each Certified Laboratory per year. Review reports contain information regarding all aspects of the Certified Laboratory's analytical operation and include recommendations for necessary corrective action including decertification if necessary.

**Proposed U.S. position paper for the Third International Conference on Recognition of National Programs for Accrediting Testing Laboratories (ILAC) Sydney, Australia, October 22-26, 1979,** *SP591*, pp. 173-178 (Aug. 1980).

Key words: definitions; directory of accreditation systems; international; laboratory accreditation; legal constraints.

The Third International Conference on Recognition of National Programs for Accrediting Testing Laboratories (ILAC/79) will be held in Sydney, Australia, October 22-26, 1979. ILAC is an informal assemblage of nations and international organizations whose objective is to examine ways in which accredited laboratories in each country could be internationally recognized. The primary work of ILAC/79 was performed by three Task Forces which have: (1) analyzed legal problems raised by the recognition of nationally recognized laboratory accreditation systems; (2) drafted an international directory of organizations which operate accreditation systems; and (3) developed a description of the needs, objectives, and effects and consequences of laboratory accreditation and prepared a list of basic terms and definitions. The Task Force reports are summarized in this position paper; proposed U.S. positions with respect to these Task Force reports are also included. The preconference briefing is being held as part of this national conference to inform all interested parties about the content of ILAC/79 deliberations and to receive comments and suggestions from the participants with respect to the position the U.S. should take at ILAC/79.

**SP592. An investigation of the Miyagi-ken-oki, Japan, earthquake of June 12, 1978,** B. R. Ellingwood, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 592*, 232 pages (Oct. 1980) SN003-003-002257-8.

Key words: bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering.

On June 12, 1978, a destructive earthquake with Richter magnitude of 7.4 occurred off the east coast of Miyagi Prefecture, Japan. Preliminary estimates by the National Land Agency of



Japan indicated that the earthquake caused an equivalent of \$800 million in total damage. There is a cooperative agreement between the Governments of the United States and Japan termed the U.S.-Japan Program in Natural Resources (UJNR). Following the earthquake, it was arranged through UJNR that teams of U.S. structural engineers and geologists would visit Miyagi Prefecture and inspect the damage caused by the earthquake. This report assembles the information and collective experiences of the investigation team so as to describe the earthquake and document its effects. Field investigations conducted by geologists and structural engineers are described in detail and some of the implications for seismic resistant design and construction of structures in the United States are also discussed.

**SP594. Nuclear cross sections for technology.** Proceedings of the International Conference on Nuclear Cross Sections for Technology, held at the University of Tennessee, Knoxville, TN, Oct. 22-26, 1979, J. L. Fowler, C. H. Johnson, and C. D. Bowman, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 594*, 1056 pages (Sept. 1980) SN003-003-02237-3.

Key words: biomedical; conference; fission; fusion; nuclear cross sections; reactors; standards; technology.

These proceedings are the compilation of 203 papers presented at the International Conference on Nuclear Cross Sections for Technology held at the University of Tennessee, Knoxville, October 22-26, 1979. Invited papers reviewed nuclear data needs for standard fission reactors, alternate fuel cycles, fusion reactors, biomedical applications, and applications in industry, as well as integral experiments, cross section measurements, cross section standards, and cross section evaluations. There were 165 contributed papers on these subjects with some emphasis on cross section measurement techniques and evaluation of cross section data. *These proceedings include the following papers (indented):*

**Nuclear data needs for LWR applications, O. Ozer, SP594, pp. 1-5 (Sept. 1980).**

Key words: benchmark analysis; ENDF/B-V; fuel cycle sensitivities; LWR data needs.

LWR's have been successfully built and operated with the use of methods and data libraries adjusted on the basis of realistic benchmark experiments. As part of an effort to develop an accurate standard data base that could be used to upgrade design methods, EPRI has participated in the development of the ENDF/B library. Sensitivity studies and benchmark analyses were carried out to determine data types that are important for the calculation of various LWR parameters and to determine problem areas associated with the use of ENDF/B data in LWR calculations. Discrepancies between calculations and measurements involving captures in  $^{238}\text{U}$  and plutonium critical systems are identified as source for concern.

**Nuclear data needs for plutonium breeders, P. Hammer, SP594, pp. 6-17 (Sept. 1980).**

Key words: fast breeders; nuclear data.

This paper aims at summarizing the present major nuclear data needs for fast breeders. The corresponding requirements are deduced from the target accuracies which are associated to the design, operation and safety related parameters. Due to the fact that these target accuracies may somewhat change from one country to another the requirements quoted here must be considered more as the present order of magnitudes than as precise figures.

The maximum admissible uncertainties which are asked presently for the nuclear data are due in particular to: the necessity of reducing the supplementary investment costs which result from the security margins taken by the designers to take into account the present neutronic uncertainties;

the necessity of improving the optimization studies devoted to the future commercial fast breeders: these studies involve the comparison of neutronics performances of new concepts, such as the heterogeneous core concept, to the classical one.

**Nuclear data needs for the analysis of generation and burn-up of actinide isotopes in nuclear reactors, H. Küsters, SP594, pp. 18-24 (Sept. 1980).**

Key words: actinide generation chain; actinides cross sections; fast critical experiments; fast reactors; L.W. reactors.

A reliable prediction of the in-pile and out-of-pile characteristics of nuclear fuel is one of the objectives of present-day reactor physics investigations. From the nuclear data point of view, the cross-sections of the dominating actinide isotopes as  $^{235}\text{U}$ ,  $^{238}\text{U}$ , and  $^{239}\text{Pu}$ , have been investigated over the energy range of interest for more than two decades. Especially the fast reactor development was accompanied by cross-section measurements in many laboratories. Even today the nuclear data do not match the accuracy requirements of fast reactor designers, so that many laboratories still adjust their data files to a large variety of integral experiments. In 1975 a first international specialists' meeting showed large discrepancies in nuclear data and corresponding group constants for nearly all of the secondary actinide isotopes (all other actinide nuclides except the main isotopes of U and Pu). Though the accuracy requirements for these secondary isotopes are not as stringent as those for the main nuclides, improvements were clearly necessary. The usual tests of nuclear data in critical or subcritical zero power facilities is concentrated on the start-up conditions of a power reactor. The change in isotopic concentration of the fuel during burn-up, especially the build-up of secondary actinides usually is checked by post irradiation examination of spent fuel. Unfortunately, the information from these experiments is often regarded as commercial. A large effort has been spent on nuclear data measurements and evaluations especially for the cross-sections of the secondary actinide isotopes in the seventies. At many conferences the status and the needs for further improvement have been described. In May 1978, on a symposium on nuclear data problems in thermal reactor application, an already satisfactory accuracy of most of the cross-sections, important for in-pile and out-of-pile investigations in thermal reactors, has been reported. At Harwell in September 1978, a broad review of the nuclear data status for reactor applications has been given. For instance, in Ref. 3 the nuclear data needs for the analysis of the out-of-pile stages of various nuclear fuel cycles have been discussed. From that discussion it transpired that further improvement of nuclear data with respect to their status in 1978 was very unlikely to reduce any of the technical difficulties in fuel handling. Proper updating of the data, used in the various laboratories, has been required. At Brookhaven in November 1978, at Cadarache in May 1979 the status of the cross-sections of the secondary actinides has been summarized. Additional information can be obtained from the International Conference on fast reactor physics in Aix-en-Provence in September 1979. Admittedly, only little new information can be reported in this paper. It will concentrate on the check of actinide nuclear data with special emphasis on the secondary actinide isotopes in LWRs and FBRs. Further needs for nuclear data improvements will be deduced from these tests.

**Fission product decay heat for thermal reactors, J. K. Dickens, SP594, pp. 25-33 (Sept. 1980).**

Key words: decay heat; fission beta energy; fission gamma energy.

In the past five years there have been new experimental



programs to measure decay heat (i.e., time dependent beta-plus gamma-ray energy release rates from the decay of fission products) following thermal-neutron fission of  $^{235}\text{U}$ ,  $^{239}\text{Pu}$ , and  $^{241}\text{Pu}$  for times after fission between 1 and  $\sim 10^5$  sec. Experimental results from the ORNL program stress the very short times following fission, particularly in the first few hundred sec. Complementing the experimental effort, computer codes have been developed for the computation of decay heat by summation of calculated individual energies released by each one of the fission products. By suitably combining the results of the summation calculations with the recent experimental results, a new Decay Heat Standard has been developed for application to safety analysis of operations of light water reactors. The new standard indicates somewhat smaller energy release rates than those being used at present, and the overall uncertainties assigned to the new standard are much smaller than those being used at present.

**Neutron total cross sections of hydrogen, carbon, oxygen and iron from 500 keV to 60 MeV**, D. C. Larson, J. A. Harvey, and N. W. Hill, *SP594*, pp. 34-38 (Sept. 1980).

Key words: carbon; hydrogen; iron; neutrons; oxygen; total cross sections; 0.5-60 MeV.

The neutron total cross sections for hydrogen, carbon, oxygen, and iron have been measured from 0.5 to 60 MeV using the Oak Ridge Electron Linear Accelerator (ORELA) as the source of neutrons. The flight path was 80 m, and the repetition rate was  $1000 \text{ sec}^{-1}$ , with a burst width of 10 ns. The resulting cross sections are graphically compared with ENDF/B-V evaluations up to 20 MeV, and with selected data from 20-60 MeV.

**Elastic scattering of 14.8 MeV neutrons from deuterons**, K. Gul, A. Waheed, M. Ahmad, M. S. Sheikh, M. Anwar, and N. A. Khan, *SP594*, pp. 39-42 (Sept. 1980).

Key words: differential cross sections; total elastic scattering cross sections.

The differential elastic scattering cross-sections of 14.8 MeV neutrons from deuterons have been measured between  $29^\circ$  and  $145^\circ$  in the centre-of-mass system using NE230 scintillator as a scatterer. The energies of neutrons have been measured by the time-of-flight technique. The present measurements support the deeper minimum reported by Berick *et al.*, and the measurements of Brullmann *et al.*, and Berick *et al.*, in the forward region. A value of 620.9 mb has been obtained for the total n-d elastic scattering cross-section at 14.8 MeV.

**Neutron scattering from  $^7\text{Li}$  at incident energies of 5.1, 6.6 and 15.4 MeV**, M. Baba, N. Hayashi, T. Sakase, T. Iwasaki, S. Kamata, and T. Momota, *SP594*, pp. 43-47 (Sept. 1980).

Key words: neutron cross sections; spectrum analysis.

$^7\text{Li}$  double-differential neutron cross sections were measured with time-of-flight method for  $E_n = 5.1, 6.6$  and 15.4 MeV at six laboratory angles between  $27.5^\circ$  and  $140^\circ$ . The results were compared with the evaluated data, and the emission spectra were analysed.

**Total cross section measurements of  $^6\text{Li}$ ,  $^7\text{Li}$ , and C from 3 to 40 MeV**, J. D. Kellie, G. P. Lamaze, and R. B. Schwartz, *SP594*, pp. 48-51 (Sept. 1980).

Key words: C(n,n); time-of-flight; total cross section.

This paper describes the measurement of the total neutron cross sections of carbon,  $^6\text{Li}$  and  $^7\text{Li}$  from 3 to 40 MeV, using the pulsed beam of the National Bureau of Standards electron linear accelerator as a source of neutrons. The measured pulse width was approximately 5 ns

FWHM and the neutron flight path was  $\sim 200$  m which gives an intrinsic resolution of  $\sim 150$  keV at the higher energies.

**A coupled channels model for radiative capture of nucleons by  $^{12}\text{C}$** , D. L. Johnson, *SP594*, pp. 52-57 (Sept. 1980).

Key words: comparison to experimental data; coupled channels model calculation; nuclear reactions.

A simple model based upon coupled channels scattering calculations for nucleons on  $^{12}\text{C}$  has been applied to the corresponding radiative capture reactions. It includes only electric dipole transitions via direct capture plus capture occurring via intermediate states consisting of only the  $2^+$  first excited state of  $^{12}\text{C}$  coupled to a nucleon in the s,d shell. It is shown that the shape and magnitude of measured excitation functions of the  $^{12}\text{C}(p,\gamma_0)$  and  $^{13}\text{C}(\gamma,n_0)$  reactions are largely reproduced for excitation energies up to about 10 MeV. Furthermore, it is shown that the excitation functions are strongly affected by competition and interference between direct capture and the indirect modes. Angular distribution data is also fairly well reproduced by the model. Implications of the success of the model will be discussed.

**Evaluation of  $^{23}\text{Na}$  for ENDF/B-V**, D. C. Larson, *SP594*, pp. 58-62 (Sept. 1980).

Key words: cross sections; evaluation; neutrons; sodium.

Version V of the Evaluated Nuclear Data File (ENDF) for sodium is described. Major changes have been made in the total, capture, inelastic scattering and (n,2n) cross sections, as well as the elastic scattering angular distributions and gamma-ray-production files. ENDF/B-IV and V and compared where major changes were incorporated. New measurements needed to fill data gaps or resolve discrepancies among existing data sets are discussed.

**Simultaneous evaluation of  $^{32}\text{S}(n,p)$ ,  $^{56}\text{Fe}(n,p)$ ,  $^{63}\text{Cu}(n,2n)$  cross sections**, C. Y. Fu, D. M. Hetrick, and F. G. Perey, *SP594*, pp. 63-67 (Sept. 1980).

Key words: cross-reaction covariances; ratio data.

Previously available evaluations of cross sections and covariances were used as input for incorporating additional correlated data sets, particularly cross-section ratios. A generalized least-squares technique was employed. The output evaluations have not only updated cross sections and covariances, but also cross-reaction covariances, all of which include the additional data incorporated.

**Evaluations of the  $\text{Fe58}(n,\gamma)\text{Fe59}$  and  $\text{Fe54}(n,p)\text{Mn54}$  reactions for the ENDF/B-V dosimetry file**, R. E. Schenter, F. Schmittroth, and F. M. Mann, *SP594*, pp. 68-72 (Sept. 1980).

Key words: covariance matrices; cross section evaluation.

A generalized least-squares adjustment procedure has been used to evaluate two important dosimetry reactions for the ENDF/B-V files. Calculations for the cross section adjustments were made with the computer code FERRET, where input data included both integral and differential experimental data results. For the Fe54 reaction, important ratio measurements were renormalized to ENDF/B-V evaluations of  $\text{U235}(n,f)$ ,  $\text{U238}(n,f)$  and  $\text{Fe56}(n,p)$ . A priori curves which are required for the calculations were obtained using Hauser-Feshbach calculations from the codes NCAP (Fe58) and HAUSER\*5 (Fe54). Covariance matrices were also calculated and are included in the evaluations.

**Neutron energy spectra and angular distributions for Al and Nb(n,xn') reactions at 15.4 MeV**, S. Iwasaki, M. Sugimoto, T.



Tamura, T. Suzuki, H. Takahashi, and K. Sugiyama, *SP594*, pp. 73-77 (Sept. 1980).

Key words: Al and Nb; comparison; total neutron spectra.

Neutron energy and angular distributions from  $(n, n')$  reactions on aluminum and niobium have been measured at an incident energy of 15.4 MeV at twelve scattering angles from  $25^\circ$  to  $155^\circ$ . From these data, angle integrated spectra have been obtained. In general, present results are consistent with those of the previous experiments in the secondary neutron energy range from 2 to 10 MeV, but some discrepancy also existed between them. Data of the ENDF/B file could not reproduce present results, particularly for niobium. Total spectra were analyzed by a precompound reaction model.

Scattering of 10 MeV neutrons on silicon, W. Pilz, D. Schmidt, D. Seeliger, and T. Streil, *SP594*, pp. 78-79 (Sept. 1980).

Key words: coupled channels and Hauser-Feshbach analysis; optical model.

The elastic and inelastic differential cross sections for 10 MeV neutrons on silicon are measured. Neutrons were produced by the  $D(d, n)$  reaction in a gas target. The cross sections of the neutrons emitted from higher excited states are corrected with respect to neutrons from the deuteron break-up using special computer program. Figure 1 shows the experimental arrangement.

The measurements were carried out with a multi-angle TOF-detector system consisting of 8 detectors, located between angles of 15 and 160 degrees. The flight paths were about 3 meters, the energy spread about 120 keV and time resolution 3 ns.

Doppler broadening effect to neutron resonance cross sections for Ag, AgCl and Ag<sub>2</sub>O, H. I. Liou, R. E. Chrien, and R. Moreh, *SP594*, pp. 80-83 (Sept. 1980).

Key words: AgCl and Ag<sub>2</sub>O; Ag metal; Doppler broadening.

The neutron capture yield of the 16.3 eV resonance in  $^{107}\text{Ag}$  has been measured, using targets of Ag metal, AgCl and Ag<sub>2</sub>O at room, liquid N<sub>2</sub> and He temperatures. The effective temperature  $T'$  defined by Lamb for weak binding, and subsequently the Debye temperature  $\theta_D$ , were extracted for each case by a least squares shape fit. For Ag metal the measured  $\theta_D$  values agree with both the simple Debye theory and a prediction of the Ag lattice dynamics. The  $\theta_D$  values for AgCl and Ag<sub>2</sub>O show some variations with temperature. The results for AgCl at  $77.2^\circ$  and  $4.066^\circ$ , however, agree with the inelastic scattering and calorimetric data.

Measurement of the  $^{10}\text{B}/^6\text{Li}$  cross section ratio below 1 keV, J. B. Czirr and A. D. Carlson, *SP594*, pp. 84-85 (Sept. 1980).

Key words: cross sections; flux monitors; standards.

The ratio of the  $^{10}\text{B}(n, \alpha)$  and  $^6\text{Li}(n, \alpha)$  standard cross sections has been measured from  $\sim 1$  to 1000 eV with statistical uncertainties of  $< 1\%$ . The measurements agree with ENDF/B-V above  $\sim 20$  eV, however a significant difference is observed below  $\sim 20$  eV. The present measurements do not explain the discrepancy between recent  $^{235}\text{U}$  measurements at ORNL and LLL using  $^{10}\text{B}(n, \alpha)$  and  $^6\text{Li}(n, \alpha)$ , respectively, as flux monitors.

The neutron total cross section of single crystal silicon at 21 °K, R. M. Brugger, R. G. Fluharty, P. W. Lisowski, and C. E. Olsen, *SP594*, pp. 86-88 (Sept. 1980).

Key words: Si(n,n); single crystal; total cross section.

The neutron total cross section of a single crystal of Si has been studied over the energy range 0.003 eV to 50 eV at the Weapons Neutron Research Facility (WNR). The neutron energies were determined by time of flight. The 28.77 cm long Si sample was held at three temperatures, 296 °K, 77 °K, and 21 °K. The 21 °K temperature was obtained by filling an encircling cryostat with liquid H<sub>2</sub>. The region of greatest interest is below 1 eV where Bragg scattering from the perfect crystal is small and where thermal diffuse scattering can be reduced by cooling the Si. Near 0.05 eV the cross section dips to less than 1/5 its value at energies greater than 1 eV. This feature has allowed single crystals of Si to be used very successfully as thermal neutron band pass filters. Our data at 296 °K and 77 °K agree with previous measurements. Very little structure caused by Bragg scattering is observed. Our measured cross sections for 21 °K are somewhat below the 77 °K data but not enough lower to justify cooling a Si filter to 21 °K to dramatically improve its transmission.

A comparison of  $(n, \alpha)$  cross section measurements for  $^{10}\text{BF}_3$  and solid  $^{10}\text{B}$  from 0.5 to 10,000 eV, A. D. Carlson, C. D. Bowman, J. W. Behrens, R. G. Johnson, and J. H. Todd, *SP594*, pp. 89-92 (Sept. 1980).

Key words: cross sections; molecular binding; neutron reactions; neutron standards; phonons.

The  $(n, \alpha)$  cross sections of  $^{10}\text{BF}_3$  gas and solid  $^{10}\text{B}$  are compared in order to study possible influences of binding effects on reaction cross sections. It is shown that for  $^{10}\text{BF}_3$  a deviation from a  $1/v$  cross section of 8% is expected. The ratio of the measured cross sections does not show this deviation.

Perturbations of nuclear cross sections associated with changes in molecular vibrational energy, C. B. Bowman and R. A. Schrack, *SP594*, pp. 93-96 (Sept. 1980).

Key words: cross section; molecules; neutron reactions; neutron time-of-flight; vibration.

The change in molecular vibration energy upon absorption of a neutron by a nucleus bound in a free molecule can influence resonance shape and other aspects of neutron reaction cross section. A formalism is developed for centrosymmetric molecules such as UF<sub>6</sub> which allows a calculation of the displacement in resonance energy and the dispersion in resonance shape arising from molecular transitions. The calculations have been applied to the 6.67 eV resonance in  $^{238}\text{U}$ . Comparison with measurements of  $^{238}\text{U}_2\text{O}_8$  and  $^{238}\text{UF}_6$  indicate satisfactory agreement. Implications of these effects for other systems are discussed.

The ratio of the  $^{10}\text{BF}_3$  and  $^3\text{He}(n, p)$  cross sections between 0.025 eV and 25,000 eV, C. D. Bowman, J. W. Behrens, R. Gwin, and J. H. Todd, *SP594*, pp. 97-100 (Sept. 1980).

Key words: cross sections; eV neutrons; ratio; standards.

The  $^{10}\text{BF}_3(n, \alpha)$  and  $^3\text{He}(n, p)$  cross sections have been compared in the energy range from 0.025 to 25,000 eV. Measurements at NBS using filtered beams gave results at 2 and 25 keV. At the Oak Ridge National Laboratory using the ORELA facility measurements were completed between 0.025 and 10,000 eV. Normalizing the ratio of  $\text{BF}_3/\text{He}$  to 1 at 0.03 eV, the ratio increases by 1% at 10 eV, by 2% at a few hundred eV, by 4% at 2 keV, and by 16% at 25 keV. The large deviations at the higher energies are expected purely from the nuclear parameterization of the cross sections. However, the deviations from  $1/v$  in the ratio below 100 eV are surprising and perhaps might have their origin in the molecular binding for  $^{10}\text{B}$  in the  $^{10}\text{BF}_3$  system.

Measurements of the total neutron cross-sections of Be, Ni and Cu at room and liquid nitrogen temperatures in the energy range from 2.2 eV to 2.2 MeV, M. Adib, A. Abdel-Kawy, R. M. A. Maayouf, Y. Eid, G. Shuriet, and I. Hamouda, *SP594*, pp. 101-104 (Sept. 1980).

Key words: Be, Ni, Cu; Bragg cut-off; coherent and incoherent scattering.

The total neutron cross-sections of Be, Ni and Cu are measured using two time-of-flight spectrometers installed in front of two of the horizontal channels of the ET-RR-1 reactor. The measurements were carried out in the energy range from 2.2 eV-2.2 MeV at room temperature and at liquid nitrogen temperature for neutron energies below 5 MeV. The coherent scattering cross-sections of these elements were determined from the Bragg cut-offs observed in the behaviour of the total cross-sections at cold neutron energies. The incoherent cross-sections of Be, Ni and Cu were obtained from the analysis of the total neutron cross-section data beyond the Bragg cut-off. The one phonon annihilation process was estimated at long neutron wavelengths and was found to be in reasonable agreement with the results of calculations.

Chemical dependence of uranium fission, R. A. Schrack and C. D. Bowman, *SP594*, pp. 105-107 (Sept. 1980).

Key words: chemical dependence; delayed neutrons; fission yield; thermal neutrons.

A difference on the order of 4% in the delayed neutron yield from  $^{235}\text{U}$  after fission induced by thermal neutrons has been previously reported for samples of  $\text{U}_3\text{O}_8$  and  $\text{UO}_2$ . Both theoretical calculations and experimental checks have been made in an attempt to verify the effect. The calculation of the effect of phonon distribution on fission cross section using an Einstein model of the lattice phonon distribution shows no significant dependence on the chemical state. Experimental measurements of the fission fragment yield from thermal-induced fission of  $^{235}\text{U}$  in  $\text{UO}_2$  and  $\text{U}_3\text{O}_8$  were made. The relative fission fragment yield was:  $\text{UO}_2/\text{U}_3\text{O}_8 = .9972 \pm .0003$  where the error is from the counting statistics only. A second experiment was carried out that compared the delayed neutron yield after irradiations in a thermal neutron flux. A relative yield of  $\text{UO}_2/\text{U}_3\text{O}_8 = .9914 \pm .012$  was obtained. Neither theory nor experiment would thus support a chemical dependence on the order of the previously reported experiment.

Advanced converter reactors, P. R. Kasten, *SP594*, pp. 108-114 (Sept. 1980).

Key words: advanced converters; denatured uranium-thorium fuel cycles; fuel cycles; nuclear data needs; thorium reactor introduction; thorium reactors.

Advanced converter reactors (ACRs) of primary U.S. interest are those which can be commercialized within about 20 years, and are: Advanced Light-Water Reactors, Spectral-Shift-Control Reactors, Heavy-Water Reactors (CANDU type), and High-Temperature Gas-Cooled Reactors. These reactors can operate on uranium, thorium, or uranium-thorium fuel cycles, but have the greatest fuel utilization on thorium type cycles. The water reactors tend to operate more economically on uranium cycles, while the HTGR is more economical on thorium cycles. Thus, the HTGR had the greatest practical potential for improving fuel utilization. If the U.S. has 3.4-4 million tons  $\text{U}_3\text{O}_8$  at reasonable costs, ACRs can make important contributions to maintaining a high nuclear power level for many decades; further, they work well with fast breeder reactors in the long term under symbiotic fueling conditions. Primary nuclear data needs of ACRs are integral measurements of

reactivity coefficients and resonance absorption integrals.

Denatured fuel cycles, C. E. Till, *SP594*, pp. 115-118 (Sept. 1980).

Key words: denatured fuel; denatured Pu; nuclear proliferation; once-through cycles.

This paper traces the history of the denatured fuel concept and discusses the characteristics of fuel cycles based on the concept. The proliferation resistance of denatured fuel cycles, the reactor types they involve, and the limitations they place on energy generation potential are discussed. The paper concludes with some remarks on the outlook for such cycles.

The use of thorium in fast breeder reactors, D. E. Bartine, *SP594*, pp. 119-121 (Sept. 1980).

Key words: cross sections; fast reactors; integral and critical experiments; symbiosis; thorium.

Recently several fuel cycles involving thorium have been suggested for use in fast breeder reactors. These cycles involve the use of thorium in fuels containing  $^{233}\text{U}$  and fissile plutonium and the use of both internal and conventional thorium blanket elements. Studies were performed in the Engineering Physics Division at ORNL to determine the performance of fast breeder reactors utilizing such cycles. In addition, there is a current effort toward analyzing reaction rates, spectra, and integral measurements of prototypic fast reactor configurations involving thorium. These experiments were performed at the PROTEUS facility of the EIR laboratory at Würenlingen, Switzerland, and at the Tower Shielding Facility at ORNL. The analysis of these experiments provides insight regarding data needs for fast reactor applications involving the thorium cycle.

Results of the fast breeder fuel cycle analysis indicate a significant penalty from replacing Pu/ $\text{UO}_2$  fuel with U-233/ $\text{ThO}_2$  fertile blanket elements. Preliminary analysis of the experiments indicates improved agreement with neutron spectra involving deep penetration in  $\text{ThO}_2$  radial blankets by utilizing ENDF/B-V thorium cross section data as compared with ENDF/B-IV. However, thorium capture rates now appear significantly underpredicted.

Deep penetration integral experiment for a thorium blanket mockup, D. T. Ingersoll and F. J. Muckenthaler, *SP594*, pp. 122-124 (Sept. 1980).

Key words: blanket; GCFR; integral experiment; neutron transmission; thorium; total cross section.

An integral experiment has been performed for verification of radiation transport methods and nuclear data used for design of the radial shield for the gas-cooled fast breeder reactor (GCFR). The experiment included a thorium oxide blanket mockup and several shield configurations. The blanket measurements were needed to reduce uncertainties in the cross-section data used for calculating neutron transmission through a thorium blanket and to bound the uncertainties in calculated gamma-ray heating rates within the blanket.

Measured neutron spectra and integral flux data are compared to 1D calculations of the transmitted flux. Calculations using ENDF/B-IV and ENDF/B-V data for thorium are compared and show the version V data to be superior above 1 MeV. The experiment, which is primarily sensitive to the total removal cross section, also showed V to be an improvement below 1 MeV, but still discrepant from the measurements.

Analysis of a Swiss thorium blanket integral experiment, J. R. White, D. T. Ingersoll, U. Schmock, and K. Gmür, *SP594*, pp. 127-130 (Sept. 1980).



**Key words:** capture cross section; ENDF/B-5; GCFR; integral experiment; thorium.

A detailed postanalysis of the ThO<sub>2</sub> axial blanket experiment (CORE 14) performed at the PROTEUS critical facility is presently being completed at ORNL. The purpose of the analysis is to compare measured reaction rates along the axial centerline of the test zone with results calculated utilizing various data libraries. In particular, the analysis is investigating the adequacy of the available thorium data. The cross section data supplied by EIR is compared to ENDF/B-4 data collapsed to the broad-group level via the AMPX modular code system. Furthermore, a comparison of C/E values using ENDF/B-4 and new ENDF/B-5 thorium data is given. Finally, some theory and modeling questions are investigated. Detailed results from the above analyses are presented which support the conclusion that the presently available <sup>232</sup>Th data appears inadequate for accurate GCFR fuel cycle studies.

**Data needs for fuel handling and waste management aspects of thorium fuel cycles,** S. Nair and H. F. Macdonald, *SP594*, pp. 131-134 (Sept. 1980).

**Key words:** cross-section accuracy requirements; fuel handling; high-level waste management; thorium HTR fuel cycles.

The cross-section data needs for strategies employing various feed fuels in a thorium-fuelled HTR have been examined from the viewpoint of fuel handling and high-level waste management. The important nuclides and their major production routes have been identified and tentative accuracy requirements are suggested for some key spectrum-averaged cross-sections not covered by the requirements for reactor physics calculations.

**Neutron scattering cross sections from (n,n') and (n,n'γ) methods—A comparison,** F. D. McDaniels, G. P. Glasgow, and M. T. McEllistrem, *SP594*, pp. 135-138 (Sept. 1980).

**Key words:** Zr, Mo, and Sm isotopes.

Neutron inelastic scattering cross sections can be obtained conveniently from (n,n'γ) yields provided a good normalization standard is available. Measurements from independent neutron and γ-ray detection experiments are compared to confirm the use of the <sup>56</sup>Fe(n,n'γ)<sup>56</sup>Fe—846.7-keV production cross section as a normalization standard.

**Double differential neutron scattering cross sections for Fe, Cu, Ni and Pb between 8 and 12 MeV,** A. Beyerle, C. Gould, W. Seagondollar, P. Thambidurai, S. El-Kadi, G. Glendinning, C. E. Nelson, F. O. Purser, and R. L. Walter, *SP594*, pp. 139-142 (Sept. 1980).

**Key words:** Fe, Cu, Ni, Pb; measure time-of-flight spectra.

Neutron emission spectra have been measured for iron, nickel, copper, and lead at incident neutron energies from 8-12 MeV. The TUNL time-of-flight system has been used to obtain data at about 5 scattering angles for each incident energy down to an emitted neutron energy of less than 500 keV. The experimental procedure and progress toward converting the yields to double-differential cross sections will be reviewed.

**Elastic neutron scattering from <sup>63</sup>Cu, <sup>65</sup>Cu, <sup>54</sup>Fe and <sup>56</sup>Fe from 8 to 12 MeV,** S. El-Kadi, R. Pedroni, G. Glendinning, C. E. Nelson, F. O. Purser, R. L. Walter, A. Beyerle, C. Gould, and W. Seagondollar, *SP594*, pp. 143-145 (Sept. 1980).

**Key words:** differential cross section; optical model comparison.

Elastic scattering cross sections have been measured for 8

to 12 MeV neutrons for <sup>63</sup>Cu, <sup>65</sup>Cu, <sup>54</sup>Fe and <sup>56</sup>Fe using the TUNL time-of-flight facility. The measurements are compared to earlier data and to optical model calculations.

**Elastic and inelastic scattering of 24 MeV neutrons from even isotopes of Ni,** Y. Yamanouti, J. Rapaport, S. M. Grimes, V. Kulkarni, R. W. Finlay, D. Bainum, P. Grabmayr, and G. Randers-Pehrson, *SP594*, pp. 146-149 (Sept. 1980).

**Key words:** coupled-channel; deformation parameter; differential cross sections; DWBA; elastic scattering; global optical potential; inelastic scattering; neutron.

Differential cross sections for the scattering of 24 MeV neutrons from <sup>58,60</sup>Ni were measured as part of a continuing study of nucleon scattering from single-closed-shell nuclei. Measurements were taken every 5° from 15° to 150° using the Ohio University time-of-flight spectrometer. Inelastic excitation of the first 2<sup>+</sup> and 3<sup>-</sup> states was measured simultaneously with the elastic scattering in each case. Results are analyzed in terms of a global nucleon-nucleus optical model potential, DWBA and coupled-channel calculations using collective model.

**Measurement of differential elastic and inelastic scattering cross sections with 14 MeV neutrons on barium and chromium,** G. Winkler, K. Hansjakob, and G. Staffel, *SP594*, pp. 150-154 (Sept. 1980).

**Key words:** discrete levels; nuclear reactions; optical and statistical model.

The elastic scattering of 14 MeV neutrons has been measured at angles from 20° to 130° with an accuracy of about 10%, the high energy part of the inelastic neutron spectrum has been measured as a function of θ and E<sub>n'</sub> in the region of θ = 20°-130° and E<sub>n'</sub> = 4-12 MeV with an energy resolution ≤ 0.5 MeV, on elemental Barium and Chromium, using time-of-flight techniques. The cross sections for forming the first 2<sup>+</sup> level of <sup>138</sup>Ba and <sup>52</sup>Cr and the 3<sup>-</sup> level of <sup>52</sup>Cr(4.56 MeV) have been measured. The results are compared with optical and statistical model calculations. The knowledge of the neutron interaction with Barium is important due to its use in reactor shielding, Chromium is expected to be an important structural material in fusion reactors.

**Determination of the capture width of the 27.7 keV s-wave resonance in <sup>56</sup>Fe,** K. Wisshak and F. Käppeler, *SP594*, pp. 155-158 (Sept. 1980).

**Key words:** capture cross section; multilevel analysis.

The capture width of the 27.7 keV s-wave resonance in <sup>56</sup>Fe has been determined using a setup completely different from previous experiments. A pulsed 3 MV Van de Graaff accelerator and the <sup>7</sup>Li(p,n) reaction served as a neutron source. Capture gamma rays were observed by a Moxon-Rae detector and gold was used as a standard. The samples were positioned at a flight path of only 7.6-8.0 cm. This allowed the use of very thin samples avoiding large multiple scattering corrections. Three metallic discs enriched in <sup>56</sup>Fe were used with a thickness between 0.6 and 0.15 mm. Capture events in the detector due to resonance scattered neutrons were discriminated by time-of-flight. The result for the capture width is Γ<sub>γ</sub> = 0.99 with a statistical uncertainty of 1.3% and a systematic uncertainty of ~5%.

**Total neutron cross section measurements on <sup>54</sup>Fe, <sup>56</sup>Fe and <sup>57</sup>Fe,** E. M. R. Cornelis, C. R. Jungmann, L. Mewissen, and F. Poortmans, *SP594*, pp. 159-162 (Sept. 1980).

**Key words:** Breit-Wigner resonances; R-matrix; time-of-flight.

High resolution total neutron cross section measurements have been performed on samples of enriched isotopes (on

loan from ORNL) of  $^{54}\text{Fe}$ ,  $^{56}\text{Fe}$  and  $^{57}\text{Fe}$  in the energy range from 35 keV up to 2 MeV. The experiments were made on a 200 meter flight path at the GELINA facility using a plastic scintillator (NE 110) as neutron detector. The R-matrix multi-level code FANAL was used to fit the broad s-wave resonances and the multi-level Breit-Wigner code SIOB to fit the narrow  $l > 0$  resonances. The analysis is completed for  $^{54}\text{Fe}$  and  $^{56}\text{Fe}$  up to a neutron energy of 300 keV.

**Neutron capture cross section measurements of  $^{56}\text{Fe}$ ,** A. Brusegan, F. Corvi, G. Rohr, R. Shelley, and T. van der Veen, *SP594*, pp. 163-167 (Sept. 1980).

Key words: cross section measurements; neutron capture data.

High resolution capture cross section measurements have been carried out on an enriched sample of  $^{56}\text{Fe}$  at the Geel linear electron accelerator. The data have been analysed up to 100 keV and the deduced capture areas and relevant resonance parameters are given. Special emphasis has been given to problems connected with the weighting method and the capture data normalization.

**Fast-neutron total and scattering cross sections of Cr, Fe and  $^{60}\text{Ni}$**  A. B. Smith, P. T. Guenther, and J. F. Whalen, *SP594*, pp. 168-172 (Sept. 1980).

Key words: Cr, Fe and  $^{60}\text{Ni}$ ; model interpretation; nuclear reactions.

Neutron total cross sections are measured with broad resolutions (50-100 keV) from  $\approx 1.0$ -4.5 MeV at intervals of  $\lesssim 50$  keV and to accuracies of  $\approx 1\%$  using a variety of sample thicknesses. Differential elastic-scattering cross sections are measured at  $\Lambda$  10 scattering angles distributed between  $20$ - $160^\circ$  from  $\approx 1.5$ -4.0 MeV at intervals of  $\lesssim 50$  keV. Angle-integrated elastic scattering cross sections are deduced from the measured values to accuracies  $\gtrsim 5\%$ . Inelastic-neutron-scattering cross sections are determined up to incident neutron energies of 4.0 MeV, at scattering angles distributed between  $20$ - $160^\circ$  and for 5 observed excitations in Cr, for 7 in Fe and for 6 in  $^{60}\text{Ni}$ . The experimental results are discussed in terms of conventional optical-statistical models with attention to cross section fluctuations and in the context of direct-scattering processes. The experimental and calculational results are compared with the corresponding evaluated quantities given in the ENDF/B file with attention to regions of agreement and inconsistency.

**Neutron resonance parameters of  $^{79}\text{Br}$  and  $^{81}\text{Br}$  up to 15 keV,** M. Ohkubo, Y. Kawarasaki, and M. Mizumoto, *SP594*, pp. 173-176 (Sept. 1980).

Key words: bromine; resonance parameters.

Resonance parameters of separated isotopes of bromine were measured using TOF spectrometer of Japan Atomic Energy Research Institute linear accelerator. Transmission and capture measurements were made with  $^6\text{Li}$ -glass and Moxon-Rae detectors, on separated isotopes ( $\sim 98\%$ ) of  $^{79}\text{Br}$  and  $^{81}\text{Br}$ . Resonance analyses were made on transmission data with an area analysis code, and on capture data with a Monte-Carlo program CAFIT. For  $^{79}\text{Br}$   $g\Gamma_n^0$  values for 156 levels below 10 keV are obtained, and for  $^{81}\text{Br}$  100 levels below 15 keV. Strength functions are obtained: for  $^{79}\text{Br}$   $S_0 = (1.27 \pm 0.14) \times 10^{-4}$  below 10 keV, and for  $^{81}\text{Br}$   $S_0 = (0.86 \pm 0.14) \times 10^{-4}$  below 15 keV. Intermediate structures are observed in the resonances of  $^{81}\text{Br}$  showing clusters of levels at 1.2, 10, 11.5 and 14 keV, where the sum of  $g\Gamma_n^0$  vs. neutron energy shows steep rises.

Cross section adjustment applied to estimation of uncertainty

in the breeding ratio of an LMFBR, J. H. Marable, C. R. Weisbin, and G. de Saussure, *SP594*, pp. 177-181 (Sept. 1980).

Key words: breeding ratio; calculational bias uncertainties; fast reactors; group cross sections; integral experiments; least-squares adjustment; LMFBR; sensitivity analysis; uncertainty analysis.

Eleven fast-reactor benchmark experiments and two neutron-field benchmark experiments were applied to a least-squares adjustment of a 26-group cross section library based primarily on ENDF/B-IV. The covariance data includes correlations between cross sections for different energies, reactions, and materials, and between integral experiments, and covariances of calculational bias factors due to specific modeling and calculational procedures. The results of the adjustment are applied to the determination of the uncertainties in the multiplication factor and in the breeding ratio of a large LMFBR design model fixed by the Large Core Code Evaluation Working Group (LCCEWG).

**Relative consistency of ENDF/B-IV and -V with fast-reactor benchmarks,** Y. Yeivin, J. J. Wagschal, J. H. Marable, and C. R. Weisbin, *SP594*, pp. 182-186 (Sept. 1980).

Key words: chi-square; data consistency; data testing; ENDF/B-IV; ENDF/B-V; fast reactors; group cross sections; integral experiments; least-squares adjustment.

The consistency of eleven selected fast-reactor and two neutron-field integral experiments with the ENDF/B-IV and -V libraries was examined by considering contributions to chi-square. Integral measurements least consistent with each given library were identified one at a time, and the particular cross sections which were significantly adjusted at each step were also identified. The results of this analysis demonstrate that, with respect to twelve out of the thirteen integral measurements considered, ENDF/B-V is a marked improvement over Version IV in the sense that (a) the integral data are significantly more consistent with Version V than with Version IV, (b) fewer cross sections need to be adjusted to achieve agreement between all the experimental data and the corresponding values calculated by Version V, and (c) the necessary adjustments are smaller.

**A test of ENDF/B library in the criticality predictions of fast assemblies,** V. K. Shukla and S. B. Garg, *SP594*, pp. 187-189 (Sept. 1980).

Key words: diffusion theory; self-shielding factors; spherical model; transport theory  $k_{eff}$ .

A criticality analysis has been carried out of several fast neutron multiplying assemblies using the 27-group cross-section set and resonance self-shielding factors which have been derived from version III and IV of ENDF/B library. These assemblies utilize metallic, oxide and carbide fuels of uranium and plutonium and represent very soft to very hard neutron spectra. The analysis indicates that fission and scattering cross-sections of uranium and its isotopes need updating in the MeV energy range.

**Basic nuclear data and the fast reactor shielding design—Formulaire PROPANE Do,** J. C. Estiot, M. Salvatores, and J. P. Trapp, *SP594*, pp. 190-193 (Sept. 1980).

Key words: method approximations; multigroup data; neutron propagation.

This paper presents a calculational scheme—formulaire PROPANE—to calculate the deep neutron penetration in the fast reactor shield. The emphasis is put on the multigroup data and method approximations. The performances of this formulaire are presented.

Nuclear data for shielding calculations: Na cross-section ad-



justment using propagation experiments, J. C. Estiot, M. Salvatores, J. P. Trapp, A. De Carli, and V. Rado, *SP594*, pp. 194-198 (Sept. 1980).

Key words: Na cross-section adjustment; sodium propagation experiments.

This paper presents an analysis of the propagation experiments in sodium, performed both with Tapiro and Harmonie source reactors. The neutron source in both experiments was varied by replacing the normal reflectors with a buffer for fast reactor blanket simulation. A satisfactory consistency was found between the two series of experiments. The resulting E-C/C values were used in an attempt to adjust sodium cross-sections. There is evidence for a slight decrease ( $\approx 5 + 7\%$ ) in the total cross-section of sodium below  $\approx 100$  keV and a significant ( $\approx 20\%$ ) decrease in all the inelastic cross-sections above  $\approx 2$  MeV.

**On the discrepancy between differential and integral results for the  $^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$  cross section,** G. Winkler, D. L. Smith, and J. W. Meadows, *SP594*, pp. 199-203 (Sept. 1980).

Key words: excitation function; fluence monitor; reactor dosimetry; threshold reactions; U-fission spectrum averaged cross sections.

The threshold-reaction  $^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$  is of special importance in reactor dosimetry for long-term fast-flux integration. The inconsistency in the available differential and integral data base has limited the applicability of that reaction as a reliable monitor. The availability of results from a recent measurement of the excitation function for the reaction  $^{63}\text{Cu}(n,\alpha)$  at ANL prompted a further investigation of this problem. The implications of the new data are discussed.

**Vitamin E: A multipurpose ENDF/B-V coupled neutron-gamma cross section library,** J. Barhen, D. G. Cacuci, W. E. Ford III, R. W. Roussin, J. J. Wagschal, C. R. Weisbin, J. E. White, and R. Q. Wright, *SP594*, pp. 204-208 (Sept. 1980).

Key words: ENDF/B-V; fusion neutronics; LMFBR analysis; LWR shielding and dosimetry; multigroup cross section libraries; weapons applications.

The U.S. Department of Energy (DOE) Office of Fusion Energy (OFE) and the Division of Reactor Research and Technology (DRRT) jointly sponsored the development of a coupled fine-group cross section library [VITAMIN-C]. The experience gained in the generation, validation and utilization of the VITAMIN-C library along with its broad range of applicability has led to the request for updating this data set using ENDF/B-V. Additional support in this regard has been provided by the Defense Nuclear Agency (DNA) and by EPRI in support of weapons analyses and light water reactor shielding and dosimetry problems, respectively. The rationale for developing the multipurpose ENDF/B-V based VITAMIN-E library is presented, with special emphasis on new models used in the data generation algorithms. The library specifications and testing procedures are also discussed in detail. The distribution of the VITAMIN-E library is currently subject to the same restrictions as the distribution of the ENDF/B-V data.

**Verification of photon-production processing techniques,** R. J. Barrett, W. E. Ford III, Y. Gohar, T. S. Bohn, R. E. MacFarlane, and R. M. Boicourt, *SP594*, pp. 209-212 (Sept. 1980).

Key words: code comparison; ENDF/B-IV; multigroup; photon-production.

Several laboratories have independently developed computer codes which use evaluated data from the ENDF/B file to produce group-averaged cross sections and transfer

matrices for neutron-induced photon production. There have been several instances in which these codes have produced discrepant data sets, thereby casting doubt on the validity of all the codes. For a series of specified test cases, the results from three of these codes (NJOY, LAPHNGAS, and MACK-IV) were systematically compared with each other and with hand calculations. Several shortcomings in the codes have been discovered and repaired. One major difference of philosophy has been resolved. Consequently, the codes have arrived at substantial agreement on all of the nearly 1200 nonzero group constants calculated in the study.

**The MATXS-TRANSX system and the CLAW-IV nuclear data library,** R. J. Barrett and R. E. MacFarlane, *SP594*, pp. 213-216 (Sept. 1980).

Key words: ENDF/B-IV; neutron and photon transport; processed cross-section library; prompt and delayed nuclear activities.

A new system for post-processing multigroup cross sections has been developed. The MATXS interface format stores group-averaged cross sections and scattering matrices for all reactions of interest for neutron transport, photon production, and photon transport, including kerma factors, thermal upscatter matrices, and self-shielded cross sections. The TRANSX code can produce a variety of working libraries for transport calculations from a single MATXS file. TRANSX capabilities include group collapsing, material mixing, coupling of neutron and photon matrices, transport corrections, interpolations of self-shielding data, calculation of fission vectors, and creation of flexible user-specified response functions. Using the MATXS-TRANSX system, we have produced the CLAW-IV library, a 73-isotope coupled set in 30-neutron and 12-photon groups. The library, available from RSIC, includes prompt and steady-state transfer tables in FIDO format, prompt and total fission spectra, and a table of useful response functions including heating and gas production.

**ENDF/B-IV and V cross section libraries for thermal power reactor analysis,** R. E. MacFarlane, *SP594*, pp. 217-220 (Sept. 1980).

Key words: ENDF/B-V; thermal reactor cross sections.

The NJOY processing system has been used to produce thermal reactor cross-section libraries from ENDF/B-IV and V evaluations for the fuel cycle codes EPRI-CELL and EPRI-CPM, for the continuous-energy Monte Carlo code MCNP, and for the Los Alamos discrete-ordinates transport codes. This consistent data source has allowed the approximate methods (equivalence theory,  $B_1$ , integral transport,  $P_L$ - $S_N$ ) to be compared with accurate Monte Carlo results. So far, this has resulted in improved methods for space-and-energy self-shielding in the resonance range (e.g., the NJOY flux calculator, epithermal disadvantage factors for EPRI-CELL, shielded elastic removal), it has shown why the newest ENDF-based libraries initially gave results worse than the old libraries, and it has pointed out problems for future study such as resonance interference effects at high burnup. Finally, the results are compared to various criticality benchmarks to evaluate the performance of ENDF/B-V for thermal reactor analysis and to establish the biases introduced by the approximate methods used in the fuel cycle codes.

**Finite element basis used in consistent nuclear data evaluation,** F. Schmittroth, *SP594*, pp. 221-223 (Sept. 1980).

Key words: covariance; cross section; evaluation.

A method for the consistent evaluation of nuclear cross sections and other data is presented. The method allows the

simultaneous inclusion of nuclear model calculations, microscopic and integral measurements, and the results of previously adjusted multigroup cross sections in a consistent evaluation. Complete covariance information is retained throughout the analysis.

**Effect of resonance interference between U-238 and CS-133 on isotopic correlation of fission product**, H. Takano, Y. Ishiguro, and S. Matsuura, *SP594*, pp. 224-227 (Sept. 1980).

Key words: burnup; fission product; JPDR-I reactor; resonance integral; resonance interference effect; spent fuel.

Interference effect between resonances of  $^{238}\text{U}$  and  $^{133}\text{Cs}$  was calculated for the spent fuel rod of Japan Power Demonstration Reactor I (JPDR-I). The resonance interference effect reduces resonance integral of  $^{133}\text{Cs}$  by 4-15 percent. The main reduction is caused by the resonance interference between the 5.9 eV level of  $^{133}\text{Cs}$  and 6.67 eV level of  $^{238}\text{U}$ . The interference effect depends considerably on both the concentration of  $^{133}\text{Cs}$  and the void fraction of coolant water, but its dependence on temperature variation of fuel rod is small. The effective resonance integral of  $^{133}\text{Cs}$  becomes small by about 5 percent when the void fraction of coolant water is changed from zero to 45 percent. It is concluded that the value of five percent is a very important correction factor which proves a linear correlation between activity ratio  $^{134}\text{Cs}/^{137}\text{Cs}$ , neutron capture product to direct fission product, and burnup.

**Neutron cross sections for fusion**, R. C. Haight, *SP594*, pp. 228-238 (Sept. 1980).

Key words: activation; dosimetry; fusion; neutron heating; neutron transport; radiation damage; tritium breeding.

First generation fusion reactors will most likely be based on the  $^3\text{H}(\text{d},\text{n})^4\text{He}$  reaction, which produces 14-MeV neutrons. In these reactors, both the number of neutrons and the average neutron energy will be significantly higher than for fission reactors of the same power. Accurate neutron cross section data are therefore of great importance. They are needed in present conceptual designs to calculate neutron transport, energy deposition, nuclear transmutation including tritium breeding and activation, and radiation damage. They are also needed for the interpretation of radiation damage experiments, some of which use neutrons up to 40 MeV. In addition, certain diagnostic measurements of plasma experiments require nuclear cross sections. The quality of currently available data for these applications will be reviewed and current experimental programs will be outlined. The utility of nuclear models to provide these data also will be discussed.

**Shielding of fusion reactors**, R. G. Alsmiller, Jr., *SP594*, pp. 239-245 (Sept. 1980).

Key words: fusion; neutral beam injection; neutrons; nuclear heating; photon dose rate; photons; shielding.

The blanket and shield assemblies of fusion reactors will contain a significant number of very sizable penetrations (neutral beam injection ducts, pumping ports, etc.). The combination of high-energy neutrons and large penetrations will introduce severe design problems that are quite different from those encountered previously. Fusion reactors with their penetrations are very complex geometric structures and in calculating nuclear effects (heating, activation, etc.) tradeoffs must be made between computing efficiency and the accuracy in the geometric modeling. The types of problems that arise due to large penetrations will be illustrated by the calculations that have been carried out to aid in the design of the shielding for the neutral beam injectors of the Tokamak Fusion Test Reactor being built at Princeton University.

**Tritium breeding in fusion**, M. T. Swinhoe, *SP594*, pp. 246-253 (Sept. 1980).

Key words: activation; breeding blankets; DT fusion tritium breeding ratio; ENDF/B; integral and differential experiments; LiOH; liquid scintillator; quenching.

Commercial DT fusion reactors need a breeding ratio (BR) of at least unity. The accuracy of BR calculations is limited by data uncertainties, especially the  $^7\text{Li}(\text{n},\text{n}'\alpha\text{t})$  cross-section. A recent absolute measurement of this cross-section (4-14 MeV) is described. These results and other experimental evidence for a discrepancy in the ENDF/B evaluated cross-section are presented. The effect of the new measurements on various reactor blanket designs is also discussed.

**Charged particle cross section requirements for advanced fusion fuel cycles**, G. W. Shuy and R. W. Conn, *SP594*, pp. 254-264 (Sept. 1980).

Key words: charged particle cross section needs; fusion; fusion reactivity.

Charged particle cross sections required for advanced fusion fuel cycle calculations are discussed. Reactions important for the d-d, d- $^3\text{He}$ , d- $^6\text{Li}$ , p- $^6\text{Li}$  and p- $^{11}\text{B}$  cycles are described. The importance of nuclear elastic scattering is emphasized. Important fusion cross sections and the energy range where data is required are identified. Of particular interest for the propagating p- $^6\text{Li}$  cycle is the  $^6\text{Li}(\text{d},\text{p})^7\text{Be}$  reaction where the  $^7\text{Be}$  can be in different energy states. The reactivity of the catalyzed d-d reaction at  $T_i = 75$  keV can be increased by 25% at  $T_e = 50$  keV to 75% at 100 keV relative to the reactivity neglecting nuclear elastic scattering. The result is due to fusion events between fast deuterons produced by elastic scattering with the back-ground ions. The fraction of energy given to electrons is likewise influenced by nuclear elastic scattering. The fraction of a 14.5 MeV proton's energy given to electrons at 100 keV decreases from 85% when only coulomb scattering is assumed to 50% when coulomb plus nuclear scattering is included.

**Measurement and analysis of neutron spectra in some assemblies of reactor materials**, I. Kimura, *SP594*, pp. 265-274 (Sept. 1980).

Key words: group constants; neutron spectrum; sensitivity coefficient; time-of-flight; transport calculation.

In order to assess group constants for reactor materials, energy spectra of neutrons from about 1 keV to a few MeV in some sample assemblies have been measured by the linac-time-of-flight method and the results are compared with those theoretically predicted by one-dimensional transport calculation. In addition to the ordinary large bulk pile system, a smaller pile surrounded by a reflector and a slab scattering method have been investigated by introducing the sensitivity coefficients of group constants to neutron spectrum. Typical results for some reactor materials taken at the Research Reactor Institute, Kyoto University are shown.

**Neutron transport in structural materials and shielding design**, M. Salvatores, *SP594*, pp. 275-284 (Sept. 1980).

Key words: bias factors; neutron transport; shielding.

In this paper the recent development in integral Benchmark experiments and their analysis is reviewed. The main problems related to data and method assessment are also briefly reviewed. In particular, the basic data processing and multigroup structure optimization and the effects of the basic data uncertainty evaluation are stressed.



The representativity of an integral experiment from the designer point of view is indicated. Moreover a procedure to deduce design oriented bias factors is outlined. Cross section adjustments are indicated as a useful tool to reduce these bias factors and their uncertainties.

**Neutron dosimetry for radiation damage in fission and fusion reactors**, D. L. Smith, *SP594*, pp. 285-296 (Sept. 1980).

**Key words:** cross sections; fission; fusion; neutron dosimetry; radiation damage; radioactivity; reactors.

The properties of materials subjected to the intense neutron radiation fields characteristic of fission power reactors or proposed fusion energy devices is a field of extensive current research. These investigations seek important information relevant to the safety and economics of nuclear energy. In high-level radiation environments, neutron metrology is accomplished predominantly with passive techniques which require detailed knowledge about many nuclear reactions. The quality of neutron dosimetry has increased noticeably during the past decade owing to the availability of new data and evaluations for both integral and differential cross sections, better quantitative understanding of radioactive decay processes, improvements in radiation detection technology, and the development of reliable spectrum unfolding procedures. However, there are problems caused by the persistence of serious integral-differential discrepancies for several important reactions. There is a need to further develop the data base for exothermic and low-threshold reactions needed in thermal and fast-fission reactor dosimetry, and for high-threshold reactions needed in fusion-energy dosimetry. The unsatisfied data requirements for fission reactor dosimetry appear to be relatively modest and well defined, while the needs for fusion are extensive and less well defined because of the immature state of fusion technology. These various data requirements are examined with the goal of providing suggestions for continued dosimetry-related nuclear data research.

**Discussion of integral experiment C/E discrepancies**, L. G. LeSage and R. D. McKnight, *SP594*, pp. 297-306 (Sept. 1980).

**Key words:** delayed neutron data; eigenvalue; ENDF/B-IV; integral experiments; reaction rate ratios; reactivity worths; ZPR critical assembly.

Calculation-to-experiment discrepancies for several key integral parameters measured in ZPR fast critical assemblies are examined. Discussion includes a brief review of experimental and calculational methods and an estimate of their uncertainties. Comparison of the bias between the calculated and experimental values with their combined estimated uncertainties is used to infer nuclear data deficiencies. Several of these C/E discrepancies indicate probable errors in the ENDF/B-IV nuclear data files.

**Cross sections for fast neutron capture on Se, Cd and Os isotopes**, M. Herman and A. Marcinkowski, *SP594*, pp. 307-310 (Sept. 1980).

**Key words:** cross sections on Se, Cd, Os; statistical model analysis.

Activation capture cross sections were measured for Se, Cd and Os isotopes in the neutron energy range from 0.5 MeV to 1.3 MeV. The results of measurements are compared with statistical model calculations.

**Optical model calculations of nucleon interactions with  $^{93}\text{Nb}$ , from 10 keV up to 50 MeV**, C. Lagrange, *SP594*, pp. 311-314 (Sept. 1980).

**Key words:** isobaric analog; n-scattering; optical potential; (p,p) and (p,n) reactions.

The neutron spherical optical potential is determined following the SPRT method by a fit to strength functions, scattering radius, total cross section and neutron elastic scattering data. Comparison to the potential obtained with existing proton scattering data, (p,p) (p,n), provides a basis for the determination of the complex symmetry term of the optical potential. Calculations using the J.L.M. optical model will be also presented and discussed.

**Neutron resonance parameters for palladium isotopes**, P. Staveloz, E. Cornelis, L. Mewissen, F. Poortmans, G. Rohr, R. Shelley, and T. Van Der Veen, *SP594*, pp. 315-318 (Sept. 1980).

**Key words:** enriched targets; palladium isotopes; resonance parameters deduced.

We have undertaken a systematic study of neutron resonance parameters for the isotopes Pd-104,105,106,108 and 110 (enriched isotopes on loan from ORNL) in response to requests for such data on important fission products. Various neutron time-of-flight experiments have been performed at GELINA—capture, elastic scattering and total cross section measurements. Parity assignments are made on the basis of low-bias to high bias ratios deduced from capture gamma-ray spectra. The resonance parameter analysis is completed for Pd-105 and partial results are available for Pd-106,108 and 110.

**Resonance parameters of  $^{96}\text{Zr}$  below 40 keV**, C. Coceva, P. Giacobbe, and M. Magnani, *SP594*, pp. 319-322 (Sept. 1980).

**Key words:** single-level analysis; Zr(n,total) cross section.

Time-of-flight neutron transmission measurements on  $\text{ZrO}_2$  enriched samples, performed with high resolution, allowed evaluation of energy, spin, parity and neutron width of fourteen  $^{96}\text{Zr}$  resonances below 40 keV. Accurate single-level analysis was carried out. Strength function estimate is significant only for p-wave, owing to the limited number of resonances.

**Neutron capture cross sections of Y, Nb, Gd, W and Au between 0.5 and 3.0 MeV**, G. Grenier, J. P. Delaroche, S. Joly, C. Lagrange, and J. Voignier, *SP594*, pp. 323-327 (Sept. 1980).

**Key words:** statistical model calculations; Y, Nb, Gd, W and Au(n, $\gamma$ ).

Absolute neutron capture cross section measurements for Y, Nb, Gd, W and Au as well as for the following isotopes  $^{155}\text{Gd}$ ,  $^{156}\text{Gd}$ ,  $^{157}\text{Gd}$ ,  $^{158}\text{Gd}$ ,  $^{182}\text{W}$ ,  $^{183}\text{W}$ ,  $^{184}\text{W}$ ,  $^{186}\text{W}$  were carried out in the 0.5 MeV-3.0 MeV energy range. For most of these isotopes, available data were scarce and discrepant. In the present work the capture cross sections were determined through direct  $\gamma$ -ray spectrum emitted by the samples (integrated spectrum method) and compared with statistical model calculations involving transmission coefficients deduced from spherical or deformed optical potential analyses.

**Neutron radiative capture and transmission measurements of  $^{147}\text{Sm}$  and  $^{149}\text{Sm}$** , M. Mizumoto, M. Sugimoto, Y. Nakajima, Y. Kawarasaki, Y. Furuta, and A. Asami, *SP594*, pp. 328-332 (Sept. 1980).

**Key words:** average capture cross sections; resonance parameters.

The neutron capture and transmission of  $^{147}\text{Sm}$  and  $^{149}\text{Sm}$  were measured at the 55 m time-of-flight station of the Japan Atomic Energy Research Institute Electron Linear Accelerator. Measurements were carried out with a large liquid scintillation detector, a  $^6\text{Li}$  glass detector and a  $^{10}\text{B}$ -NaI detector using enriched samples of  $^{147}\text{Sm}$  (98.34%) and



$^{149}\text{Sm}$  (97.72%). The average capture cross sections were deduced from 3.3 to 300 keV with an estimated accuracy of 5 to 15%. The transmission data were analyzed with a multi-level Breit Wigner formula to obtain neutron widths of resonances up to 2 keV for  $^{147}\text{Sm}$  (212 resonances) and 520 eV for  $^{149}\text{Sm}$  (157 resonances). The S-wave strength functions and average level spacings were found to be  $10^4 S_0 = 4.8 \pm 0.5$ ,  $\bar{D} = 5.7 \pm 0.5$  eV for  $^{147}\text{Sm}$  and  $10^4 S_0 = 4.6 \pm 0.6$ ,  $\bar{D} = 2.2 \pm 0.2$  eV for  $^{149}\text{Sm}$ .

**Calculation of neutron cross sections for tungsten isotopes,** E. D. Arthur and C. A. Philis, *SP594*, pp. 333-335 (Sept. 1980).

Key words: coupled-channel methods; Hauser-Feshbach; neutron cross-section calculations; preequilibrium.

Neutron-induced cross sections on tungsten isotopes have been calculated in the energy range between 0.2 and 20 MeV using preequilibrium-statistical model techniques. The success of these calculations, which form part of an effort to improve the evaluated neutron and gamma-ray production cross sections for tungsten appearing in ENDF/B, depends strongly on the determination of consistent input parameter sets applicable over the entire range of interest. For example, neutron optical model parameters have been derived through a simultaneous analysis of total cross sections, resonance data, and angular distributions. These parameters, when used in multistep Hauser-Feshbach calculations, produce good agreement with varied experimental data such as neutron inelastic scattering excitation functions and (n,2n) cross sections. Likewise, gamma-ray strength functions have been determined through fits to neutron capture data that produce calculated results that compare well to measured gamma-ray production cross sections. A description of the techniques used in such parameter determinations as well as comparison of calculated results to experimental data will be presented.

**Coherent optical and statistical model analysis of  $^{182,183,184,186}\text{W}$  neutron cross sections,** J. P. Delaroche, G. Haouat, J. Lachkar, Y. Patin, J. Sigaud, and J. Chardine, *SP594*, pp. 336-339 (Sept. 1980).

Key words: elastic and inelastic scattering cross sections; energy range 10 keV-15 MeV; optical and statistical model calculations; potential scattering radii; s- and p-wave strength functions; total cross sections; W isotopes.

Previously reported s- and p-wave strength functions, potential scattering radii and total cross sections along with scattering data below 15 MeV have been analysed in the frame of coupled channel formalism. Potential parameters, deformation parameters and transmission coefficients have been obtained. Statistical model calculations involving the above transmission coefficients have been performed in order to determine compound elastic and inelastic scattering cross sections as well as capture cross sections. These optical and statistical model calculations yield good agreement with most of the available cross section measurements.

**The neutron capture cross sections of natural Yb,  $^{170}\text{Yb}$ ,  $^{175}\text{Lu}$  and  $^{184}\text{W}$  in the energy range from 5 to 200 keV for the  $^{176}\text{Lu}$ -chronometer,** H. Beer, F. Käppeler, and K. Wisshak, *SP594*, pp. 340-343 (Sept. 1980).

Key words: capture cross sections; nucleosynthesis; Lu-cosmochronometer.

The neutron capture cross sections of natural Yb,  $^{170}\text{Yb}$ ,  $^{175}\text{Lu}$  and  $^{184}\text{W}$  have been measured in the keV neutron energy range with a pulsed Van de Graaff accelerator using the kinematically collimated neutron beam from the  $^7\text{Li}(p,n)$  and the  $\text{T}(p,n)$  reaction. Prompt capture gamma

rays were registered by a Moxon-Rae detector. All measurements were performed in a single run relative to the  $^{197}\text{Au}$  cross section as a standard. The cross sections of  $^{175}\text{Lu}$  and  $^{170}\text{Yb}$  were used to investigate the  $^{176}\text{Lu}$ -cosmic clock.

**Stellar nucleosynthesis and the 24-keV neutron capture cross sections of some heavy nuclei,** T. Bradley, Z. Parsa, M. L. Stelts, and R. E. Chrien, *SP594*, pp. 344-347 (Sept. 1980).

Key words: activation cross sections at 24 keV; stellar nucleosynthesis.

The neutron capture cross sections of  $^{112}\text{Sn}$ ,  $^{130}\text{Ba}$ ,  $^{146}\text{Nd}$ ,  $^{148}\text{Nd}$ ,  $^{186}\text{W}$ ,  $^{190}\text{Os}$  and  $^{192}\text{Os}$  at 24 keV neutron energy were measured with respect to  $^{197}\text{Au}$  by activation in a 24 keV neutron beam at the Brookhaven High Flux Beam Reactor. The reliability of this technique was verified by remeasuring the cross section of  $^{186}\text{W}$  and comparing it to previous measurements. This continuing series of measurements will provide a more reliable data base for nucleosynthesis calculations.

**The measurement of Maxwellian averaged capture cross sections for  $^{138}\text{Ba}$ ,  $^{140}\text{Ce}$ ,  $^{175}\text{Lu}$  and  $^{176}\text{Lu}$  with a special activation technique,** H. Beer and F. Käppeler, *SP594*, pp. 348-350 (Sept. 1980).

Key words: capture cross sections; s-process synthesis.

The capture cross sections of  $^{138}\text{Ba}$ ,  $^{140}\text{Ce}$ ,  $^{176}\text{Lu}$ , and the capture cross section of  $^{175}\text{Lu}$  to the 3.68 h isomeric state in  $^{176}\text{Lu}$  have been determined at 30 keV neutron energy using the activation technique. Neutrons were generated via the  $^7\text{Li}(p,n)$  reaction just above the reaction threshold at a 3 MV pulsed Van de Graaff accelerator. The neutron beam was kinematically collimated with an energy spectrum similar to a Maxwellian distribution, so that the activation measurements yielded directly Maxwellian averaged capture cross sections.

**Nuclear development needs for fusion-fission hybrid reactors,** D. L. Jassby, *SP594*, pp. 351-359 (Sept. 1980).

Key words: cross-section data; fission; fusion; heat transfer; hybrid blanket; tokamak.

A fusion-fission (hybrid) reactor consists of a D-T or D-D fusion-neutron source surrounded by a neutron-absorbing "blanket" containing fertile materials (Th-232, U-238, Li-6, Li-7). The hybrid reactor's basic attraction derives from its ability to perform certain practical functions—notably power multiplication and fissile breeding—without requiring either start-up or make-up fissile feed. Apart from the development of an adequate fusion-neutron generator, development needs for the hybrid reactor include (1) improved information on neutron cross sections at energies of 3 to 16 MeV, in nuclides of thorium, protactinium, uranium, neptunium, and plutonium, and on secondary gamma-ray spectra due to inelastic neutron scattering and (n, xn) events in these nuclides; (2) cross-section sensitivity analyses of breeding performance; (3) resolution of compatibility problems among potential fuels, claddings, and coolants; (4) more extensive data on coolant flow and heat transfer properties, for analyzing severe thermal hydraulics problems arising from sharp gradients in heat production; (5) quantitative information on the adverse effect of cyclic power operation on fuel-clad interaction and mechanical properties; (6) determination of radiation damage effects on candidate blanket materials. Because the basic source of neutrons in a hybrid reactor operates independently of the means by which these neutrons are utilized, many blanket development requirements can be satisfied simultaneously by testing in separate and independent blanket modules of a fusion test reactor.



**Burning nuclear wastes in fusion reactors**, H. W. Meldner and W. M. Howard, *SP594*, pp. 360-363 (Sept. 1980).

**Key words:** actinide burn-up; fusion pellets; neutron cross sections; neutron spectra.

We have studied actinide burn-up in ICF reactor pellets; i.e., 14 MeV neutron fission of the very long-lived actinides that pose storage problems. A major advantage of pellet fuel region burn-up is safety: only milligrams of highly toxic and active material need to be present in the fusion chamber, whereas blanket burn-up requires the continued presence of tons of actinides in a small volume. The actinide data tables required for Monte Carlo calculations of the burn-up of  $^{241}\text{Am}$  and  $^{243}\text{Am}$  are discussed in connection with a study of the sensitivity to cross section uncertainties. More accurate and complete cross sections are required for realistic quantitative calculations.

**Safeguards**, W. A. Higinbotham, *SP594*, pp. 364-367 (Sept. 1980).

**Key words:** calorimetry; gamma-ray spectrometry; neutron interrogation; safeguards.

Domestic safeguards have been developed to prevent the theft of nuclear materials or the sabotage of nuclear facilities. International safeguards are intended to detect diversion of materials or misuse of nuclear facilities by a nation. An important safeguards activity, in both cases, is materials accounting. Conventional accounting employs measurement of weight or volume, the taking of representative samples, and chemical analysis to determine the concentration of U or Pu, and isotopic ratios. Non-destructive assay methods, based on the measurement of the natural or induced radioactive emissions of U and Pu, are of increasing importance for national and IAEA safeguards. These techniques are based on the information developed in the R&D on neutron cross sections and nuclear decay schemes. Calculations of the burnup of uranium fuels in a reactor and of the plutonium in spent fuel depend heavily on the knowledge of nuclear cross sections and on the neutron spectra in operating reactors. Examples of important safeguards non-destructive and other verification techniques are presented.

**Fast-neutron capture cross sections of importance in technological applications**, W. P. Poenitz, *SP594*, pp. 368-379 (Sept. 1980).

**Key words:** fast neutron capture; fission product nuclei.

The importance of the capture cross section of the major fertile nuclei,  $^{238}\text{U}$  and  $^{232}\text{Th}$ , leads to the consideration of these data. The  $^{238}\text{U}(n,\gamma)$  cross section is considered of priority as it is part of the  $^{238}\text{U}$ - $^{239}\text{Pu}$  cycle. Experimental techniques used in the measurements of these data are considered. Data measured more recently are compared with provisions made for the possible explanations of differing results. It is concluded that the  $^{238}\text{U}(n,\gamma)$  cross section is known with  $\sim 5\%$  above 10 keV and fulfills the uncertainty limit for this cross section set to achieve design accuracy for  $k_{\text{eff}}$  and the breeding ratio above 500 keV. Below 500 keV, the present uncertainty falls short of the required 1.5-3.0% uncertainty. Specific recommendations are made to resolve existing discrepancies and data uncertainties.

**Measurement of the fast neutron capture cross section of  $^{238}\text{U}$  relative to  $^{235}\text{U}(n,f)$** , L. R. Fawcett, Jr., W. P. Poenitz, and D. L. Smith, *SP594*, pp. 380-384 (Sept. 1980).

**Key words:** activation; gamma counting.

The capture cross section of  $^{238}\text{U}$  was measured using the activation technique and  $^{235}\text{U}(n,f)$  as a reference cross section. Capture events were measured by detection of two

prominent  $\gamma$ -transitions in the decay of the  $^{239}\text{U}$  daughter nuclide,  $^{239}\text{Np}$ , employing a high resolution Ge(Li) detector. The system was calibrated with samples activated in a thermal neutron flux relative to the capture cross section of gold, and with an absolutely calibrated  $\alpha$ -emitter,  $^{243}\text{Am}$ , which decays to  $^{239}\text{Np}$ . Cross section measurements were carried out in the neutron energy range from 30 keV to 3 MeV. Emphasis was on absolute values between 150 keV and 1 MeV where the  $^{238}\text{U}(n,\gamma)$  cross section and its ratio to  $^{235}\text{U}(n,f)$  are not very sensitive to energy scale uncertainties and the  $^{238}\text{U}(n,f)$  cross section is small. Background from fission products was found to restrict the accuracy of the measured data at energies  $> 1.5$  MeV.

**Selected topics in research program on IBR-2**, V. I. Luschi-kov, L. B. Pikelner, Y. P. Popov, I. M. Frank, E. I. Sharapov, and Y. S. Yazvitskii, *SP594*, pp. 385-393 (Sept. 1980).

**Key words:** IBR-2 reactor; isomeric shift; neutron resonances; polarized neutrons and nuclei; pulsed neutron source.

The physical start-up of the IBR-2 fast pulsed reactor took place in the laboratory of Neutron Physics, JINR. Design values for instantaneous thermal neutron fluxes are:  $10^{17} \text{ cm}^{-2} \text{ s}^{-1}$  inside the moderator and  $10^{16} \text{ cm}^{-2} \text{ s}^{-1}$  from its surface. In combination with the heavy current, short pulse injector (electron induction accelerator LIU-30 being under construction now) it will become a high intensity neutron source for the time-of-flight investigations in the energy range from  $10^{-7}$  to  $10^6$  eV. The characteristics of the complex IBR-2 + LIU-30 are described. The neutron beams and their use in the condensed matter and applied research are mentioned. The program for  $n\alpha$ -,  $n\gamma$ - and  $nf$ -cross section measurements as well as neutron cross section study for few nucleon systems are reported. The prospects for nuclear physics research on the LIU-30 nonmultiplying target facility are outlined using as examples the experiments with polarized neutrons and nuclei and some others. The description is illustrated with the results obtained recently on the operating IBR-30 pulsed reactor.

**Thermal neutron capture cross section in deuterium**, V. P. Alfimenkov, S. B. Borzakov, J. Wierzbicki, B. P. Osipenko, L. B. Pikelner, V. G. Tishin, and E. I. Sharapov, *SP594*, pp. 394-396 (Sept. 1980).

**Key words:** radiative cross section; thermal neutron capture.

The radiative thermal  $nD$  capture cross section  $\delta_D$  was measured by the time-of-flight method at the IBR-30 pulsed reactor using Ge(Li) detector,  $\text{D}_2\text{O}$  water sample and the  $\delta_{\text{Cl}}$  thermal cross section as the standard. The result  $487(24) \text{ fub}$  is in favour of the theoretical value found in the frame of the three body problem.

**Status of gamma ray production cross section data**, K. Sugiyama, *SP594*, pp. 397-407 (Sept. 1980).

**Key words:** fast neutron; gamma rays of discrete and continuum.

The gamma rays produced by the interaction of neutrons with matter are an important aspect of the problem concerning the utilization of nuclear energy. This paper presents a review of the gamma ray production cross sections in neutron energy of MeV; experimental measurements and theoretical calculations. Emphasis is given to the applied purpose rather than the nuclear structure studies described by van Heerden at Harwell Conference on Neutron Physics and Nuclear Data last year. Current measurements are discussed; not only the discrete lines but continuum fractions of the gamma rays. Some efforts on the theoretical calculations are presented for the explanations of the data.



**Gamma-ray production cross sections for fast neutron interactions with Al, Ni, Cu and Nb,** Y. Hino, T. Yamamoto, S. Itagaki, and K. Sugiyama, *SP594*, pp. 408-412 (Sept. 1980).

**Key words:** Al, Ni, Cu and Nb(n,xy) reactions; differential cross sections; discrete lines; unfolding analysis; unresolved gamma-rays.

Gamma-ray production cross sections have been measured for the (n,xy) reactions in Al, Ni, Cu and Nb at the neutron energies of 5.3, 5.9, 6.4 and 7.0 MeV. The Dynamitron accelerator and a deuterium gas target were used to produce pulsed monoenergetic neutrons. Gamma rays were detected with a heavily shielded 70-cm<sup>3</sup> coaxial Ge(Li) detector placed at an angle of 125°. A time-of-flight technique was adopted to discriminate against pulses due to scattered neutrons and background radiations. Absolute cross sections of discrete gamma-ray lines are obtained. Total and unresolved gamma-ray production cross sections are also obtained by unfolding the pulse height spectra with a modified "FERDOR" code. The present results are discussed in comparison with previous data, and are in general agreement with those of ORNL.

**Neutron spectrum at 90° from 800 MeV (p,n) reactions on a Ta target,** S. D. Howe, P. W. Lisowski, N. S. P. King, G. J. Russell, and H. J. Donnert, *SP594*, pp. 413-416 (Sept. 1980).

**Key words:** intranuclear cascade predictions; neutron yield; Ta(p,xn).

The neutron time-of-flight spectrum produced by a thick tantalum target bombarded by 800-MeV protons has been measured at an angle of 90°. The data were taken at the Weapons Neutron Research facility using a cylindrical Ta target with a radius of 1.27 cm and a length of 15 cm. An NE-213 liquid scintillator was used to detect the neutrons over an energy range of 0.5-350 MeV. The neutron yield is presented and compared to a intranuclear-cascade/evaporation model prediction.

**Analysis of neutron yield produced by high energy proton, H.** Takahashi and Y. Nakahara, *SP594*, pp. 417-421 (Sept. 1980).

**Key words:** evaporation; fission; high energy proton; neutron yield analysis; spallation.

Vasil'kov et al.'s experiments for neutron yield and neutron capture distribution produced by 400 and 660 MeV protons were analyzed by using ENDF/B-IV data and the BNL codes NMTC and TWOTRAN. The calculated total neutron radiative capture by <sup>238</sup>U is 77 and 60% of the measured values for protons of 660 and 400 MeV, respectively. The calculated distribution has the higher peak in the central part of the target system, and steeper gradient both in the r and z directions, compared to experimental. The leakage rate of neutrons from the target assembly is calculated as more than 20%, which is much higher than the 10% estimated from the experiment. The total neutron captures determined using ENDF/B-IV are 3.8 and 3.0% higher than those determined using ENDF/B-III for protons of 660 and 400 MeV, respectively.

**Calculated particle production spectra and multiplicities from nucleon-fissile element collisions at medium energies,** F. S. Alsmiller, R. G. Alsmiller, Jr., T. A. Gabriel, R. A. Lillie, and J. Barish, *SP594*, pp. 422-426 (Sept. 1980).

**Key words:** actinide fission; high energy cross sections; intranuclear cascade; statistical model.

A fission channel has been added to the intranuclear-cascade-evaporation model of nuclear reactions so that this model may be used to obtain the differential particle production data that are needed to study the transport of

medium-energy nucleons and pions through matter. The earlier work of Hahn and Bertini on the incorporation of fission-evaporation competition into the intranuclear-cascade-evaporation model has been retained and the statistical model of fission has been utilized to predict particle production from the fission process. Approximate empirically derived kinetic energies and deformation energies are used in the statistical model. The calculated residual nuclei distributions are in reasonable agreement with experimental data, but the neutron multiplicities at the higher incident nucleon energies  $\lesssim 500$  MeV are sensitive to the level density parameter used.

**Photoneutron leakage from the W( $\gamma$ ,n) reaction at radiation therapy centers,** R. J. Holt, H. E. Jackson, and J. R. Specht, *SP594*, pp. 427-428 (Sept. 1980).

**Key words:** photoneutron energy spectrum; radiation therapy.

The energy spectrum of photoneutrons from W( $\gamma$ ,n) was observed for an electron energy of 10 MeV by using the ANL high-current electron linac and a neutron time-of-flight spectrometer.

**NELMA project. I. Objectives of the methodical aspects,** G. C. Madueme, *SP594*, pp. 429-431 (Sept. 1980).

**Key words:** nuclear methods in agriculture; nuclear methods in medicine; oil well logging.

The significance of the NELMA Project is presented. The main aim is to inject new and useful frontiers into the medical care facilities in Nigeria and to provide broader scopes for applying excited nuclear probes to research in bio-agricultural economics as well as in nuclear and solid state physics.

**The <sup>127</sup>I(n,2n)<sup>126</sup>I reaction as a fast neutron flux monitor,** D. C. Santry, *SP594*, pp. 433-435 (Sept. 1980).

**Key words:** activation method; measured cross section.

The activation method was used to measure the production of 12.88 day <sup>126</sup>I as a function of neutron energy. Monoenergetic neutrons were produced with a tandem Van de Graaff using the reaction D(d,n)<sup>3</sup>He and T(d,n)<sup>4</sup>He. Cross sections were measured from a threshold energy of 9.2 MeV up to 20 MeV relative to the known cross sections for the <sup>32</sup>S(n,p)<sup>32</sup>P reaction. The study has shown that the <sup>127</sup>I(n,2n) reaction has a flat response around 14 MeV and this factor combined with the suitable decay characteristics of <sup>126</sup>I provides a reaction suitable as a standard for determining integrated fast-neutron fluxes of neutron generators and thermonuclear fusion machines.

**Resonance neutron radiography for nondestructive evaluation and assay applications,** J. W. Behrens, R. A. Schrack, A. D. Carlson, and C. D. Bowman, *SP594*, pp. 436-439 (Sept. 1980).

**Key words:** epithermal neutron energy; neutron radiography; nondestructive assay; nondestructive evaluation; position-sensitive proportional counter.

Resonance neutron radiography is being developed at the NBS for both nondestructive evaluation (NDE) and non-destructive assay (NDA) applications. To illustrate the method we determined the distribution of solder between two silver-brazed metal rings and measured the thickness of the braze. Our technique was also used to nondestructively assay <sup>234</sup>U, <sup>235</sup>U, and <sup>238</sup>U in a fresh UO<sub>2</sub> nuclear fuel pellet. The National Bureau of Standards linear accelerator provided a pulsed source of neutrons over the energy range from 0.3 eV to 20 eV. A linear position-sensitive proportional counter (PSPC) was designed and built having a spatial resolution of 1.2 mm. The PSPC had a sensitive



length of 50 mm and contained 3 atm  $^3\text{He}$ , 7.5 atm Xe, and 0.5 atm  $\text{CO}_2$ . Transmission values over the resonances were used to identify and assay the materials.

**Fast neutron radiotherapy: Fundamental aspects and clinical results,** J. J. Broerse, *SP594*, pp. 440-446 (Sept. 1980).

Key words: cross sections; neutron depth dose; neutron radiotherapy; radiobiology; uncertainties.

Renewed applications of fast neutrons for clinical radiotherapy, were initiated by fundamental radiobiological findings. Studies of the responses of normal tissues and tumour systems after irradiation with fast neutrons had shown two essential differences with the effect after X-irradiation, notably a reduced oxygen effect and a reduced repair of sublethal damage. Furthermore wide variations in relative biological effectiveness had been observed for different tumours and normal tissues. The results of the clinical applications of fast neutrons are promising for specific tumours. However, the studies have indicated the need for coordinated clinical trials on a national and international scale. To allow a direct evaluation of clinical results obtained at the different neutron radiotherapy centers it will be essential to optimize the delivery of the dose to the target volume and to determine the energy dissipation with a sufficient degree of precision and accuracy. The need for better dose distributions and further knowledge of nuclear data, including cross sections, will be exemplified.

**Neutron dosimetry,** P. R. Almond and J. B. Smathers, *SP594*, pp. 447-455 (Sept. 1980).

Key words: ionization chambers; kerma; neutron dosimetry; stopping power ratios; tissue equivalence.

The basis for measuring absorbed dose with ionization chambers is presented and the major parameters involved are discussed. These included the energy required to produce an ion pair (W/e) and stopping power ratio's, kerma and tissue equivalence. The necessity for determining the photon absorbed dose along with the neutron dose is discussed, along with measurements of neutron spectrum.

**The clinical application of *in vivo* neutron activation analysis,** S. H. Cohn, K. J. Ellis, I. Zanzi, D. Vartsky, and J. F. Aloia, *SP594*, pp. 456-457 (Sept. 1980).

Key words: body composition; clinical application; elemental analysis; *in vivo* measurement; neutron activation.

The development of the *in vivo* neutron activation technique has opened an era of research into the elemental composition of human beings. Until recently, few data has been recorded on the exact amounts of the elements of which the human body is composed.

Neutron activation is an analytical tool based on nuclear rather than chemical reactions. The essential physical parameters involved include isotopic abundance, cross-section, half-lives of the product isotopes, and energy emission of the product.

Total body neutron activation (TBNA) designed for *in vivo* studies requires a beam of fast neutrons to be delivered to the subject. Capture on a neutron by an atom of a target element creates an excited nucleus. This isotope reverts to a stable condition by the emission of one or more gamma rays either immediately (within  $\sim 10^{-12}$  s), (prompt gamma activation), or after a decay period characteristic of the activation product (delayed gamma activation). The energy of the gamma ray is characteristic of the target element and its intensity (count rate in a suitable detector) is a measure of the amount of that element. The induced radioactivity in the subject is measured by a suitable detector that has to be shielded against background radiation. The data thereby obtained are treated by standard gamma spectrometric

methods of analysis.

**Accelerators for radionuclide production,** J. C. Clark, *SP594*, pp. 458-463 (Sept. 1980).

Key words: accelerator; radionuclide production.

Of 60 questionnaires sent out to institutes known to be operating accelerators, replies were received relating to 55 individual accelerators all of which had a program for radionuclide production. The majority of the noncommercially operated accelerators were seen to be concentrating their efforts on producing radionuclides which were not generally available from the 9 commercially operated accelerators. Notable exceptions however were  $^{123}\text{I}$  and  $^{201}\text{Tl}$ . Some of the problems encountered in the use of these accelerators for large scale radionuclide production will be discussed.

**Evaluation of the fission and capture cross sections of  $^{240}\text{Pu}$  and  $^{241}\text{Pu}$  for ENDF/B-V,** L. W. Weston and R. Q. Wright, *SP594*, pp. 464-468 (Sept. 1980).

Key words: capture; fission; neutron nuclear data evaluations.

Since there were appreciable new data which were not available for ENDF/B-IV, new evaluations for  $^{240}\text{Pu}$  and  $^{241}\text{Pu}$  were carried out for ENDF/B-V. The evaluation of the fission and capture cross sections will be reviewed and problem areas discussed. The neutron energy range of concern was from  $10^{-5}$  eV to 20 MeV. Significant changes were made over the entire neutron energy region because of the new experimental data available. The problems in the evaluations due to discrepancies in the nuclear data will be emphasized, particularly the 1-eV resonance in  $^{240}\text{Pu}$  and the 0.3-eV resonance in  $^{241}\text{Pu}$ . The evaluation of the fission and capture cross sections for ENDF/B-V represents an improvement over the previous evaluation; however, there continues to be a need for accurate experimental data.

**What can be learned from the channel analysis of the  $^{232}\text{Th}$  neutron fission cross section,** H. A. Yehia, J. Jary, J. Trochon, J. W. Boldeman, and A. R. de L. Musgrove, *SP594*, pp. 469-474 (Sept. 1980).

Key words: fission barriers derived; fission channel analysis; statistical model; triple humped shapes.

Channel analyses of the neutron fission cross section of  $^{232}\text{Th}$  have been made in two laboratories. The calculated fission cross sections and fission fragment anisotropies are compared with the experimental data. Despite some differences in the methods used, the conclusions on the physical aspects of the fission process are very similar.

**Measurement of the integral capture and fission cross sections for  $^{232}\text{Th}$  in the CFRMF,** R. A. Anderl and Y. D. Harker, *SP594*, pp. 475-478 (Sept. 1980).

Key words: CFRMF; ENDF/B; integral cross sections.

The recent evaluation of the cross-section data bases for  $^{232}\text{Th}$  capture and fission emphasized significant normalization discrepancies between the available differential data. To help resolve the normalization discrepancies, the capture and fission integral cross sections have been measured for  $^{232}\text{Th}$  in the fast neutron zone of the Coupled Fast Reactivity Measurements Facility (CFRMF). The cross sections are derived from the radiometric determination of the saturation reaction rates for fission and capture based on the Ge(Li) spectrometric measurement of the absolute gamma emission rates of the 537-keV and 1596-keV lines in the  $^{140}\text{Ba}$ - $^{140}\text{La}$  decay and the 311.9-keV line in the  $^{233}\text{Pa}$  decay. For capture and fission, respectively, the measured integral cross sections are  $291 \text{ mb} \pm 3\%$  and  $19.6$

mb  $\pm$  5%. The ratios of the integral cross sections computed with ENDF/B-IV thorium cross sections and the CFRMF neutron spectrum to the above values are 0.99 for capture and 0.90 for fission.

**The fission cross section of  $^{230}\text{Th}$  and  $^{232}\text{Th}$  relative to  $^{235}\text{U}$ ,** J. W. Meadows, *SP594*, pp. 479-482 (Sept. 1980).

Key words: cross sections; nuclear reactions.

The fission cross sections of  $^{230}\text{Th}$  and  $^{232}\text{Th}$  have been measured relative to  $^{235}\text{U}$  from near threshold to near 10 MeV. The weights of the thorium samples were determined by isotopic dilution. The weight of the uranium deposit was based on specific activity measurements of a  $^{234}\text{U}$ - $^{235}\text{U}$  mixture and low geometry alpha counting. Corrections were made for thermal background, loss of fragments in the deposits, neutron scattering in the detector assembly, sample geometry, sample composition and the spectrum of the neutron source. Generally the systematic errors were  $\sim 1\%$ . The combined systematic and statistical errors were typically 1.5%.

**The evaluation of  $^{235}\text{U}(n,f)$  above 100 keV for ENDF/B-V and the implications of a unified  $^{235}\text{U}$  mass scale,** W. P. Poenitz, J. W. Meadows, and R. J. Armani, *SP594*, pp. 483-487 (Sept. 1980).

Key words: alpha counting; normalization uncertainties; shape evaluation.

A previously reported evaluation of  $^{235}\text{U}(n,f)$  in the fast neutron energy range was updated to include data published up to the 1978 Harwell Conference on Neutron Physics. The shape of the cross section resulting from this evaluation and a normalization factor extracted from data provided within the framework of this evaluation were used by the Subcommittee on Standards and Normalizations of the Cross Section Evaluation Working Group to establish  $^{235}\text{U}(n,f)$  for ENDF/B-V above 100 keV.  $^{235}\text{U}$  sample mass comparisons made between different laboratories were compiled in order to investigate the implications of different sample masses on recent  $^{235}\text{U}(n,f)$  data. A new intercomparison of several such samples was carried out using absolute and relative alpha-counting and relative fast neutron fission counting. The result of this work is a unified  $^{235}\text{U}$  mass scale with an uncertainty of 0.6%.

**A measurement of U-235 absolute alpha value in the neutron energy range from 0.1 to 30 keV,** G. V. Muradyan, Y. G. Schepkin, Y. V. Adamchuk, and M. A. Voskanyan, *SP594*, pp. 488-490 (Sept. 1980).

Key words: alpha-value; multiplicity spectrum; multisectional detector.

In order to measure the neutron-physical constants with high accuracy and to investigate ways of formation and decay of excited nuclei a method has been developed at the I.V. Kurchatov AEI, based on the gamma-quanta and neutrons multiplicity spectrometry. During 1974-1978 there have been constructed a number of multisectional  $4\pi$ -detectors which have demonstrated great possibilities for this method. A detector permitting the required accuracy of measurements of neutron cross sections and their ratios has been chosen and designed on the basis of these works. The detector with  $4\pi$ -geometry has 46 sections and was based on NaI(Tl) crystals with the total volume of the scintillator of  $\sim 100$  l. The detector was used at the 26-m station.

Up to 37 time-of-flight spectra are obtained in each measurement. 16 of them corresponds to 1-fold, 2-fold, ..., 15-fold and 16-fold coincidences between detector sections when the energy released in each section is not less than a given value,  $E_s$  and in the whole detector not less than  $E\Sigma$ . The selection of coincidences is performed within the time

interval  $\tau_0$  beginning from the moment of appearing the pulse with the total energy  $E > E\Sigma$ . At the same time analogous time-of-flight spectra are separated under the additional condition of recording fission neutrons within the gate of the width  $\tau_1$ , delayed for the time  $\tau_2$  with respect to the total energy pulse.

In this paper the results of U-235 absolute alpha value measurements are presented. The measurements are carried out by the detector described above over the energy range from 0.1 to 30 keV with the high accuracy-better than 5%. The equipment parameters and measurement conditions are listed in Table 1.

**High-resolution fission cross section of  $^{231}\text{Pa}$ ,** S. Plattard, G. F. Auchampaugh, N. W. Hill, G. de Saussure, R. B. Perez, and J. A. Harvey, *SP594*, pp. 491-495 (Sept. 1980).

Key words: cross section; fission; high-resolution.

The  $^{231}\text{Pa}$  fission cross section was measured with high resolution at ORELA from 0.1 to 12 MeV and between 0.4 eV and 10 keV. The data show evidence for 1) fractionated vibrational structures in the threshold region of the fission cross section, and 2) narrow fission resonances above 0.4 eV with an average fission width  $\langle \Gamma_f \rangle = 8 \mu\text{eV}$ .

**Fission cross section of  $^{245}\text{Cm}$  from  $10^{-3}$  eV to  $10^4$  eV,** R. M. White, J. C. Browne, R. E. Howe, J. H. Landrum, and J. A. Becker, *SP594*, pp. 496-499 (Sept. 1980).

Key words: deduced levels; multilevel R-matrix analysis.

The neutron-induced fission cross section of  $^{245}\text{Cm}$  has been measured from .001 eV to 10 keV using the LLL 100-MeV Linac. The resonance data are analyzed with a multilevel-multichannel R-matrix code. The statistical distribution of R-matrix parameters extracted from the analysis are investigated and comparisons are made with previous work.

**First and second chance fission calculations for actinides and related topics,** G. Maino, E. Menapace, M. Motta, and A. Ventura, *SP594*, pp. 500-503 (Sept. 1980).

Key words: fission probabilities; Hauser-Feshbach formalism; optical model.

First and second chance contributions to neutron induced fission cross sections in an energy range of interest for reactor applications ( $E_n \leq 13$  MeV) were obtained by extensive and consistent calculations for  $^{241}\text{Am}$ ; moreover, a simplified semiempirical approach was applied to  $^{235}\text{U}$  and  $^{239}\text{Pu}$ .

**Finite geometry and multiple scattering corrections for neutron cross section measurements,** H. H. Hogue and A. G. Beyerle, *SP594*, pp. 504-508 (Sept. 1980).

Key words: angular distribution; computer programs; corrections; energy distribution; finite geometry; Monte Carlo method; multiple scattering; neutron; scattering.

Computer programs EFFIGY and EFFIGYC have been developed to calculate finite geometry and multiple scattering corrections for fast neutron cross-section measurements. These programs employ the Monte Carlo method to simulate time-of-flight spectra of neutrons scattered by single- or multiple-element, cylindrical or annular samples illuminated by a pulsed, monoenergetic neutron source. EFFIGY calculates corrections to angular distributions of discrete neutron groups appearing in the scattering spectra for low nuclear excitation. In addition, EFFIGYC corrects the energy distribution of the "continuum" of neutrons produced by  $(n,n')$  reactions leading to overlapping levels, and removes a contribution to the scattering spectra due to source neutrons from other than the monoenergetic source reaction.



**Fast neutron detection capabilities of NaI(Tl) scintillator and HgI<sub>2</sub> semiconductor gamma ray spectrometers**, F. E. Cecil, K. Killian, and M. Rymes, *SP594*, pp. 509-511 (Sept. 1980).

**Key words:** excited states; NaI detector.

The utilization of NaI(Tl) scintillators as a high efficiency, fast neutron monitor, through the reaction  $^{127}\text{I}(n,n')^{127}\text{I}^*(E_x = 57 \text{ keV})^{127}\text{I}(E_x = 0)$ , has been established. The total gamma ray production cross sections for the 57 keV gamma ray production cross sections for the 57 keV gamma ray in  $^{127}\text{I}$  by inelastic scattering of 3 MeV and 14 MeV neutrons are  $0.43 \pm 0.04 \text{ b}$  and  $0.28 \pm 0.03 \text{ b}$  respectively. Temperature and count rate limitations on this utilization have been determined. The same reaction should allow HgI<sub>2</sub> semiconductor gamma ray detectors with intrinsic energy resolution potentially for superior to NaI(Tl) to be utilized to monitor fast neutrons.

**Fission track recorder techniques for fission rate measurements**, H. P. Chou, R. H. Johnson, and F. M. Clikeman, *SP594*, pp. 512-515 (Sept. 1980).

**Key words:** fission rate; fused quartz track recorder; microcomputer; track counting.

Fused quartz fission track recorders have been used for fission rate measurements. A scanning optical microscope interfaced with a microcomputer has been developed to perform fission track counting. The stability of the system has been extensively checked. An overall reproducibility of  $\pm 3\%$  (one standard deviation) has been achieved. Programming for this system provides a partial scanned image, the total number of fission tracks, a track size distribution, and the locations of individual tracks.

**Analysis of particulates for very light elements by forward scattering of alpha particles**, G. W. Wolfe, *SP594*, pp. 516-520 (Sept. 1980).

**Key words:** elastic scattering; elemental analysis; PIXE.

PIXE analysis is limited to elements heavier than Sodium. A technique has been developed for obtaining quantitative information about the levels of elements Hydrogen through Fluorine by forward scattering of 18 MeV alphas, and may be obtained simultaneously with PIXE. Using substrate thicknesses less than  $1 \text{ mg/cm}^2$ , sensitivities from  $2.7 \text{ } \mu\text{g/cm}^2$  for Hydrogen to  $124 \text{ } \mu\text{g/cm}^2$  for Carbon, may be obtained after corrections, with determinations accurate to  $\pm 15\%$ , in 200 second irradiation times. Substantial corrections must be made.

**The spectrometry of multiplicity of secondary radiation as a method of measurement of neutron cross-section and investigation of nuclei**, G. V. Muradyan, *SP594*, pp. 521-523 (Sept. 1980).

**Key words:** multiplicity spectrum; neutron cross section; secondary radiation.

The present paper deals with the new method of neutron cross-section measurement and the investigation of ways of formation and decay of excited nuclei. The idea of the procedure from the view-point of measurement of partial neutron cross-sections has been described in  $\pm 11$ . It involves the measurement of total multiplicity spectrum of gamma-quanta and neutrons arising from reactions with neutrons. The object of the present article is the further generalization of the multiplicity spectrometry method and the broadening of the range of problems under investigation. At the same time a brief review of experiments on the multiplicity spectrometry is given.

**Neutron total cross section measurement at WNR**, P. W. Lisowski, M. S. Moore, G. L. Morgan, and R. E. Shamu,

*SP594*, pp. 524-526 (Sept. 1980).

**Key words:** carbon; cross section measurements; total cross section.

The techniques involved in measuring fast-neutron total cross sections at the Weapons Neutron Facility (WNR) of the Los Alamos Scientific Laboratory are described. Results of total cross section measurements on natural carbon covering the range 2.5 to 250 MeV are presented.

**Study of neutron-induced charged particle reactions on deuterium using a quadrupole triplet spectrometer**, V. Kulkarni, P. Grabmayr, G. Randers-Pehrson, R. W. Finlay, J. Rapaport, and S. M. Grimes, *SP594*, pp. 527-530 (Sept. 1980).

**Key words:** charged particle reactions; deuterium; quadrupole triplet spectrometer.

A Quadrupole Triplet Spectrometer similar to the one at Lawrence Livermore Laboratory has been constructed at Ohio University to study neutron-induced charged particle reactions. The  $\text{D}(n,p)2n$  break-up reaction was studied at incident neutron energies of 11 and 25 MeV, and the angular distribution of the  $\text{D}(n,d)n$  elastic scattering was measured at  $E_n = 9$  and 11 MeV.

**Efficient neutron production using low energy electron beams**, C. D. Bowman, *SP594*, pp. 531-533 (Sept. 1980).

**Key words:** bremsstrahlung; electron beams; linear accelerator; neutron physics; neutron radiography; neutrons.

A comparison of  $(\gamma,n)$  and atomic cross sections shows that neutron production with an electron beam can be as energy efficient with 10 MeV electrons as with the conventionally used 30 to 100 MeV electrons. Neutron production from W using 100 MeV electrons is compared with a thin W converter followed by a deuterium-containing target using electrons near 10 MeV.

**Performance improvements of the Geel linac neutron source**, J. M. Salomé and K. H. Böckhoff, *SP594*, pp. 534-536 (Sept. 1980).

**Key words:** linear accelerator; post-acceleration beam compression; rotating U target; stationary U target.

The Geel Electron Linear Accelerator, acronymed GELINA, is a 150 MeV S-band Linac which—together with its targets—serves as a pulsed neutron source in a multiple neutron time-of-flight spectrometer.

**Recent modifications of the TUNL fast neutron cross section facility**, L. W. Seagondollar, A. G. Beyerle, C. R. Gould, F. O. Purser, S. El-Kadi, S. G. Glendinning, and C. E. Nelson, *SP594*, pp. 537-541 (Sept. 1980).

**Key words:** D and T gas targets; fast neutron time-of-flight  $\sigma(\theta)$  equipment; movable detectors.

The Triangle Universities Nuclear Laboratory fast neutron cross section facility has been modified so that tritium as well as deuterium gas targets may be used and so that two detectors can be used simultaneously to measure angular distributions of neutrons scattered from samples of interest. The targets, the new detector, and associated equipment are described.

**A study of source neutron reactions**, P. Grabmayr, J. Rapaport, R. W. Finlay, V. Kulkarni, and S. M. Grimes, *SP594*, pp. 542-544 (Sept. 1980).

**Key words:** gas target; measured  $\sigma(E_n, 0^\circ)$ ; nuclear reactions.

The breakup of deuterons incident on deuterium and  $^3\text{He}$  has been studied at energies between 5 and 8 MeV by the

neutron time-of-flight method. Shifting the beam energy by 250 keV results in a better match of the shapes of the continuous spectra of breakup on D and  $^3\text{He}$ . Thus it is possible to correct contaminations of the source neutron spectra.

**Neutron spectra measurements upon a spherical assembly of thorium**, R. C. Block, M. Becker, D. R. Harris, B. K. Malaviya, S. A. Bokharee, R. W. Emmett, P. S. Feigenbaum, S. H. Levinson, H. T. Maguire, Jr., S. A. Hayashi, and S. Yamamoto, *SP594*, pp. 545-547 (Sept. 1980).

Key words: cross section; ENDF/B; keV; LINAC; MeV; multigroup calculation; neutron flux spectra; thorium; time-of-flight.

A cooperative research program between the Kyoto University Research Reactor Institute (KUR) and the Gaertner Linac Laboratory at RPI has carried out neutron spectra measurements upon a thorium assembly. The assembly consists of 300 kg of thorium contained in a 0.6-m-dia. stainless steel sphere and is the same assembly reported by Nishihara et al. A 1-kw air-cooled spheroidal Ta photoneutron target was developed for use with this assembly. Neutron spectra measurements have been carried out from approximately 1 keV to 15 MeV at radii of 15 and 20 cm with angles of  $90^\circ$  and  $130^\circ$  respectively. The high-energy spectra were obtained with the 50-cm-dia.-by-12.5-cm-thick proton recoil detector at 100 meters, and the low-energy spectra were obtained with the 30-cm-dia.-by-5-cm-thick  $^{10}\text{B}$ -Vaseline-plus-NaI detector at 33 meters. In order to compare with experiment, spectra are being calculated with the DTF-IV one-dimensional transport code with ENDF/B-IV data, and results will be presented.

**Integral measurements for higher actinides in CFRMF**, Y. D. Harker, R. A. Anderl, E. H. Turk, and N. C. Schroeder, *SP594*, pp. 548-551 (Sept. 1980).

Key words: integral capture cross section; integral fission cross section.

To improve upon the lack of fast integral data for higher actinides, an effort has been underway to measure integral capture and fission cross sections for  $^{242}\text{Pu}$ ,  $^{241}\text{Am}$  and  $^{243}\text{Am}$  in the fast neutron zone of the Couple Fast Reactivity Measurements Facility (CFRMF). Fission cross sections are determined based on the  $\text{Ge(Li)}$  gamma spectrometric measurements of the absolute emission rates of the 537-keV and/or 1596-keV lines in the  $^{140}\text{Ba}$ - $^{140}\text{La}$  decay. The capture rate for  $^{242}\text{Pu}$  is based on the measurement of the absolute emission rate of the 84.0 keV line in the  $^{243}\text{Pu}$   $\beta^-$  decay. Although the capture cross sections for  $^{241}\text{Am}$  and  $^{243}\text{Am}$  are not obtained directly, the cross sections for production of  $^{242}\text{Cm}$  and  $^{244}\text{Cm}$  are based on the quantitative alpha spectrometry and total alpha counting. Measured integral and capture cross sections for  $^{242}\text{Pu}$  are  $357 \text{ mb} \pm 10\%$  and  $146 \text{ mb} \pm 15\%$ . Corresponding spectral averaged cross sections calculated using ENDF/B-IV data are 489 mb and 238 mb, respectively. For  $^{241}\text{Am}$  fission and capture, the measured cross sections are  $504 \text{ mb} \pm 12\%$  and  $1.01 \text{ b} \pm 3\%$ , respectively. For  $^{243}\text{Am}$  fission and capture, the measured cross sections are 0.352 b and .10 b, respectively.

**Evaluation of actinide cross sections by integral experiments in fast critical assembly FCA**, T. Mukaiyama, H. Mitani, K. Koyama, M. Obu, and H. Kuroi, *SP594*, pp. 552-556 (Sept. 1980).

Key words: actinide recycle; cross section evaluation; fast critical facility; fast reactor; integral experiment; least square fitting; neutron spectrum; sample perturbation.

The preliminary study has been performed to determine

the effects of actinide cross sections uncertainties upon the long term characteristics of the actinide burning reactor. A program for the integral measurement of the actinides is planned at JAERI to improve the actinide cross section data. The small sample (20 gr) perturbation and the reaction rate ratio are to be measured in the neutron spectra of varying hardness. Measurements are planned for  $^{237}\text{Np}$ ,  $^{238}\text{Pu}$ ,  $^{241}\text{Am}$  and  $^{243}\text{Am}$ .

**Neodymium, samarium and europium capture cross-section adjustments based on EBR-II integral measurements**, R. A. Anderl, Y. D. Harker, and F. Schmittroth, *SP594*, pp. 557-562 (Sept. 1980).

Key words: dosimetry; EBR-II; Eu isotopes; integral cross sections; Nd; Sm.

Integral capture measurements have been made for highly-enriched isotopes of neodymium, samarium and europium irradiated in a row 8 position of EBR-II with samples located both at mid-plane and in the axial reflector. Broad response, resonance, and threshold dosimeters were included to characterize the neutron spectra at the sample locations. The saturation reaction rates for the rare-earth samples were determined by post-irradiation mass-spectrometric analyses and for the dosimeter materials by the gamma-spectrometric method. The HEDL maximum-likelihood analysis code, FERRET, was used to make a "least-squares adjustment" of the ENDF/B-IV rare-earth cross sections based on the measured dosimeter and fission-product reaction rates. Preliminary results to date indicate a need for a significant upward adjustment of the capture cross sections for  $^{143}\text{Nd}$ ,  $^{145}\text{Nd}$ ,  $^{147}\text{Sm}$  and  $^{148}\text{Sm}$ .

**Measurements and analyses of neutron transport through iron**, N. E. Hertel, R. H. Johnson, J. J. Dorning, and B. W. Wehring, *SP594*, pp. 563-568 (Sept. 1980).

Key words: integral tests of ENDF/B-IV; iron.

Integral experiments have been performed using a thick homogeneous spherical shell of iron to test existing neutron cross section data. Neutron leakage spectra were measured for Cf-252-fission and DT-fusion neutron sources using an NE-213 spectrometry system. An associated particle detector monitored the absolute DT neutron source strength and the amount of DD neutron contamination in the DT source spectrum. The leakage spectra were calculated using the continuous-energy Monte Carlo code VIM and the discrete- $S_n$  code ANISN. For neutron energies between 1 and 5 MeV, the calculations underpredicted the leakage spectrum by factors of 2 to 1.4 for the Cf neutron source and of 3 to 2 for the DT neutron source. The large discrepancies are attributed to inadequate representation of cross-section resonance structure (viz., minima); inadequate representation of the angular and secondary energy distributions for continuum inelastic scattering and (n, 2n) reactions may also contribute to these discrepancies.

**Neutron energy spectra in the fast breeder blanket facility**, D. W. Vehar, R. H. Johnson, and F. M. Clikeman, *SP594*, pp. 568-571 (Sept. 1980).

Key words: calculated neutron spectrum; fast breeder blanket facility; fast reactor; neutron spectrum; proton-recoil; 2DB.

Neutron energy spectra have been measured for the initial loading of the FBBF, in the energy range from 1 keV to 3 MeV and for radii of 0.385, 0.563 and 0.711 m. Hydrogen- and methane-filled proton-recoil detectors are used for the measurements. Energy spectra are calculated using the two-dimensional diffusion code 2DB and a self-shielded cross section set based on ENDF/B-IV. Measured and calculated spectra are compared on an absolute basis for a



source strength of  $10^{10}$  neutrons per second. The calculations overpredict the measured total flux between 1 keV and 3 MeV at a radius of 0.385 m and underpredict it at a radius of 0.711 m. Thus, the calculated flux decreases with radius more rapidly than the measured flux. The shape of the neutron spectrum is predicted reasonably well at all three radii, although less structure is seen in the calculations due to the large energy group widths.

**$^{238}\text{U}$  and  $^{232}\text{Th}$  capture rates in the FBBF**, G. A. Harms, F. M. Clikeman, R. H. Johnson, R. C. Borg, and K. O. Ott, *SP594*, pp. 572-575 (Sept. 1980).

Key words: blankets; breeding; capture rates; fast breeder blanket facility; fast reactors; foil activation.

The Fast Breeder Blanket Facility (FBBF) is designed to test mock-ups of fast reactor blankets. The FBBF currently has a two-region blanket consisting of natural  $\text{UO}_2$ , aluminum, and stainless steel. Neutron capture rates for  $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{197}\text{Au}$ , and  $^{55}\text{Mn}$  were measured at the midplane of the FBBF. A two-dimensional diffusion calculation of reaction rates in the facility was performed and the results compared with the measurements. The C/E values range from 0.99 to 0.57 for  $^{238}\text{U}$ , 0.97 to 0.89 for  $^{232}\text{Th}$ , 0.95 to 0.85 for  $^{197}\text{Au}$ , and 1.21 to 0.88 for  $^{55}\text{Mn}$ . The calculation agreed well for materials not present in the FBBF ( $^{232}\text{Th}$  and  $^{197}\text{Au}$ ) but diverged for  $^{238}\text{U}$  and  $^{55}\text{Mn}$  which are significant constituents of the facility. An independent Monte Carlo calculation gave  $^{238}\text{U}$  capture rates that agree well with the experimental results.

**Gamma-ray heating in the fast breeder blanket facility**, K. R. Koch, F. M. Clikeman, and R. H. Johnson, *SP594*, pp. 576-580 (Sept. 1980).

Key words: blankets;  $\text{CaF}_2\text{:Dy}$ ; fast breeder reactors; FBBF; gamma-ray heating; thermoluminescent dosimeters; TLD.

Gamma-ray heating rates in both stainless steel and lead have been measured in the Fast Breeder Blanket Facility using  $\text{CaF}_2\text{:Dy}$  thermoluminescent dosimeters. The TLD responses in stainless steel or lead holders were corrected by applying spectral-weighted f-factors. Corrections for neutron responses were based on  $\text{CaF}_2$  TLD neutron sensitivities. Radial experimental heating rates are presented and have been compared to results of a radial calculation performed as three separate steps: a neutron diffusion calculation, a distributed gamma-production calculation and a gamma-ray transport calculation. The calculation underestimates the gamma-ray heating by 20% and 42% in stainless steel and by 1% and 32% in lead at the smallest and largest blanket radii respectively. The use of the multigroup method in blanket calculations seems to cause underestimations of several nuclear parameters in the outer blanket of the Fast Breeder Blanket Facility.

**Benchmark tests of Japanese evaluated nuclear data library (JENDL)**, Y. Kikuchi, A. Hasegawa, T. Hojuyama, M. Sasaki, Y. Seki, T. Kamei, and I. Otake, *SP594*, pp. 581-585 (Sept. 1980).

Key words: benchmark tests; control rod worth; Doppler coefficient; JENDL-1; reaction rate distribution; reaction rate ratio; reactivity worth; sodium void coefficient; structural materials.

Various benchmark tests were performed on JENDL-1. JENDL-1 predicted various neutronic characteristics of fast reactors fairly well. It was pointed out, however, that JENDL-1 underestimated the fission rate ratio on  $^{239}\text{Pu}$  to  $^{238}\text{U}$  and might give some errors in predicting the reaction rate distribution in outer core and blanket region. The effects of cross sections of structural materials were investi-

gated concerning the latter problems.

**Request for evaluating neutron cross section of structural material for shielding application**, M. Kawai, N. Yamano, and K. Koyama, *SP594*, pp. 586-590 (Sept. 1980).

Key words: elastic scattering cross section; partial inelastic scattering cross section; resonance self-shielding effect; sensitivity analysis; shielding application; structural material; total cross section; unresolved resonance.

The effect of resonance structure in neutron cross sections of structural material up to a few MeV and the role of the partial inelastic scattering cross sections are investigated from the viewpoint of shielding application by using ENDF/B-IV and JENDL-1. Sensitivity and  $S_N$ -transport calculations are performed in the case of iron sphere and slab geometries. The results obtained are as follows: 1) The neglect of resonance self-shielding leads to underestimation of neutron dose rate at the distance of 100 cm from the source by 30% (for elastic scattering in unresolved resonance region), and 5% (for inelastic scattering). 2) The neutron flux below 10 keV at 30 cm from the source increases about 60% by considering low energy discrete levels of  $^{57}\text{Fe}$ . 3) Fast neutron spectrum is much affected by the secondary neutron spectrum data of the continuum level.

**Integral experiments for fusion reactor design: Experimentation**, G. T. Chapman and G. L. Morgan, *SP594*, pp. 591-595 (Sept. 1980).

Key words: data unfolding; energy spectra; integral experiment; pulse-shape discrimination.

Integral experiments that measure the energy spectra of neutrons and gamma rays due to the transport of  $\sim 14$ -MeV  $\text{T(d,n)}$   $^4\text{He}$  neutrons through thick steel and borated polyethylene shield configurations have been performed at the Oak Ridge National Laboratory. Descriptions of the facility and experimental techniques are given along with curves showing data representative of the results.

**Integral experiments for fusion reactor design: Analysis**, R. T. Santoro, R. G. Alsmiller, Jr., J. M. Barnes, and E. M. Oblow, *SP594*, pp. 596-598 (Sept. 1980).

Key words: gamma ray spectra; integral experiments; neutron spectra; radiation transport.

Integral experiments that measure the energy spectra of neutrons and gamma rays due to the transport of  $\sim 14$  MeV D-T neutrons through laminated SS-304 and borated polyethylene shield assemblies have been performed. Measured and calculated energy spectra and integrated flux distributions are compared for a typical shield assembly as a function of detector location.

**Use of nuclear techniques in oil well logging**, K. S. Quisenberry, *SP594*, pp. 599-603 (Sept. 1980).

Key words: neutron source shapes; nuclear data; nuclear logging; radiation transport.

Radiation transport codes are being applied to modeling the response of nuclear logging tools. The cross sections, benchmark experiments and neutron source spectral data that are required for this purpose are described. A neutron porosity tool is used to illustrate such calculations.

**Neutron induced radioactivity for mineral exploration**, F. E. Senftle, *SP594*, pp. 604-614 (Sept. 1980).

Key words: accelerator; borehole sonde; capture  $\gamma$ -ray analysis; source-to-detector distance.

Borehole neutron activation-gamma-ray spectrometry is a

useful method for mineral exploration. Isotopic or accelerator neutron sources are used with either scintillation or semiconductor detectors in the borehole tools depending on the application, rock formation, required measurement time, etc. The basic neutron processes in rock formations are summarized to point out the problem of spectrometer calibration. The source-to-detector distance is an important consideration to achieve optimum sensitivity. There are several possible solutions of the calibration problem. Some of these are demonstrated by applications of neutron activation to mineral exploration in the field. Although many problems still need to be solved to make borehole neutron-gamma-ray spectrometry a more general analytical tool, the method is a powerful qualitative exploration device applicable to many elements in most rock formations. Under certain conditions, e.g., in a coal seam, it can also be a good quantitative tool.

**Nuclear techniques in marine metal exploration, W. Michaelis, *SP594*, pp. 615-626 (Sept. 1980).**

**Key words:** metal exploration; natural gamma radiation; neutron activation analysis; neutron inelastic scattering; nuclear cross sections; nuclear reactors; radiative neutron capture; reaction interferences; scattered gamma radiation; XRF analysis. <sup>252</sup>Cf.

The growing concern about the future availability of raw materials has increasingly drawn attention to the extensive marine metalliferous mineral deposits. Nuclear techniques can provide powerful analytical tools for exploring these resources. The measurement of natural gamma radiation, x-ray fluorescence analysis and a variety of neutron techniques based on <sup>252</sup>Cf, ( $\alpha$ ,n) and (d,n) sources are now in use or appear to make progress. Improvement of the relevant cross sections could considerably advance the technical development both in the field and in the laboratory. Particular consideration should be given to a number of energy-dependent cross sections pertaining to neutron and gamma transport in field applications of activation analysis or radiative capture, to neutron cross sections for production of gamma rays from inelastic collisions, to cross sections of threshold reactions which either ensure elemental selectivity or are the source of elemental interferences and, finally, to cross sections for quasi-prompt activation with 14 MeV neutrons.

**Neutron cross sections of importance to astrophysics, J. C. Browne, *SP594*, pp. 627-633 (Sept. 1980).**

**Key words:** neutron cross sections; nuclear clocks; stellar processes.

Neutron reactions of importance to the various stellar burning cycles are discussed. The role of isomeric states in the branched s-process is considered for particular cases. Neutron cross section needs for the <sup>187</sup>Re-<sup>187</sup>Os, <sup>87</sup>Rb-<sup>87</sup>Sr clocks for nuclear cosmochronology are discussed. Other reactions of interest to astrophysical processes are presented.

**Open problems in nuclear data evaluations, S. Pearlstein, *SP594*, pp. 634-638 (Sept. 1980).**

**Key words:** nuclear data; nuclear data evaluation; nuclear data measurements.

Nuclear data measurements are often discrepant or incomplete. Despite these difficulties, after reviewing the information at hand, experts periodically prescribe their best estimates of nuclear data for use by scientists. Some of the obstacles the experts face are poor energy calibrations, inadequate data, overly detailed data, and the necessity for coalescing multidisciplinary information. These and other aspects of nuclear data evaluation are discussed.

**Application of nuclear models, P. G. Young, E. D. Arthur, and D. G. Madland, *SP594*, pp. 639-649 (Sept. 1980).**

**Key words:** nuclear data evaluation; nuclear model codes; nuclear reaction theory.

The development of our extensive experimental nuclear data base over the past three decades has been accompanied by parallel advancement of nuclear theory and models used to describe and interpret the measurements. This theoretical capability is important because of many nuclear data requirements that are still difficult, impractical, or even impossible to meet with present experimental techniques. Examples of such data needs are neutron cross sections for unstable fission products, which are required for neutron absorption corrections in reactor calculations; cross sections for transactinide nuclei that control production of long-lived nuclear wastes; and the extensive dosimetry, activation, and neutronic data requirements to 40 MeV that must accompany development of the Fusion Materials Irradiation Test (FMIT) facility. In recent years systematic improvements have been made in the nuclear models and codes used in data evaluation and, most importantly, in the methods used to derive physically based parameters for model calculations. The newly issued ENDF/B-V evaluated data library relies in many cases on nuclear reaction theory based on compound-nucleus Hauser-Feshbach, preequilibrium and direct reaction mechanisms as well as spherical and deformed optical-model theories. The development and application of nuclear models for data evaluation are discussed in this paper, with emphasis on the 1-40 MeV neutron energy range.

**R-Matrix analyses of light-element reactions for fusion applications, G. M. Hale and D. C. Dodder, *SP594*, pp. 650-658 (Sept. 1980).**

**Key words:** charged-particle reactions; evaluated fusion cross sections; multichannel R-matrix analyses; nucleon systems.

Comprehensive R-matrix analyses of reactions in light systems done at LASL contain cross-section information of interest in fusion applications. Results for analyses of the 4-, 5-, 6-, and 7-nucleon systems are presented, with particular emphasis on cross sections for the T(d,n), D(d,n) D(d,p), T(t,2n), and <sup>6</sup>Li(p,<sup>3</sup>He) fusion reactions.

**Evaluated data collections from ENSDF, W. B. Ewbank, *SP594*, pp. 659-661 (Sept. 1980).**

**Key words:** ENSDF; evaluation; nuclear levels; nuclear reactions; nuclear structure data; radioactivity; reaction gamma rays.

For several years the Nuclear Data Project has been maintaining an Evaluated Nuclear Structure Data File (ENSDF), which is designed to include critically evaluated values for most nuclear spectroscopic quantities. The information in ENSDF is the same as in the *Nuclear Data Sheets*, which illustrates two particular output formats (drawings and tables). Spectroscopic information for nuclei with  $A < 45$  is put into ENSDF from the evaluations of Ajzenberg-Selove and of Endt and van der Leun. An international network has been organized to provide regular revisions of the data file. Computer facilities have been developed to retrieve collections of evaluated data for special calculations or detailed examination.

**Evaluations of fission product capture cross sections for ENDF/B-V, R. E. Schenter, D. L. Johnson, F. M. Mann, F. Schmittroth, and H. Gruppelaar, *SP594*, pp. 662-666 (Sept. 1980).**

**Key words:** capture cross sections; fast reactors.



Capture cross section evaluations have been made for the 36 most important fission product absorbers in a fast reactor system. These evaluations were obtained using a generalized least-squares approach with calculations being performed with the computer code FERRET. These results will provide the major revisions to the ENDF/B-IV Fission Product Cross Section File which will be released as part of ENDF/B-V. Input for the cross section adjustment calculations included both integral and differential experimental data results. The differential cross sections and their uncertainties were obtained from the CSIRS library. Integral measurement results came from CFRMF and STEK Assemblies 500, 1000, 2000, 3000, 4000. Comparisons of these evaluations with recent capture measurements will be presented.

**Beta and gamma decay heat evaluation for the thermal fission of  $^{235}\text{U}$ ,** G. K. Schenter and F. Schmittroth, *SP594*, pp. 667-671 (Sept. 1980).

Key words: decay heat; evaluation; fission-products.

Beta and gamma fission product decay heat curves are evaluated for the thermal fission of  $^{235}\text{U}$ . Experimental data that include beta, gamma, and total measurements are combined with summation calculations based on ENDF/B in a consistent evaluation. Least-squares methods are used that take proper account of data uncertainties and correlations.

**Fast neutron scattering cross sections for actinide nuclei,** G. Hauat, C. Lagrange, J. Lachkar, J. Jary, Y. Patin, and J. Sigaud, *SP594*, pp. 672-676 (Sept. 1980).

Key words: calculated direct-interaction and compound-nucleus cross sections; deduced coupled-channel optical potential parameters; enriched targets; nuclear reactions; quadrupole and hexadecapole deformation parameters.

Differential cross sections for neutron elastic and inelastic scattering from  $^{232}\text{Th}$ ,  $^{233}\text{U}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$  and  $^{242}\text{Pu}$  have been obtained at incident energies ranging from 0.6 to 3.4 MeV. The overall energy resolution of the time-of-flight spectrometer was sufficient to easily separate at all energies the elastic and inelastic neutron groups for  $^{232}\text{Th}$ ,  $^{233}\text{U}$ ,  $^{238}\text{U}$  and  $^{242}\text{Pu}$ . Cross sections for groups of states have been obtained for  $^{235}\text{U}$  and  $^{239}\text{Pu}$ . Comparisons of these results with the latest available evaluations show large discrepancies. The present measured cross sections have been combined with measured total cross sections and low-energy scattering properties in an analysis based on combined coupled-channel and compound-nucleus formalisms. Optical potential parameters and nuclear deformation parameters have been deduced and are discussed.

**Measurement of  $^{238}\text{U}(n,n'\gamma)^{238}\text{U}$  cross sections,** D. K. Olsen, G. L. Morgan, and J. W. McConnell, *SP594*, pp. 677-679 (Sept. 1980).

Key words: cross sections; gamma-ray transitions; inelastic scattering.

Production cross sections for gamma-ray transitions produced by 0.5 to 5.0-MeV neutrons on  $^{238}\text{U}$  have been measured employing a 95-cm<sup>3</sup> Ge(Li) detector at 125°, the ORELA neutron source, and a recoil proton telescope. From these data and other decay scheme information, inelastic scattering cross sections for levels from 680 to 1224 keV of excitation have been constructed and compared with statistical model calculations and the ENDF/B-V evaluation.

**Neutron inelastic scattering cross sections of  $^{238}\text{U}$  via  $(n,n'\gamma)$ ,** A. Mittler, G. P. Couchell, W. A. Schier, S. Ashar, J. H. Chang, and A. T. Y. Wang, *SP594*, pp. 680-684 (Sept. 1980).

Key words: inferred level cross sections for 20 states; measured  $\sigma_\gamma(E_n, 125^\circ)$ ; nuclear reactions  $^{238}\text{U}(n,n'\gamma)$ ; time-of-flight.

Level cross sections of  $^{238}\text{U}$  have been deduced from gamma-ray measurements at 125° following inelastic neutron scattering over an incident energy range of 0.70 to 1.96 MeV. A pulsed source of neutrons was produced via the  $^3\text{H}(p,n)^3\text{He}$  reaction. The spectrometer system consisted of a 40-cm<sup>3</sup> Ge(Li) detector surrounded by a large annular NaI anti-Compton detector, used in conjunction with time-of-flight electronics. Forty-five gamma transitions were observed for twenty-seven levels up to 1516 keV. Finite sample corrections, including neutron attenuation, gamma-ray attenuation and neutron multiple scattering were made for the disc-shaped scatterer. Results are compared to statistical compound-nucleus model calculations and ENDF.

**Neutron inelastic scattering cross sections of  $^{232}\text{Th}$  obtained from  $(n,n'\gamma)$  measurements,** J. J. Egan, J. D. Menachery, G. H. R. Kegel, and D. J. Pullen, *SP594*, pp. 685-689 (Sept. 1980).

Key words: comparison with calculated excitation functions; inferred level cross sections for 22 states; measured  $\sigma_\gamma(E_n, 125^\circ)$ ; nuclear reactions  $^{232}\text{Th}(n,n'\gamma)$ ; time-of-flight.

The  $^{232}\text{Th}(n,n'\gamma)$  reaction has been studied up to 2.1 MeV bombarding energy for states with excitation energies from 700 to 1700 keV. Seventy-five gamma-ray transitions from forty-three above the first excited state have been observed from a disk scatterer with a 40-cm<sup>3</sup> Ge(Li) detector surrounded by an anti-Compton annulus of NaI(Tl). The time-of-flight technique was employed to further reduce background. Cross sections for twenty-two states are reported here. The data have been corrected for the finite sample effects of neutron and gamma-ray attenuation, and neutron multiple scattering. The results are compared to those of McMurray *et al.* and to the predictions of the compound nucleus statistical model. A compound nucleus plus direct interaction calculation is also shown for the 1<sup>-</sup> state at 714 keV.

**Neutron total cross section of  $^{233}\text{U}$  from 0.01 to 1.0 eV,** J. A. Harvey, C. L. Moore, and N. W. Hill, *SP594*, pp. 690-691 (Sept. 1980).

Key words: measured  $\sigma_T$  for  $^{233}\text{U}$ ; resonance at 0.15 eV.

At the last Nuclear Cross Sections and Technology Conference, B. R. Leonard stressed the importance of improved total cross section data for  $^{233}\text{U}$  in the energy region from 0.1 to 0.2 eV. We have measured the neutron total cross section of  $^{233}\text{U}$  from 0.01 to 1.0 eV at ORELA using a repetition rate of 25 sec<sup>-1</sup> and a 17.872 flight path. Two samples of  $^{233}\text{U}$  enriched to 99.76% with inverse thicknesses of 165.2 and 321.1 barns/atom were measured. The data were corrected for neutron and gamma ray backgrounds which were  $\leq 1\%$ . Results from the two samples are in good agreement. The data are compared to earlier data and to ENDF/B-V evaluation.

**Transmission and self-indication measurements with U-235 and Pu-239 in the 2 eV-20 energy region,** T. Bakalov, G. Ilchev, S. Toshkov, T. K. Mai, N. Janeva, A. A. Van'kov, Y. V. Grigoriev, and V. F. Ukraintsev, *SP594*, pp. 692-697 (Sept. 1980).

Key words: fission chamber; self-indication; self-shielding and fission factors; time-of-flight; He proportional counter.

The transmission and self-indication measurements with U-235 and Pu-239 have been carried out using the  $^3\text{He}$  proportional counter and fission chambers in the 2 eV-20 keV energy region. The TOF technique was used with JINR pulse fast reactor IBR-30 in Dubna as a neutron

source, the resolution being 100 nsec/m ( $^3\text{He}$  counter measurements) and 53 nsec/m (fission chamber measurements). The sample thickness was varied from 0.0013 atom/barns to 0.172 atom/barns. Average total cross sections with self-shielding factors and self-shielding fission factors were determined for energies within ABBN nuclear constant set.

**Total-neutron cross sections of heavy nuclei**, W. P. Poenitz, J. F. Whalen, and A. B. Smith, *SP594*, pp. 698-702 (Sept. 1980).

Key words: heavy nuclei; total neutron cross section.

Total-neutron cross sections of the heavy and actinide nuclei  $^{181}\text{Ta}$ ,  $^{197}\text{Au}$ ,  $^{232}\text{Th}$ ,  $^{233}\text{U}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$  and  $^{240}\text{Pu}$  were measured from 30 keV to 4.8 MeV. The experimental procedures emphasized a high consistency of the measured data. Systematic uncertainties, excluding those associated with sample masses, were  $\leq 0.5\%$  and statistical uncertainties were typically  $\leq 1.0\%$ . At low energies attention was given to resonance self-shielding effects. The experimental results are in good agreement with  $^{232}\text{Th}$ ,  $^{233}\text{U}$  and  $^{238}\text{U}$  data previously reported from this laboratory and at higher energies with the comparable values reported by Foster and Glasgow, excepting  $^{240}\text{Pu}$  which was not studied in the latter work. The measured total-cross-sections were interpreted in terms of a spherical optical model and a deformed coupled-channels model.

**Total cross section of  $^{242}\text{Pu}$  between 0.7 and 170 MeV**, M. S. Moore, P. W. Lisowski, G. L. Morgan, G. F. Auchampaugh, and R. E. Shamu, *SP594*, pp. 703-706 (Sept. 1980).

Key words: critical mass; total cross section.

Various evaluations of the neutron cross sections of  $^{242}\text{Pu}$  lead to widely different predictions of bulk neutronics properties such as critical mass. These evaluations also show rather different behavior of the energy dependence of the total cross section. We have measured the total cross section of  $^{242}\text{Pu}$  from 0.7 to 170 MeV to a statistical accuracy of  $\approx 0.5\%$  below 6 MeV, using 8 g of high purity material and the WNR, pulsed neutron facility. Recent evaluations by Madland and Young and by Lagrange and Jary are found to be reasonably consistent with the data obtained. Best agreement, however, is found by using the simple prescription  $\sigma_T(^{242}\text{Pu}) = \sigma_T(^{238}\text{U}) + [\sigma_T(^{239}\text{Pu}) - \sigma_T(^{235}\text{U})]$ . The remarkable accuracy of this description for  $^{242}\text{Pu}$  suggests that it could be extended to other deformed actinides for which inadequate amounts of material exist for direct measurements of  $\sigma_T$  in the MeV region, as an evaluation constraint.

**Neutron total cross section measurements on  $^{249}\text{Cf}$** , R. F. Carlton, J. A. Harvey, N. W. Hill, M. S. Pandey, and R. W. Benjamin, *SP594*, pp. 707-710 (Sept. 1980).

Key words: fission; level spacing; multilevel analysis; neutron total cross section; strength function.

Neutron total cross section measurements have been performed on a sample of  $^{249}\text{Cf}$  (5.65 mg total weight) using the ORELA as a source of pulsed neutrons. The sample, whose inverse thickness was 1542 barns/atom, consisted of 85.3%  $^{249}\text{Cf}$  and 14.4%  $^{249}\text{Bk}$  and was cooled to liquid nitrogen temperature. Analyses were also made of data from a thin sample ( $1/N = 17430$ ) of 65%  $^{249}\text{Cf}$  in the region of the large fission resonance at 0.7 eV. Fifty-five resonances in  $^{249}\text{Cf}$  were observed and analyzed over the energy range 0.1 eV to 90 eV using an R-matrix multilevel formalism. The resonance parameters obtained have been used to determine the level spacing and the s-wave neutron and fission strength functions. Thermal total cross section measurements have also been performed.

**Intercomparison of coupled channel and spherical optical models in the analysis of thorium neutron cross sections**, S. B. Garg, A. Sinha, and V. K. Shukla, *SP594*, pp. 711-714 (Sept. 1980).

Key words: local; nonlocal and coupled channel descriptions; optical model analysis;  $\text{Th}(n,n)$ ; total and inelastic cross sections.

A comparison has been made of local, nonlocal and deformed optical models in the prediction of neutron cross-sections of  $^{232}\text{Th}$ . Coupled channel study makes use of the adiabatic approximation and local and nonlocal optical model parameters have been extracted by making use of the measured total and elastic scattering cross-sections.

**Simultaneous evaluation of the nuclear data for heavy nuclides**, H. Matsunobu, Y. Kanda, M. Kawai, T. Murata, and Y. Kikuchi, *SP594*, pp. 715-719 (Sept. 1980).

Key words: absolute measurement; consistency; fission cross section; JENDL-2; nuclear data; optical potential parameter; relative measurement; simultaneous evaluation.

The nuclear data of  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$ ,  $^{240}\text{Pu}$ , and  $^{241}\text{Pu}$  were simultaneously evaluated in the energy range of 100 eV to 20 MeV by using recent experimental data and theoretical calculations for Japanese Evaluated Nuclear Data Library-Version 2 (JENDL-2). The optical potential parameters were so searched for that the total cross sections of these heavy nuclides were well reproduced with simple systematics.

**Neutron cross section standards**, O. A. Wasson, *SP594*, pp. 720-727 (Sept. 1980).

Key words: neutron flux; review; standard cross section.

A review of the status of the neutron induced reactions which have suitable properties for use as neutron standard cross sections is given. The application of these standards in instruments to measure neutron fluence rate as well as an assessment of the impact of the recent measurements is presented.

**Absolute measurement of  $\bar{\nu}_p$  for  $^{252}\text{Cf}$  by the large liquid scintillator tank technique**, R. R. Spencer, *SP594*, pp. 728-732 (Sept. 1980).

Key words: fission; large liquid scintillator; neutron multiplicity; proton-recoil detector.

A vigorous effort to dispel the scandal of the  $\sim 2\%$  dispersion in reported experimental values of  $^{252}\text{Cf}$   $\bar{\nu}_p$ , the average number of neutrons emitted in spontaneous fission, has been underway over the past 5 years. The goal is to reduce the uncertainty in this fundamental parameter to the  $\pm 0.25\%$  level needed for reactor physics applications. Both new measurements and reevaluation of older measurements are involved. At ORNL a new measurement is being carried out using the large liquid scintillator neutron detector. Findings of the most recent experiment, incorporating improvements suggested in a preliminary study, will be discussed.

**Data discrepancies in and new experiments for  $\text{D} + \text{D}$ ,  $\text{D} + \text{T}$ , and  $\text{T} + \text{T}$  fusion reactions**, N. Jarmie, R. A. Hardekopf, R. E. Brown, F. D. Correll, and G. G. Ohlsen, *SP594*, pp. 733-737 (Sept. 1980).

Key words: absolute cross section measurement; data discrepancies.

We investigate the accuracy of the basic fusion data for the reactions  $\text{T}(d,n)^4\text{He}$ ,  $\text{T}(t,2n)^4\text{He}$ ,  $\text{D}(d,n)^3\text{He}$ , and  $\text{D}(d,p)\text{T}$  in the 10-100 keV bombarding energy region of interest in the design of fusion reactors, magnetic or iner-



tial. The history of the data base for these reactions, particularly the most critical one:  $T(d,n)^4\text{He}$ , is based on 25-year-old experiments whose accuracy (often assumed to be 5%) has rarely been questioned. In all except the  $d + d$  reactions significant differences among data sets exist. The errors of the basic data sets may be considerably larger than previously expected and the effect on design calculations should be significant. Much of the trouble apparently lies in the accuracy of the energy measurements which are difficult at low energies. We feel that systematic errors of up to 50% are possible in the reactivity values of the present  $T(d,n)^4\text{He}$  data base. The errors in the reactivity would propagate proportionately into the errors in fusion probabilities in reactor calculations. The  $D(d,n)^3\text{He}$  and  $D(d,p)^3\text{H}$  cross sections appear to be well known and consistent. The  $T(t,2n)^4\text{He}$  cross section is poorly known and may be subject to large systematic errors. Improved absolute measurements in the 10-100 keV bombarding energy region for the above reactions are underway at Los Alamos. The experiment features a windowless cryogenic target, calibration of the target density with a high energy Van-de-Graaff beam, measurement of the beam intensity with a calorimeter, use of a negative ion source for the 10 to 100 keV measurements, and a time-of-flight laser spectrometer to determine the absolute energy. Both the source and target will be capable of handling tritium. Accuracies of better than 5% are anticipated.

**The  $^{252}\text{Cf}$   $\bar{\nu}$  discrepancy and the sulfur discrepancy, J. R. Smith, *SP594*, pp. 738-742 (Sept. 1980).**

**Key words:** absorption cross section; manganese bath; pile oscillator; small-angle scattering; sulfur.

The cantankerous discrepancy among measured values of  $\bar{\nu}$  for  $^{252}\text{Cf}$  appears at last to be nearing a final resolution. A recent review has summarized the progress that has been achieved through revaluation upward by 0.5% of two manganese bath values of  $\bar{\nu}$  and the performance of a new liquid scintillator measurement. A new manganese bath measurement at INEL is in reasonably good agreement with previous manganese bath values of  $^{252}\text{Cf}$   $\bar{\nu}$ . It now appears that the manganese bath values could still be systematically low by as much as 0.4% because the BNL-325 thermal absorption cross section for sulfur may be as much as 10% low. There is a bona fide discrepancy between measurements of the sulfur cross section by pile oscillators and the values derived from transmission measurements. The resolution of this discrepancy is a prerequisite to the final resolution of the  $^{252}\text{Cf}$   $\bar{\nu}$  discrepancy.

**Neutron capture cross section standards for BNL-325, N. E. Holden, *SP594*, pp. 743-746 (Sept. 1980).**

**Key words:** resonance integral; thermal cross section.

The most common cross section standards for capture reactions in the thermal neutron energy region are gold, cobalt, and manganese. In preparation for the fourth edition of BNL-325, data on the thermal cross section and resonance integral were evaluated for these three standards. For gold, only measurements below the Bragg scattering cutoff were used and extrapolated to a neutron velocity of 2200 meters/second. A non  $1/v$  correction due to the 4.9 eV resonance was made. The resonance integral is based on Jirflow's integral measurement and Tellier's parameters. The resonance integrals for cobalt and manganese are based solely on integral measurements because the capture widths of the first major resonance either vary by 20% in various measurements (cobalt), or have never been measured (manganese). Recommended thermal cross sections and resonance integrals are respectively gold:  $98.65 \pm 0.09$  barns,  $1550 \pm 28$  barns, cobalt:  $37.18 \pm 0.06$  barns,  $74.2 \pm 2.0$

barns, and manganese:  $13.3 \pm 0.2$  barns, and  $14.0 \pm 0.3$  barns.

**NBS neutron monitor and dosimeter calibration facility, K. C. Duvall, O. A. Wasson, and M. M. Meier, *SP594*, pp. 747-751 (Sept. 1980).**

**Key words:** calibration; detection; dosimetry; facilities; fluence; flux; monitor; neutron; sources; standardization.

A standard neutron flux in the energy range of .2 to 1.2 MeV has been established at the NBS 3 MV positive ion Van de Graaff laboratory. The neutron flux is produced from the  $^7\text{Li}(p,n)^7\text{Be}$  reaction and monitored by a precision calibrated black neutron detector. The flux is emitted within a cone of  $4.5^\circ$  half angle and is spatially uniform to within  $\pm 1\%$ . The facility has been recently used for the calibration of neutron monitors and dosimeters submitted by government and industry. The detector responses are measured relative to our standard neutron flux in terms of response per unit fluence. These calibration factors have been determined with an accuracy better than  $\pm 5\%$ .

**Capture cross section and gamma-ray spectrum calculations for medium-weight nuclei, M. A. Gardner and D. G. Gardner, *SP594*, pp. 752-756 (Sept. 1980).**

**Key words:** calculated  $E1$   $\gamma$ -ray strength functions; calculated  $\sigma(n,\gamma)$  and  $\gamma$ -ray spectra; calculated  $\sigma(n,\gamma)$  for  $^{89}\text{Y}$  and  $^{90}\text{Zr}$ .

We have applied a double-peak, energy-dependent Breit-Wigner model of the  $E1$  gamma-ray strength function to nuclei from As to Rh, to predict their neutron capture cross sections and capture gamma-ray spectra. We found that a consistent set of model parameters could be obtained in this mass region to describe the step in the low-energy tail of the  $E1$  strength function. This step allows: (a) agreement with photonuclear data at high energies, (b) the correct  $\Gamma_\gamma$  to be obtained for agreement with neutron capture cross-section data, and (c) the calculation of the observed hardness in the capture gamma-ray spectra. For nuclei at or near the closed,  $N = 50$  shell, however, the model's double-peak assumption breaks down. In these cases, good results are still obtained if the same set of model parameters is applied except that the  $E1$  strength function is formulated in terms of the first, narrower peak.

**A consistent nuclear model for compound and precompound reactions with conservation of angular momentum, C. Y. Fu, *SP594*, pp. 757-761 (Sept. 1980).**

**Key words:** exciton model; Hauser-Feshbach and precompound analysis; nuclear reactions.

The exciton model is modified such that it automatically reduces to the usual evaporation formula after equilibrium has been reached. The result is further modified to conserve angular momentum in a form compatible with the Hauser-Feshbach formula. This allows a consistent description of intermediate excitations from which tertiary reaction cross sections can be calculated for transitions to discrete residual levels with known spins and parities. Level densities used for the compound component of reaction cross sections are derived from direct summation of the particle-hole state densities used for the precompound component.

**Improved formulas for compound nucleus cross sections, J. W. Tepel, H. M. Hofmann, and M. Herman, *SP594*, pp. 762-764 (Sept. 1980).**

**Key words:** compound-nucleus reactions; cross sections; elastic enhancement factors; factorization; Hauser-Feshbach theory; statistical models; width fluctuation correction factor.



In an extension of previous work on the theory of statistical cross sections model calculations have been performed in the region of weak absorption, which is of particular interest in applied work involving neutron capture or neutron scattering at low energies. Improved formulas for calculating compound nucleus cross sections and width fluctuation correction factors are presented. Although we agree with Moldauer that the factorization condition for cross sections is not always satisfied in few channel cases where strongly and weakly absorbing channels are mixed, the formulas provide a good description of the computer-generated cross sections. In addition, the structure of the improved formula has been chosen as to describe cases where many weakly absorbing channels contribute.

**Neutron emission spectra induced by 14-MeV neutrons from the evaluated nuclear data file (ENDF/B-V)—A critical review,** D. M. Hetrick, D. C. Larson, and C. Y. Fu, *SP594*, pp. 765-769 (Sept. 1980).

**Key words:** ENDF/B-V; neutron emission spectra; nuclear model codes.

Neutron emission spectra induced by 14.6-MeV incident neutrons, retrieved from ENDF/B-V, are graphically compared with experimental data by Hermsdorf *et al.*, and Clayeux and Voignier. The elements selected for the comparisons include Na, Mg, Al, Si, Ca, Ti, V, Cr, Fe, Ni, Cu, Nb, W, and Pb. In addition to comparing the evaluated total neutron emission spectra with experimental data, individually evaluated spectra from contributing reactions are presented. Only a few of the evaluated spectra were found to agree well with the measured spectra; namely, those evaluations which utilized advanced nuclear model codes with precompound effects and competing binary and tertiary reactions. Recommendations for removing several defects in most evaluations are made.

**A new parameterization of the El gamma-ray strength function,** D. G. Gardner and F. S. Dietrich, *SP594*, pp. 770-774 (Sept. 1980).

**Key words:** calculated  $\sigma(n,\gamma)$  and  $\gamma$ -ray spectra for  $^{181}\text{Ta}$  and  $^{197}\text{Au}$ ; calculated  $\sigma(n,\gamma)$  for  $^{186,187,188}\text{Os}$ ; gamma-ray strength functions; GD parameter systematics.

We have satisfactorily correlated the giant dipole (GD) parameters of peak energy, width, and cross section for elements from V to Bi, assuming two overlapping peaks with a separation dependent on deformation. The energy dependence of the GD resonance is assumed to have a Breit-Wigner form, but with an energy-dependent width. The resulting gamma-ray strength function model is used to predict neutron capture cross sections and gamma-ray spectra for isotopes of Ta, Os, and Au.

**Gamma-ray production cross sections for MeV neutrons,** H. Kitazawa, Y. Harima, H. Yamakoshi, Y. Sano, T. Kobayashi, and M. Kawai, *SP594*, pp. 775-777 (Sept. 1980).

**Key words:** gamma-ray production cross section; gamma-ray strength function; spin-dependent evaporation model; yrast level.

Gamma-ray production cross sections for MeV neutrons are calculated for several nuclei over the wide nuclear mass number from 27 to 208. The results are compared with experimental data. It is found that the model and assumptions adopted in the present calculation are adequate for description of the gross dependence of gamma-ray production cross section on neutron energy and nuclear mass number, unless the radiative neutron capture process is dominant in comparison with other possible ones.

**Semiempirical calculation of excitation functions,** E. L. Pe-

terson, *SP594*, pp. 778-782 (Sept. 1980).

**Key words:** excitation functions  $E = 5\text{--}80$  MeV; nuclear reactions; semiempirical model.

A simple model for the calculation of excitation functions is described. The geometrical cross section, allowing for transparency, is divided into statistical, direct and preequilibrium portions. These cross sections are allocated to individual reactions by examining the relative contributions of all possible reactions emitting the same number of particles. The cross section for each reaction product is then calculated as a function of energy. A computer code has been written that calculates excitation functions in the range between 5 and 80 MeV for reactions emitting from one to six particles. The results are compared with experimental values for proton reactions with  $^{27}\text{Al}$ ,  $^{58}\text{Ni}$ ,  $^{59}\text{Co}$  and  $^{209}\text{Bi}$ .

**R-matrix analysis of neutron elastic and inelastic scattering data,** H. D. Knox, R. O. Lane, D. A. Resler, and P. E. Koehler, *SP594*, pp. 783-787 (Sept. 1980).

**Key words:** elastic cross section; inelastic cross section; multichannel; multilevel; neutron; R-matrix.

A multichannel multilevel R-matrix analysis program capable of analyzing neutron elastic and inelastic scattering data has been developed. The program has been used to analyze  $^7\text{Li} + n$  data with good fits obtained for elastic and inelastic (0.478 MeV level) cross sections up to 8 MeV. A description of the program and the results of the  $^7\text{Li} + n$  study are given.

**Calculation of prompt fission neutron spectra,** D. G. Madland and J. R. Nix, *SP594*, pp. 788-792 (Sept. 1980).

**Key words:** comparisons to  $^{235}\text{U}(n,f)$  and  $^{252}\text{Cf}(sf)$ ; experimental prompt neutron spectra; fermi-gas model; fission calculation of prompt fission neutron spectrum as function of fissioning nucleus and excitation energy; nuclear-evaporation model; radioactivity.

We present a new calculation of the prompt fission neutron spectrum  $N(E)$  as a function of both the fissioning nucleus and its excitation energy. The calculation, based upon standard nuclear-evaporation theory, accounts for the physical effects of (1) the distribution of fission-fragment residual nuclear temperature, and (2) the energy dependence of the cross section for the inverse process of compound-nucleus formation. Using a residual nuclear temperature distribution based upon the Fermi-gas model, we have performed calculations for two different assumptions concerning the cross section for compound-nucleus formation. Use of a constant cross section leads to a closed expression for the neutron energy spectrum while use of an energy-dependent cross section, calculated with the optical model, yields a numerical integration. Results obtained for the two assumptions agree well with experimental data although there is a preference for the energy-dependent cross section calculation.

**Simple parameterization for optical reaction cross sections,** K. H. N. Murthy, A. Chatterjee, and S. K. Gupta, *SP594*, pp. 793-795 (Sept. 1980).

**Key words:** alphas; energies up to 50 MeV; inputs for further calculations; optical reaction cross sections for neutrons; over the periodic table; protons.

Optical model reaction cross sections for neutrons, protons and alpha particles, are directly parameterized using simple expressions reflecting the mass number and energy dependence. The cross sections can be calculated within an accuracy of 5-10% over the whole periodic table and the energy range up to 50 MeV. These cross sections are useful



inputs for calculating various partial reaction cross sections using statistical models of nuclear reactions.

**Exact solution of the exciton model master equations for nuclear reactions**, S. K. Gupta and A. Chatterjee, *SP594*, pp. 796-799 (Sept. 1980).

**Key words:** exciton model; master equations; neutron angular distributions; preequilibrium and equilibrium components.

An exact solution is obtained for the time integrated Pauli master equations of the exciton model. The solution expresses the mean lifetimes of exciton states in terms of the various transition rates of the model in a simple closed form. Using these solutions both the preequilibrium and equilibrium components of nuclear reactions can be obtained in an integrated manner. The solutions are applicable also for the case of the generalized master equations which can be used to calculate angular distributions. An application of the solutions for the calculation of neutron spectra in the neutron induced reactions on  $^{93}\text{Nb}$  is discussed.

**Delayed neutron calculations using ENDF/B-V data**, T. R. England, R. E. Schenter, and F. Schmittroth, *SP594*, pp. 800-803 (Sept. 1980).

**Key words:** ENDF/B-V data; neutron calculations; neutron precursors; neutron yields.

Data from 20 fission yield sets in ENDF/B-V are used with the emission probabilities ( $P_n$ ) of 105 delayed neutron precursors to calculate 6-group and total equilibrium delayed neutron yields ( $\bar{\nu}_d$ ). Results are compared with recent evaluations and selected measurements of  $\bar{\nu}_d$ . Least squares data adjustment methods are in progress to improve agreement; preliminary results indicate significant improvement when fission yields are adjusted.

**Utilization of the reaction  $^{10}\text{B}(\text{d},\text{n})^{11}\text{C}$  as a high temperature deuterium plasma diagnostic**, L. K. Len and F. E. Cecil, *SP594*, pp. 804-806 (Sept. 1980).

**Key words:** deuterium plasma diagnostic; reaction cross section; reaction  $^{10}\text{B}(\text{d},\text{n})^{11}\text{C}$ .

We have measured the thick target yield of the reaction  $^{10}\text{B}(\text{d},\text{n})^{11}\text{C}$  for monoenergetic deuteron beams of energies between 75 and 170 keV. These yields, together with recently published range energy relations for hydrogen ions in matter, permitted our deduction of the reaction cross section as a function of energy. By integrating the cross section over a Maxwell Boltzman population distribution, we obtained the reaction yields for Boron samples exposed to a deuterium plasma of temperatures between  $20 \times 10^6$  and  $200 \times 10^6$  °K.

**Measurement of the 2.35-MeV window in  $\text{O} + \text{n}$** , C. H. Johnson, J. L. Fowler, N. W. Hill, and J. M. Ortolfo, *SP594*, pp. 807-811 (Sept. 1980).

**Key words:** calculate deuterium plasma neutron spectrum; fusion; measured  $\sigma_T$  for  $\text{O}(\text{n},\text{n})$ .

Calculations are made showing that the ion temperature of a deuterium plasma with a Maxwellian distribution can be found by measuring the transmission of the d-d neutrons through liquid oxygen. The method is useful for temperatures up to 6 keV. It does not depend on the absolute neutron yield but does require accurate total neutron cross sections for oxygen. In this experiment the cross section of natural oxygen was measured from 2.0 to 3.0 MeV by neutron time-of-flight at the Oak Ridge Electron Linear Accelerator (ORELA). The fitted cross sections have a  $110.9 \pm 1.7$  mb minimum at 2351.5 keV.

**The status of neutron dosimetry and damage analysis for the**

**fusion materials program**, L. R. Greenwood, *SP594*, pp. 812-816 (Sept. 1980).

**Key words:** displacement damage; neutron dosimetry; nuclear activation cross sections.

The status of neutron flux and spectral measurements is described for fusion material irradiations at reactor,  $\text{T}(\text{d},\text{n})$ ,  $\text{Be}(\text{d},\text{n})$ , and spallation neutron sources. Such measurements are required for the characterization of an irradiation in terms of displacement damage, gas and transmutant production. Emphasis is placed on nuclear data deficiencies with specific recommendations for cross section measurements and calculations.

**Nuclear data needs for FMIT**, R. E. Schenter, F. M. Mann, and D. L. Johnson, *SP594*, pp. 817-820 (Sept. 1980).

**Key words:** nuclear data needs for FMIT.

The Fusion Material Irradiation Testing Facility (FMIT) is designed to test samples in a high energy neutron environment so that data obtained in fission reactors can be extrapolated to that needed in fusion devices. Although most of the flux is centered around  $\sim 14$  MeV, the neutron distribution will extend from thermal energies to 50 MeV.

Data needed in design include total, elastic, and removal cross sections for shielding, neutron yields for source calculations, and selected transmutation cross sections for dose determinations. Data needed for operation include transport and dosimetry cross sections for flux determinations, damage energy, transmutation, and gas production cross sections for damage analyses, and selected data for machine operation and maintenance. Detailed reaction lists are given.

**The spatial dependence of flux and damage in the FMIT test cell**, F. M. Mann, F. Schmittroth, L. L. Carter, and J. O. Schiffgens, *SP594*, pp. 820-823 (Sept. 1980).

**Key words:** fitted thick target yield; nuclear models.

Experimental  $\text{Li}(\text{d},\text{n})$  thick target yields have been combined with nuclear models to determine the microscopic  $\text{Li}(\text{d},\text{n})$  cross section as a function of incoming deuteron energy ( $E_d \leq 40$  MeV), of outgoing neutron energy ( $0 \leq E_n \leq 50$  MeV), and of outgoing neutron angle ( $0 \leq \Theta \leq 180^\circ$ ). A generalized least squares adjustment procedure using all the experimental data for  $14 \leq E_d \leq 50$  provided the overall normalization and the angular distribution, while the Serber stripping model and the evaporation model provided the neutron energy dependence.

The cross sections are applied to the conditions appropriate to the FMIT (Fusion Materials Irradiation Testing) facility to determine flux and damage parameter levels inside the test cell.

**Measurements of neutron spectra from 35 MeV deuterons on thick lithium for the FMIT facility**, D. L. Johnson, F. M. Mann, J. W. Watson, J. Ullmann, and W. G. Wyckoff, *SP594*, pp. 824-828 (Sept. 1980).

**Key words:** angular distribution; fusion materials irradiation test (FMIT) facility;  $\text{Li}(\text{d},\text{xn})$ ; nuclear reactions; thick target yields and spectra; time-of-flight technique; total yield.

Neutron yield spectra were measured for 35 MeV deuterons on thick natural lithium. The time of flight technique was used and data were obtained for laboratory emission angles of  $0^\circ$  to  $150^\circ$ . The yield of neutrons greater than 1 MeV was determined at each angle and was integrated to find the total yield.

**Measured and evaluated bismuth data for fusion-fission-hybrid and electro-nuclear breeding applications**, P. T. Guenther, A. B. Smith, D. L. Smith, J. F. Whalen, and R.

Key words: comprehensive evaluation; ENDF format; optical-model interpretations.

Neutron total and scattering cross sections of elemental bismuth are measured to energies of approximately 4.5 MeV. The experimental results are used to deduce an optical-statistical model that is quantitatively descriptive of the measured values and of higher-energy results reported in the literature. The measured and calculated values, together with the body of information available in the literature, are utilized to derive a comprehensive evaluated nuclear-data file in the ENDF format. This evaluation extends from  $10^{-5}$  eV to 20 MeV, addresses neutron induced and photon-emission processes and is oriented toward the needs of fusion-fission-hybrid and electro-nuclear breeding applications.

**The influence of nuclear data uncertainties on thorium fusion-fission hybrid blanket nucleonic performance**, E. T. Cheng and D. R. Mathews, *SP594*, pp. 834-838 (Sept. 1980).

Key words: blanket energy multiplication; cross section sensitivity; cross section uncertainty; fusion-fission hybrid blanket; tritium breeding; uranium production.

The fusion-fission hybrid blanket proposed for the Tandem Mirror Hybrid Reactor employs thorium metal as the fertile material. Based on the ENDF/B-IV nuclear data, the  $^{233}\text{U}$  and tritium production rate and blanket energy multiplication averaged over the blanket lifetime of about 9 MW-yr/m<sup>2</sup> are 0.76 and 1.12 per D-T neutron and 4.8, respectively. At the time of the blanket discharge, the  $^{233}\text{U}$  enrichment in the thorium metal is about 3%. The thorium cross sections given by the ENDF/B-IV and V were reviewed, and the important partial cross sections such as (n,2n), (n,3n) and (n, $\gamma$ ) were found to be known to  $\pm 10$ -20% in the respective energy range of interest. A sensitivity study showed that the  $^{233}\text{U}$  and tritium production rate and blanket energy multiplication are relatively sensitive to the thorium capture and fission cross section uncertainties. In order to predict the above parameters within  $\pm 1\%$ , the Th(n, $\gamma$ ) and Th(n,xf) cross sections must be measured within about  $\pm 2\%$  in the energy range 3-3000 keV and 13.5-15 MeV, respectively. The present level of uncertainty in these data is  $\pm 10$  and 5%. This indicates that although presently adequate for preliminary design, additional cross section measurements to improve the accuracy of the Th(n, $\gamma$ ) and Th(n,xf) cross sections in these energy ranges may be needed in order to accurately calculate the blanket performance thorium-base fusion-fission hybrid reactor blankets.

**Sensitivity of the performance of symbiotic energy systems to tritium production data**, J. P. Renier and J. G. Martin, *SP594*, pp. 839-843 (Sept. 1980).

Key words: cross-section uncertainty; CTR; denatured fuel; economics; ENDF/B-V; fuel cycle; symbiotic energy system; tritium breeding.

For D-T fusion-powered U-233 factories, economics and robustness are strongly affected by the need to breed tritium. The sensitivity analysis of the symbiotic energy system to tritium production data is performed for systems with neutronically uncoupled lithium and thorium blankets. Neutronics calculations utilizing XSDRNPM with 100 neutron group libraries and AMPX cross-section processing, revealed only a minor tritium breeding change between ENDF/B-IV and -V data for  $^6\text{Li}$ ,  $^7\text{Li}$ , and Pb. For blankets with no multipliers, breeding is most sensitive to the  $^7\text{Li}$  cross-sections, which are not known with precision, and on which ENDF/B-V has introduced no modifications. Differ-

ences of 7% in tritium breeding result into uncertainties in U-233 production costs of typically 15%, while the number of supported fission converters (CR=0.9) varies by 25%. Clearly more certainty in the  $^7\text{Li}$  data is needed to properly assess the potential of symbiotic systems.

**Measurement of (n, $\alpha$ ) cross sections on Cr, Fe and Ni in the 5 to 10 MeV neutron energy range**, A. Paulsen, H. Liskien, F. Arnotte, and R. Widera, *SP594*, pp. 844-847 (Sept. 1980).

Key words: angular distributions; Cr, Fe, Ni(n, $\alpha$ ) cross sections; 5-10 MeV.

A measuring programme has been set up at the CBNM Van de Graaff accelerator facility for the determination of (n, $\alpha$ ) cross sections on the main constituents of fast reactor structural materials, namely the elements Cr, Fe and Ni. The  $\alpha$ -particles are detected in a reaction chamber by telescope counter arrangements at five observation angles between 14 and 140°. The experimental apparatus and procedure are explained. The results for nickel and iron in the energy range from 5 to 10 MeV are presented. Corresponding measurements on chromium are running.

**Neutron nuclear cross section data for fusion technology**, C. V. S. Rao and J. R. Rao, *SP594*, pp. 848-852 (Sept. 1980).

Key words: experimental trends; statistical model.

The investigations on the interaction of fast neutrons with the potential structural materials are of primary importance for the design of fusion reactor. Cross sections for nine fast neutron induced reactions in the isotopes of Molybdenum, which is a candidate for the first wall of the fusion reactor, have been measured using the versatile mixed powder technique and the high resolution Ge(Li) detector.

The highlight of the present work is a new element of procedure, self-absorption effects and self-scattering effects which are taken into account experimentally.

A study of the trends of the fast neutron cross sections was undertaken which is generally very useful from the view point of fusion reactor technology. This is because one requires the cross section data for various nuclides in the isotopes and isotonic chains (transmuted species) of the natural elements composing the potential structural materials.

**Production cross sections for (n,t) reactions in  $^{40}\text{Ca}$ ,  $^{54}\text{Fe}$ ,  $^{86}\text{Sr}$ ,  $^{89}\text{Y}$ ,  $^{102}\text{Pd}$ ,  $^{112}\text{Sn}$ ,  $^{106,114}\text{Cd}$ ,  $^{130}\text{Te}$ ,  $^{139}\text{La}$ ,  $^{204}\text{Pb}$ , and  $^{209}\text{Tl}$  with 14.6 MeV neutrons**, T. W. Woo and G. N. Salaita, *SP594*, pp. 853-856 (Sept. 1980).

Key words: cross section; elements; gamma-ray spectrometry; neutrons.

The cross sections for (n,t) reaction of 14.6 MeV neutrons with isotopes of the natural elements calcium, iron, yttrium, palladium, tin, lanthanum, and lead, and with enriched isotopes strontium-86, cadmium-114, tellurium-130, and thallium-205 were measured by the activation technique using high-energy resolution gamma-ray spectrometry. The experimental results are generally in good agreement with cross section values obtained from an empirical equation and with recently reported measurements. The cross section ratio of (n,t) and (n,p) were calculated on the basis of the statistical model.

**KeV neutron capture cross sections for the s-process isotopes of Se, Br and Kr and the abundance of krypton in the solar system**, B. Leugers, F. Käppeler, F. Fabbri, and G. Reffo, *SP594*, pp. 857-862 (Sept. 1980).

Key words: neutron capture cross sections; solar Kr abundance; s-process systematics.



The neutron capture cross sections of natural Kr,  $^{84}\text{Kr}$  and three samples enriched in  $^{83}\text{Kr}$ ,  $^{82}\text{Kr}$  and  $^{80}\text{Kr}$  were measured with the time-of-flight technique in the energy range between 3 and 250 keV. The energy resolution was 1.5 ns/m. Capture gamma rays were detected by two  $\text{C}_6\text{D}_6$  detectors using the pulse height weighting technique offline. From these data, Maxwellian averaged cross sections  $\langle \sigma v \rangle / V_T$  have been determined for all stable Kr isotopes with an accuracy of typically 10%, except for  $^{78}\text{Kr}$  and  $^{86}\text{Kr}$ , where the uncertainties are 30% and 100%, respectively. In addition, the cross sections for all s-process isotopes of Se, Br and Kr were calculated with a Hauser-Feshbach formalism with width fluctuation corrections, using carefully evaluated level densities and radiative decay widths. In the calculations all available experimental information about these cross sections was considered to include the local behavior of parameters. With this improved set of cross sections, the solar system abundance of Kr was determined from s-process systematics.

**Complete evaluation of  $^{241}\text{Am}$  between thermal energy and 15 MeV—nuclear models used—Consistency with integral data.** E. Fort, M. Darrouzet, H. Derrien, P. Hammer, and L. Martin-Deidier, *SP594*, pp. 862-866 (Sept. 1980).

Key words: complete damping; consistency; coupled channels; integral data; microscopic data analysis.

In this evaluation both integral and microscopic data are considered as reference data. Calculations are performed with SLBW formalism in the resolved resonance region and statistical formalism elsewhere. Neutron penetrabilities are obtained from coupled channel calculations, considering  $^{241}\text{Am}$  as a symmetric rotational nucleus. For fission, the agreement is excellent between evaluated and integral data and is confirmed by the most recent microscopic measurements. High values for capture cross-sections are supported by integral measurements.

**The branching ratio in  $^{242}\text{Am}$  following neutron capture in  $^{241}\text{Am}$ .** K. Wisshak, J. Wickenhauser, and F. Käppler, *SP594*, pp. 867-871 (Sept. 1980).

Key words: capture cross section; isomeric ratio in  $^{242}\text{Am}$  at 14.75 MeV and 30 keV.

The branching ratio in  $^{242}\text{Am}$  has been determined in a differential experiment at neutron energies of 14.75 MeV and 30 keV. For that purpose, the total capture cross section has been determined with an accuracy of  $\sim 5\%$  in the energy range 10-250 keV using kinematically collimated neutrons from the  $^7\text{Li}(p,n)$  and  $\text{T}(p,n)$  reaction. The partial capture cross section to the ground state of  $^{241}\text{Am}$  was measured by activation. At 14.75 MeV monochromatic neutrons were obtained from a triple axis spectrometer at the FR2 reactor and at 30 keV quasi monoenergetic neutrons were produced by the  $^7\text{Li}(p,n)$  reaction at proton energies 25 keV above threshold. The  $^{242}\text{gAm}$  nuclei were detected via the electron spectrum emitted in the beta decay to  $^{242}\text{Cm}$ . The electrons were separated in a mini orange spectrometer from the intense alpha-, gamma- and x-ray background of the  $^{241}\text{Am}$  sample. Preliminary results show good agreement with existing integral measurements and theoretical calculations.

**Evaluation of the  $^{237}\text{Np}$  neutron cross sections in the energy range from  $10^{-5}$  eV to 5 MeV.** H. Derrien and E. Fort, *SP594*, pp. 872-876 (Sept. 1980).

Key words: evaluation; neutron cross-sections; optical model; resonances; statistical model.

The  $^{237}\text{Np}$  neutron cross-sections have been evaluated in the energy range from thermal to 5 MeV. A set of resonance parameters including a negative level, is recommend-

ed after examination of the available experimental data. This set is used 1) to calculate the cross-sections from the thermal region to 150 eV, and 2) to provide the statistical parameters suitable to the calculations in the unresolved region. At higher energies the transmission coefficients  $T_r$  are calculated by the coupled channel optical model code ECIS. They are then used as input in the statistical model code FISINGA. The optical model parameters, including the deformation parameters, are those used by Lagrange for the Pu isotopes, slightly modified to reproduce at 40 keV the total cross-sections obtained from the pure statistical parameters. The recommendations of Lynn concerning the level density parameters have been used. In this paper we describe the various steps of the evaluation.

**Measurement of the total Nd-145 neutron cross section.** V. A. Anufriev, A. G. Kolesov, S. I. Babich, and V. A. Safonov, *SP594*, p. 877 (Sept. 1980).

Key words: fast chopper; Nd-145; resonance parameters; total cross section; 0.02-350 eV.

The total cross section of Nd-145 in the energy range from 0.02 to 350 eV has been measured by the time-of-flight method at the SM-2 reactor neutron spectrometer. The measurements were carried out using a sample of  $\text{Nd}_2\text{O}_3$  enriched in Nd-145 (84.8%). In the studied energy range 21 levels of Nd-145 have been found and for 19 of them the resonance parameters have been calculated by the area and shape methods. To describe the total experimental cross section in the energy range from 0.02 to 1 eV a "negative" level with  $E_0 = 2.5$  eV and  $2g_n = 0.95$  meV has been introduced. This neutron level contributes 85% to the total cross section for this neutron energy range. The total cross section with  $E_0 = 0.025$  eV has been determined to be  $64 \pm 4$  b. Based on the parameters obtained the resonance capture integral  $I$  has been calculated ( $I = 245 \pm 30$  b).

**Automated system for nuclear data measurements and optimization.** N. G. Volkov, A. N. Gudkov, V. V. Kovalenko, V. M. Kolobashkin, V. A. Kubjak, N. I. Morozova, E. V. Poljushkina, and K. G. Finogenov, *SP594*, pp. 878-880 (Sept. 1980).

Key words: apparatus spectrum; data library; fission products; full energy peak; gamma-ray spectrum; multiplets; optimization; peak/Compton ratio; simulation.

A computerized system for simulation and optimization of the experiments for fission products yields measurements is described. In the course of simulating, the shape of the apparatus gamma-ray spectrum is calculated, thus providing the experimenter with means for experiment planning and optimization.

**Neutron resonances of odd-odd radioactive isotopes.** V. P. Vertebnyi, P. N. Vorona, A. I. Kaltchenko, and V. G. Krivenko, *SP594*, pp. 881-885 (Sept. 1980).

Key words: neutron resonance; radioactive isotopes.

Kiev nuclear reactor WWR-M was used to study low energy neutron resonances for the set of radioactive isotopes: odd-odd isotopes  $^{192}\text{Ir}$ ,  $^{154}\text{Eu}$ ,  $^{152}\text{Eu}$  and odd-even one  $^{155}\text{Eu}$ . It was found an argument that odd-odd isotope radiative widths are much larger than those for neighbouring odd-even isotopes. Neutron resonance energies for  $^{192}\text{Ir}$  are those (in eV): 0.252; 0.55; 2.07; 3.14; 4.38; 9.47; 12.87, for  $^{154}\text{Eu}$ -0.196; 0.898; 1.42; 5.2; 5.7; 6.9; 9.4, for  $^{155}\text{Eu}$ -0.603; 4.2; 10.8. The observed average level spacings  $D_{\text{obs}}$  after including corrections for missing of the weak levels are those:  $^{192}\text{Ir}$ -( $0.63 \pm 0.14$ )eV,  $^{154}\text{Eu}$ -( $0.92 \pm 0.17$ ),  $^{152}\text{Eu}$ -( $0.25 \pm 0.04$ )eV. The resonance parameters and their properties are discussed just as the neutron cross sections of

nuclei-fission products— $^{153}\text{Eu}$ ,  $^{154}\text{Eu}$  and  $^{155}\text{Eu}$ .

**Perturbation theory and sensitivity analysis in fission products kinetics**, L. N. Usachev, Y. G. Bobkov, and A. S. Krivtsov, *SP594*, pp. 886-889 (Sept. 1980).

Key words: capture cross section of pseudo fission product; fission products kinetics; ratio  $^{134}\text{Cs}/^{137}\text{Cs}$ ; residual decay heat; sensitivity analysis.

Earlier the authors have published the procedure of determining the nuclear data accuracies which provide target accuracies of the fast reactor core characteristics and different important actinide nuclides build-up. This procedure is based on the sensitivity analysis and the optimal planning of the experiments. The development of this procedure for the fission products kinetics problem is reported in the given paper. The perturbation theory for the evolution equation was realized for the system of basic and adjoint equations describing the fission products kinetics in the fast reactor. Neutron capture and radioactive decay were taken into account for 190 nuclides with the lifetime over 24 hours. For 700 short-lived nuclides there were taken into account only for radioactive decays. The target accuracies of the fission products average capture cross section, the residual heat generation, the build-up of fuel burn-up indicators, were chosen for sensitivity analysis and experiment planning approach realization.

**Total neutron cross section of  $^{45}\text{Sc}$  at the 2 keV interference minimum**, V. F. Razbudey, A. V. Muravitsky, V. P. Vertebny, and A. L. Kiriluk, *SP594*, pp. 890-892 (Sept. 1980).

Key words: resonance neutrons; total cross sections.

The scandium neutron cross section at 2 keV interference minimum  $\delta_{\min}$  is equal to  $0.27 \pm 0.07$  barn from measurements at the WWR-M reactor. This figure is much lower than the value of  $0.71 \pm 0.03$  barn recently reported by other authors.

Transmissions  $T$  of a high purity metallic scandium 22.5-cm-thickness sample were measured with scandium filters of variable thickness (from 63 to 173 cm).

The simple formula suited for experiments like the present one was deduced for

$$\delta_{\min} = \delta_{\text{tot}}^{\text{obs}} - 1/2n \ln(1 + n/N)$$

where  $\delta_{\text{tot}}^{\text{obs}} \equiv -1/n \ln T$  is an observed total cross section of the sample,  $n$  and  $N$  are thicknesses (atom/barn) of the sample and the filter respectively.

**Scattering cross sections of neutrons up to 3.0 MeV by chromium, iron and nickel isotopes**, M. V. Pasechnik, I. A. Korzh, and E. N. Mozhzhukhin, *SP594*, pp. 893-897 (Sept. 1980).

Key words: optical model; statistical and coupled-channel analysis.

Experimental differential cross sections for the elastic and inelastic neutron scattering on  $^{50,52,54}\text{Cr}$ ,  $^{56}\text{Fe}$  and  $^{58,60,62,64}\text{Ni}$  and excitation functions for three lowest levels of the above isotopes in 1.5-3.0 MeV energy range are presented. The experimental data are compared with the calculations using the optical model and statistical theory without and with account of level width fluctuations.

**Neutron scattering by nickel isotopes in energy range 5-7 MeV**, I. A. Korzh, V. A. Mishchenko, E. N. Mozhzhukhin, M. V. Pasechnik, and N. M. Pravdivy, *SP594*, pp. 898-902 (Sept. 1980).

Key words: nickel; optical, statistical, and coupled-channel analysis.

Differential cross sections for elastic and inelastic scatter-

ing of 5.0, 6.0, and 7.0 MeV neutrons by nickel and its even isotopes are measured. The experimental data are compared with the theoretical values calculated using the optical model, statistical theory of nuclear reactions, and coupled-channel method.

**Neutron-spectrometric analysis of the samples**, V. M. Ivanov, L. V. Karin, V. I. Nazarenko, N. I. Kroshkin, and V. A. Safonov, *SP594*, pp. 903-906 (Sept. 1980).

Key words: measurements; number of nuclei; samples; spectrometric analysis; transmission.

Potentialities of sample non-destructive analysis based on resonance neutron transmission through samples have been studied in energy range from 0.1 to 50 eV. Measurements of unirradiated and irradiated samples were performed with a mechanical chopper. Quantitative contents of both initial U-238 nuclei and built-up Pu-240 and Pu-242 as well as some built-up fission products have been determined. High activity of the samples doesn't affect the measurement results.

**Resonance parameters of Nd-147 ( $T_{1/2} = 11\text{ds}$ ) isotope neutron levels**, V. A. Anufriev, S. I. Babich, V. N. Nefedov, V. A. Poruchikov, V. S. Artomonov, R. N. Ivanov, and S. M. Kalebin, *SP594*, p. 907 (Sept. 1980).

Key words: Nd-147; resonance parameters; time-of-flight method.

The results have been presented on the measurements of Nd-147 ( $T_{1/2} = 11\text{ds}$ ) radioactive nucleus neutron resonances. The measurements have been performed by the time-of-flight method at the SM-2 reactor neutron spectrometer. Nd-147 was accumulated during neutron irradiation ( $1.5 \cdot 10^{21}\text{n/cm}^2$ ) of Nd oxide (97.5% of Nd) in SM-2 reactor. The content of Nd-147 ( $2.3 \cdot 10^{19}\text{at./b}$ ) in the irradiated sample was determined from decay produced Pm-147 which was analyzed on three resonance levels with the energies of 5.36, 6.57 and 6.92 eV. In the range from 0.01 to 170 eV eleven levels of Nd-147 have been found and for seven of them the resonance parameters have been calculated by the area method. From the obtained parameters the resonance capture integral  $I$  has been calculated ( $I = 210 \pm 90\text{ b}$ ).

**Neutron parameters of curium 242, 244-248 isotopes in the resonance region**, S. I. Babich, N. G. Kocherygin, A. G. Kolesov, V. A. Poruchikov, V. A. Safonov, V. N. Nefedov, V. S. Artomonov, T. S. Belanova, R. N. Ivanov, and S. M. Kalebin, *SP594*, p. 908 (Sept. 1980).

Key words: Cm isotopes; fast chopper; neutron parameters; transmission measurements.

The transmission measurements have been made on curium oxide samples using the fast chopper at the SM-2 reactor. The resonance parameters were obtained for curium 242, 244-248 isotopes levels.

The values of the mean level spacings— $D$ , the average radiation widths, the neutron strength function— $S_0$ , the resonance absorption integrals— $I_{0.4}$ , and the energy regions of measurements are given.

**The OKLO phenomenon and the role of nuclear data in it's study**, E. Roth, R. Hagemann, and N. N. Ruffenach, *SP594*, pp. 909-915 (Sept. 1980).

Key words: age of deposit; duration; fission products; fluence; Gabon; natural fission reactor; temperature.

The study of the OKLO phenomenon requires, but also provides, in some cases better nuclear data than were available at the time of its discovery. Examples of this situation are given particularly for rare earth's fission yields and



neutron capture cross sections.

**Three Mile Island, A. R. Buhl, *SP594*, pp. 916-919 (Sept. 1980).**

**Key words:** China syndrome myth; hydrogen bubble myth; reactor cooling; reactor safety system; sequence of events; Three Mile Island.

The Three Mile Island accident was the worst accident ever experienced by the nuclear power industry. Although the radiation exposures were extremely low, the potential for greater public exposure did exist. Fortunately, the health and safety of the public were not affected by radiation, nor was anyone killed or injured; however, thousands of lives were disrupted by fear and anxiety and by a limited evacuation.

**Status and comparison of new, planned, and upgraded pulsed "white" neutron source facilities since 1970, G. F. Auchampaugh, *SP594*, pp. 920-928 (Sept. 1980).**

**Key words:** comparison neutron yields; GELINA; HELIOS; KFK; ORELA; PSR; "white" neutron sources; WNR.

The status of pulsed "white" neutron sources has changed in the last several years. The Weapon Neutron Research (WNR) facility at the Los Alamos Meson Physics Facility has become operational. Work has continued on the conceptual design for the proton storage ring at WNR, which will increase the proton intensity on target by 50 to 1000 times and modify the frequency of the proton beam from 1 to 720 Hz. A prebuncher has been installed at the Oak Ridge Electron Linear Accelerator to compress 15-ns-wide pulses into about 3-ns-wide pulses without loss in neutron intensity. Also, the electron linear accelerator at Geel has been upgraded with new waveguides, increasing the electron energy to 150 MeV, and with modifications to the buncher and gun, which improve the performance of the machine at narrow pulses. The Atomic Energy Research Establishment at Harwell has just finished construction of a new 136-MeV electron linear accelerator which will be commissioned this fall. The characteristics of these new facilities are discussed and compared in this paper.

**Neutron cross section measurements at ORELA, J. W. T. Dabbs, *SP594*, pp. 929-935 (Sept. 1980).**

**Key words:** computers; data acquisition; electron linac; gas scintillator; inelastic neutron scattering; majority logic; neutron cross sections; prebuncher; pulsed neutron source; time-of-flight.

ORELA (Oak Ridge Electron Linear Accelerator) has been for the last decade the most powerful and useful pulsed neutron time-of-flight facility in the world, particularly in the broad midrange of neutron energies (10 eV-1 MeV). This position will be enhanced with the addition of a pulse narrowing "prebuncher," recently installed and now under test. Neutron capture, fission, scattering, and total cross sections are measured by members of the Physics and Engineering Physics Divisions of ORNL, and by numerous guests and visitors. Several fundamental and applied measurements will be described, with some emphasis on instrumentation used. The facility comprises the accelerator and its target(s), 10 evacuated neutron flight paths having 18 measurement stations at flight path distances 8.9 to 200 meters, and a complex 4-computer data acquisition system capable of handling some 17 000 32-bit "events"/sec from a total of 12 data input ports. The system provides a total of  $2.08 \times 10^6$  words of data storage on 3 fast disk units. In addition a dedicated PDP-10 timesharing system with a 250 megabyte disk system and 4 PDP-15 graphic display satellites permits on-site data reduction and analysis. More than

10 man-years of application software development supports the system, which is used directly by individual experimenters.

**Use of high resolution  $\gamma$ -ray spectroscopy for neutron cross sections, M. L. Stelts, *SP594*, pp. 936-946 (Sept. 1980).**

**Key words:** average resonance capture; gamma-ray spectra; neutron capture; neutron strength functions; photon strength functions.

The use of high resolution spectroscopy to resolve some problems in neutron cross section measurements will be discussed. Topics included are: Measurements of capture cross sections with the time-of-flight technique in the presence of high backgrounds, measurements of activation cross sections, and determination of neutron fluxes. The use of high resolution spectral data to determine resonance spins will be discussed. Data will be presented on measurement of p-wave neutron strength functions from high resolution  $\gamma$ -spectra from average neutron capture at 2- and 24-keV energy.

**New fission fragment detectors for cross section and angular distribution measurements at CBNM, H. H. Knitter and C. Budtz-Jørgensen, *SP594*, pp. 947-955 (Sept. 1980).**

**Key words:** actinides; fission fragments; ionization chambers; mass distribution.

The accurate knowledge of the fission cross section of the highly active minor actinides belonging to the uranium based fuel cycle are of growing importance as the nuclear industry matures. For the measurement of such cross sections two fission fragment detectors are described which can be used in the presence of very high alpha backgrounds rates. For the understanding of the physics of the fission process, angular and energy distribution measurements can be helpful, for example for the determination of the quantum numbers J and K of the transition states. For this purpose a detector was developed which has an angular efficiency of  $2\pi$ , an angular resolution of 5% on  $\cos \theta$ , an energy resolution of 1.5% and a timing resolution sufficient for the application in time-of-flight experiments.

**Least squares methodology applied to LWR-PV damage dosimetry, experience and expectations, J. J. Wagschal, B. L. Broadhead, and R. E. Maerker, *SP594*, pp. 956-960 (Sept. 1980).**

**Key words:** adjustment; dosimetry; ISNF; least squares unfolding; LWR-PV damage; standard fields.

The development of an advanced methodology for Light Water Reactors (LWR) Pressure Vessel (PV) damage dosimetry applications is the subject of an ongoing EPRI-sponsored research project at ORNL. This methodology includes a generalized least squares approach to a combination of data. The data include measured foil activations, evaluated cross sections and calculated fluxes. The uncertainties associated with the data as well as with the calculational methods are an essential component of this methodology. Activation measurements in two NBS benchmark neutron fields ( $^{252}\text{Cf}$  ISNF) and in a prototypic reactor field (Oak Ridge Pool Critical Assembly—PCA) are being analyzed using a generalized least squares method. The sensitivity of the results to the representation of the uncertainties (covariances) was carefully checked. Cross element covariances were found to be of utmost importance.

**$^{235}\text{U}(n,f)$  cross section measurements and normalization problems, C. Wagemans, G. Coddens, and A. J. Deruytter, *SP594*, pp. 961-965 (Sept. 1980).**

**Key words:** fission integrals; measured 0.02 eV to 30 keV.

At Gelina measurements of the  $^{235}\text{U}$  fission cross section were performed relative to  $^{10}\text{B}(n,\alpha)^7\text{Li}$  and  $^7\text{Li}(n,\alpha)^3\text{H}$  independently. The neutron energy range from thermal up to 30 keV was covered, allowing a normalization to the 2200 m/s reference cross section. Surface barrier detectors and back-to-back foils were used. Thus the fission fragments and the neutron flux are measured at the same time and from the same position in the neutron beam. Special attention is given to problems such as background determination, overlap filters, normalization and secondary standards (resonance integrals). Especially the present status of the resonance integrals  $\int_{7.8 \text{ eV}}^{11 \text{ eV}} \sigma_f(E) dE$  and  $\int_{0.1 \text{ keV}}^{1 \text{ keV}} \sigma_f(E) dE$ , often used for normalization purposes, is reviewed. Finally, an intercomparison of the present  $\sigma_f$ -values as well as a comparison with other recent results is made.

**Absolute measurement of the U-235 fission cross section from 0.2-1.2 MeV**, M. M. Meier, O. A. Wasson, and K. C. Duvall, *SP594*, pp. 966-970 (Sept. 1980).

Key words: absolute fission cross section; neutron detector; neutron flux monitor; neutron standards; uranium-235 fission cross section.

The absolute U-235 neutron induced fission cross section has been measured at the NBS 3MV Van de Graaff laboratory from 0.2 to 1.2 MeV. The neutron flux monitor was a large plastic scintillator whose efficiency was both calculated and measured with the associated particle technique. The neutron source was the  $^7\text{Li}(p,n)^7\text{Be}$  reaction. Pulsed-beam time-of-flight techniques were used. The fission detector consisted of a large volume multiplated chamber with a measured mass of  $^{235}\text{U}$ . The cross sections, which were measured with a typical one standard deviation of 2.8%, are approximately 3% lower than the ENDF/B-V evaluation.

**$^{237}\text{Np}$  fission cross section measurements in the MeV energy region**, A. D. Carlson and B. H. Patrick, *SP594*, pp. 971-975 (Sept. 1980).

Key words: cross section; fission; MeV neutrons; neptunium-237; standard; uranium-235.

Measurements of the energy dependence of the  $^{237}\text{Np}$  neutron fission cross section have been made from 1 to 20 MeV at the NBS neutron time-of-flight facility. These data were measured relative to the hydrogen scattering cross section with an annular proton telescope. The error for these shape measurements is 2-3% throughout the entire energy region.

**Absolute fast fission cross section measurements on  $^{237}\text{Np}$** , D. J. Grady, G. T. Baldwin, and G. F. Knoll, *SP594*, pp. 976-979 (Sept. 1980).

Key words: absolute fission cross sections; manganese bath; photoneutron sources.

We have extended our series of absolute fission cross section measurements to  $^{237}\text{Np}$  at 770 and 964 keV. Nearly monoenergetic fluxes of neutrons were obtained using La-Be and Na-Be photoneutron sources. These small, spherical sources were calibrated in the U of M manganese bath facility, using NBS-II as a standard. Dual target foils were used in symmetric orientation to allow accurate calculation of the average neutron flux magnitude. Deposit masses were determined by microbalance weighings. Fission fragments passing through limited solid angle apertures were recorded on polyester track etch films. Preliminary results give values of 1.191 and 1.365 barns at 770 and 964 keV, respectively. Final error estimates are expected to be between 2 and 3%.

**The cross section for the  $^{56}\text{Fe}(n,p)$  reaction for 14.73 MeV neutrons**, T. B. Ryves and E. J. Axton, *SP594*, pp. 980-984 (Sept. 1980).

Key words: evaluation; 14.73 MeV;  $^{56}\text{Fe}(n,p)$  cross section.

A value for the cross section for the  $^{56}\text{Fe}(n,p)^{56}\text{Mn}$  reaction for 14.73 MeV neutrons has been derived from a critical evaluation of measurements performed as part of an international comparison of fast neutron flux density organized by the Bureau International des Poids et Mesures between 1974 and 1978.

**$^{12}\text{C} + n$  polarization measurements and the carbon standard**, J. L. Weil, T. W. Burrows, and F. D. McDaniel, *SP594*, pp. 985-987 (Sept. 1980).

Key words: calculated scattering phase shifts; measured asymmetry.

The asymmetry of polarized neutrons scattered from carbon has been measured at several angles for neutron energies of 4.60, 4.82 and 5.17 MeV. From an analysis of the measured asymmetries together with previously measured total and differential cross sections, the scattering phase shifts of carbon have been determined with more precision and accuracy than previously available, making carbon more useful as a neutron scattering standard.

**Parasitic absorption and leakage corrections for  $\text{MnSO}_4$  baths**, H. Goldstein and L. Chen, *SP594*, pp. 988-989 (Sept. 1980).

Key words: leakage;  $\text{MnSO}_4$ -bath; sulfur.

Using ENDF/B-V cross sections plus new evaluations for sulfur, corrections for fast neutron absorption and leakage have been calculated for measurements of  $\bar{\nu}$  by the  $\text{MnSO}_4$  bath techniques. Transport calculations were performed in spherical geometry, chiefly with ANISN, using a specially devised 118 group cross section set.

**The application of a time-correlated associated particle method for absolute cross-section measurements of heavy nuclides**, R. Arlt, W. Grimm, M. Josch, G. Musiol, H. G. Ortlepp, G. Pausch, R. Teichner, W. Wagner, I. D. Alkhazov, L. V. Drapchinsky, V. N. Dushin, S. S. Kovalenko, O. I. Kostochkin, K. A. Petrzhak, and V. I. Shpakov, *SP594*, pp. 990-994 (Sept. 1980).

Key words: absolute measurements; fission cross sections; time correlated associated particle method.

The joint fission cross-section measurements program of the V. G. Khlopin Radium Institute and the Technical University of Dresden is described. The errors and uncertainties of the time correlated associated particle method of fission cross-section measurements for 2.6, 8.5, and 14.7-MeV neutrons are discussed. Experimental results of absolute fission cross-section measurements of  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{237}\text{Np}$ , and  $^{239}\text{Pu}$  for 14.7 MeV-neutrons and of  $^{235}\text{U}$  for 2.6 and 8.2-MeV neutrons are given.

**Absolute measurements of induced fission cross sections of heavy nuclides for both  $^{252}\text{Cf}$  fission spectrum neutrons and 14.7-MeV neutrons**, V. M. Adamov, I. D. Alkhazov, S. E. Gusev, L. V. Drapchinsky, V. N. Dushin, A. V. Fomichev, S. S. Kovalenko, O. I. Kostochkin, L. Z. Malkin, K. A. Petrzhak, L. A. Pleskachevsky, V. I. Shpakov, R. Arlt, and G. Musiol, *SP594*, pp. 995-999 (Sept. 1980).

Key words: absolute measurements; fission cross section; time correlated associated particle method.

An application of the time correlated associated particle method to absolute induced fission cross-section measurements for  $^{252}\text{Cf}$  fission spectrum neutrons and 14.7-MeV



neutrons is described. The errors and uncertainties of the proposed modification of the TCAPM are given. New results of absolute cross-section measurements of  $^{235}\text{U}$  and  $^{238}\text{U}$  for both  $^{252}\text{Cf}$  fission spectrum neutrons and 14.7-MeV neutrons as well as of  $^{235}\text{U}$  for 14-15-MeV neutrons are presented. The experimental results of cross-section measurements of  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{237}\text{Np}$ ,  $^{239}\text{Pu}$ , and  $^{242}\text{Pu}$  obtained earlier have been revised on the basis of more realistic calculations of neutron scattering.

**SP595. International and national standards on dimensional coordination, modular coordination, tolerances and joints in building.** H. J. Milton. *Nat. Bur. Stand. (U.S.), Spec. Publ. 595*, 154 pages (Oct. 1980) SN003-003-02254-3.

Key words: building module; dimensional coordination; metric design and construction; modular coordination; standards.

This publication lists international, multi-national [regional], and national standards from over 50 countries dealing with the principles and application of dimensional or modular coordination in building, including joints and tolerances. It is based on NBSIR 79-1791, with the same title, which was sent to national and multi-national standards organizations for review and comment.

The document shows the widespread adoption of the international building module of 100 mm (also designated as M) as a basis for dimensional rationalization in building design, production and construction. The listing includes international (ISO) standards, multi-national (COPANT, ICAITI, and CMEA) standards, and national standards from all major countries. Brief summaries of contents have been included where available, and titles in English for documents printed in other languages. Appendixes illustrate international cooperation on the subject, a multi-lingual vocabulary of 20 key terms, and review comments received.

The main purpose of the document is to assist the U.S. construction community by providing information on international precedent to facilitate decisionmaking relative to new standards for dimensional [modular] coordination in building, especially those to be developed in metric (SI) units. Key findings have been summarized. The document may also assist exporters of building products and/or services.

**SP596. Ultrasonic materials characterization.** Proceedings of the First International Symposium on Ultrasonic Materials Characterization held at the National Bureau of Standards, Gaithersburg, MD, June 7-9, 1978, H. Berger and M. Linzer, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 596*, 644 pages (Nov. 1980) SN003-003-02264-1.

Key words: attenuation; defect characterization; flaws; materials characterization; nondestructive testing; residual stress; ultrasonics; velocity.

Nondestructive testing has traditionally involved a search for flaws in materials or structures; it has long been appreciated that voids, cracks, inclusions, and similar flaws can lead to failure. Obviously, once a flaw has been detected, it is natural to consider methods that will give more information. What is the flaw size, type, location, or orientation? This information is necessary if a realistic assessment of the influence of the flaw on performance is to be made. In addition, it is now more widely recognized that parameters such as hardness, grain size, bonding, and residual stress can also have a strong influence on material performance. The use of ultrasonic nondestructive testing to characterize materials both in terms of properties and flaws is the subject of this volume. Therefore, this volume is about nondestructive characterization of parameters that influence the performance of materials. *These proceedings include the following papers (indented):*

**Detection and analysis of near surface-cracks by ultrasound,** H. Wüstenberg, A. Erhard, and J. Kutzner, *SP596*, pp. 3-10

(Nov. 1980).

**Determination of orientation and size of badly oriented defects by means of focused probes,** D. De Vadder, P. Azou, and R. Saglio, *SP596*, pp. 11-16 (Nov. 1980).

**Stress intensity factor measurement of surface cracks,** M. T. Resch, B. T. Khuri-Yakab, G. S. Kino, and J. C. Shyne, *SP596*, pp. 17-22 (Nov. 1980).

**The application of adaptive filtering to defect characterization,** Y. Murakami, B. T. Khuri-Yakab, G. S. Kino, J. M. Richardson, and A. G. Evans, *SP596*, pp. 23-28 (Nov. 1980).

**Sizing of cracks with scattered ultrasonic waves,** S. Golan, *SP596*, pp. 29-36 (Nov. 1980).

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**Quantitative determination of grain size and detection of inhomogeneities in steel by ultrasonic backscattering measurements,** K. Goebbels and P. Höller, *SP596*, pp. 67-74 (Nov. 1980).

**A phase insensitive transducer—Theory and application,** J. S. Heyman, J. H. Cantrell, Jr., and J. D. Whitcomb, *SP596*, pp. 75-82 (Nov. 1980).

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**Ultrasonic tomography for mapping residual stress,** B. P. Hildebrand and T. J. Harrington, *SP596*, pp. 179-192 (Nov. 1980).

**Measurement of stress field in metals,** G. S. Kino, J. Hunter, G. Johnson, A. Selfridge, D. M. Barnett, G. Hermann, and C.

Steele, *SP596*, pp. 193-200 (Nov. 1980).

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sistors using transmission acoustic microscopy, C. C. Lee, J. K. Wang, C. S. Tsai, S. K. Wang, and P. Hower, *SP596*, pp. 387-391 (Nov. 1980).

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Acoustical chirp frequency and computer correlation technique for debond inspection in solid rocket motor sections, H. D. Collins, *SP596*, pp. 415-423 (Nov. 1980).

Through-transmission ultrasonic attenuation measurements on adhesively-bonded structures, W. E. Woodmansee, *SP596*, pp. 425-432 (Nov. 1980).

Ultrasonic examination of electrical contact assemblies for bond integrity, D. C. Stewart, *SP596*, pp. 433-438 (Nov. 1980).

Ultrasonic interactions with thin air layers in solids, S. C. Gustafson, *SP596*, pp. 439-446 (Nov. 1980).

Generalized ultrasonic impediography, J. P. Lefebvre and J. Aiguier, *SP596*, pp. 447-450 (Nov. 1980).

Laser probe detection of Stoneley wave interactions with material boundary defects, R. O. Claus, *SP596*, pp. 451-456 (Nov. 1980).

Mathematical theories of the diffraction of elastic waves, Y. H. Pao, *SP596*, pp. 457-473 (Nov. 1980).

Characterization of dynamic shear modulus in inhomogeneous media using ultrasonic waves, V. K. Varadan and V. V. Varadan, *SP596*, pp. 475-482 (Nov. 1980).

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Low frequency behavior of amplitude and phase shift in elastic wave scattering, J. M. Richardson, *SP596*, pp. 509-516 (Nov. 1980).

A note on nondestructive detection of voids by a high frequency inversion technique, J. K. Cohen and N. Bleistein, *SP596*, pp. 517-519 (Nov. 1980).

Motion picture of the computer simulation of elastic waves generated by transducers, K. Harumi, T. Saito, and T. Fujimori, *SP596*, pp. 521-532 (Nov. 1980).

Ultrasonic characterization of austenitic welds, L. Adler, K. V. Cook, and D. W. Fitting, *SP596*, pp. 533-540 (Nov. 1980).

Austenitic stainless steel casting inspection potential, J. L. Rose, A. J. Rogovsky, and P. Wieser, *SP596*, pp. 541-550 (Nov. 1980).

Improvement of signal-to-noise ratio for the ultrasonic testing of coarse grained materials by signal averaging techniques, S. Kraus and K. Goebbels, *SP596*, pp. 551-559 (Nov. 1980).

Austenitic stainless steel weld inspection, S. J. Mech, J. S. Emmons, and T. E. Michaels, *SP596*, pp. 561-569 (Nov. 1980).



**Application of adaptive learning networks to ultrasonic signal processing: Detecting cracks in stainless steel pipe welds**, R. Shankar and A. N. Mucciardi, *SP596*, pp. 571-576 (Nov. 1980).

**Use of a compact ultrasonic delay line for the calibration of a pulse echo instrument**, M. Onoe and H. Yamada, *SP596*, pp. 577-585 (Nov. 1980).

**New and improved ASTM type ultrasonic standard reference blocks**, D. L. Conn, *SP596*, pp. 587-594 (Nov. 1980).

**Performance differences in quartz ultrasonic search units**, G. J. Posakony, *SP596*, pp. 595-603 (Nov. 1980).

**Characterization of probes used for periodic inspection**, F. H. Dijkstra, *SP596*, pp. 605-615 (Nov. 1980).

**Proposal of a characterization sheet for ultrasonic transducers**, E. E. Borloo and P. Jehenson, *SP596*, pp. 617-626 (Nov. 1980).

**The measurement and generation of ultrasound by lasers**, C. H. Palmer, *SP596*, pp. 627-630 (Nov. 1980).

**Thermoelastically generated MHz waves from metallic thin film-liquid interfaces**, R. J. von Gutfeld, *SP596*, pp. 631-636 (Nov. 1980).

**Opto-acoustic and acousto-electric wideband transducers**, H. A. F. Rocha, P. M. Griffen, and C. E. Thomas, *SP596*, pp. 637-642 (Nov. 1980).

**Point density and defect characterization via measurements of ultrasonic bulk waves**, R. O. Claus and C. R. Johnson, Jr., *SP596*, pp. 643-649 (Nov. 1980).

**Visualization of ultrasonic bulk waves in solids with an internal light probe**, B. B. Djordjevic and R. E. Green, Jr., *SP596*, pp. 651-656 (Nov. 1980).

**Light diffraction by ultrasonic beams having phase difference  $\delta$** , O. Leroy, P. Kwiek, and A. Sliwinski, *SP596*, pp. 657-667 (Nov. 1980).

**SP597. Technical digest—Symposium on optical fiber measurements, 1980.** Digest of a Symposium sponsored by the National Bureau of Standards in cooperation with the IEEE Transmission Systems Sub-Committee on Fiber Optics (COMMSOC) and the Optical Society of America, held at National Bureau of Standards, Boulder, CO, Oct. 28-29, 1980, G. W. Day and D. L. Franzen, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 597*, 148 pages (Oct. 1980) SN003-003-02239-0.

**Key words:** attenuation; bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; index profile; measurements.

This volume contains summaries of twenty-nine papers presented at the Symposium on Optical Fiber Measurements held October 28-29, 1980 at the National Bureau of Standards in Boulder, Colorado. Subjects included are the measurement of attenuation, bandwidth/distortion, and index profile, joint/defect characterization, measurements on single mode fibers, applied measurements and measurement standards. *These proceedings include the following papers (indented):*

**Multimode waveguide attenuation measurements**, R. M. Hawk, *SP597*, pp. 1-9 (Oct. 1980).

**Loss measurements of graded-index fibers: Accuracy versus convenience**, P. Kaiser, *SP597*, pp. 11-14 (Oct. 1980).

**An accurate method for the measurement of fiber attenuations**, A. B. Sharma, E. J. R. Hubach, and S. J. Halme,

*SP597*, pp. 15-18 (Oct. 1980).

**A fiber concatenation experiment using a standardized loss measurement method**, A. H. Cherin and E. D. Head, *SP597*, pp. 19-22 (Oct. 1980).

**Automated loss measurement set for optical cables**, L. C. Hotchkiss, *SP597*, pp. 23-26 (Oct. 1980).

**Comparative measurements regarding the attenuation of optical fibers for the Eindhoven-Helmond field trial**, A. Diekema, L. H. M. Engel, G. A. M. Goltstein, P. Matthijssse, and J. W. Versluis, *SP597*, pp. 27-30 (Oct. 1980).

**Profile characterization of optical fibers and preforms**, H. M. Presby and D. Marcuse, *SP597*, pp. 31-36 (Oct. 1980).

**Linearity and resolution of refracted near-field scanning technique**, M. Young, *SP597*, pp. 37-40 (Oct. 1980).

**A comparison of techniques to measure the diameter of light-guide fiber**, D. H. Smithgall and C. M. Schroeder, *SP597*, pp. 41-44 (Oct. 1980).

**An automatic inspection system for single fiber connector plugs**, N. K. Cheung and N. M. Denkin, *SP597*, pp. 45-48 (Oct. 1980).

**Bandwidth measurement in multimode optical fibers**, I. Kobayashi, *SP597*, pp. 49-54 (Oct. 1980).

**An interrelationship between loss and dispersion in multimode fibers**, L. G. Cohen and S. J. Jang, *SP597*, pp. 55-58 (Oct. 1980).

**Optimization of concatenated fiber bandwidth via differential mode delay**, M. J. Buckler, *SP597*, pp. 59-62 (Oct. 1980).

**Attenuation and pulse broadening along concatenated fiber links**, F. P. Kapron, F. M. E. Sladen, P. M. Garel-Jones, and D. G. Kneller, *SP597*, pp. 63-66 (Oct. 1980).

**Difficulties encountered in the measurement of optical fiber interconnection performance**, K. S. Gordon and F. M. E. Sladen, *SP597*, pp. 67-72 (Oct. 1980).

**Loss characterization of biconic single-fiber connectors**, P. Kaiser, W. C. Young, N. K. Cheung, and L. Curtis, *SP597*, pp. 73-76 (Oct. 1980).

**Contribution to splice loss evaluation by the backscattering technique: A statistical comparison with insertion loss data**, A. LeBoutet, *SP597*, pp. 77-80 (Oct. 1980).

**Optical cable fault location using a correlation technique**, K. Okada, I. Kobayashi, K. Hashimoto, T. Shibata, T. Kosugi, and Y. Nagaki, *SP597*, pp. 81-84 (Oct. 1980).

**Optical time domain reflectometry by photon counting**, P. Healey and P. Hensel, *SP597*, pp. 85-88 (Oct. 1980).

**Characterization of single mode fibers**, K. I. White, B. P. Nelson, J. V. Wright, M. C. Brierly, and A. Beaumont, *SP597*, pp. 89-92 (Oct. 1980).

**Effect of curvature on the cutoff wavelength of single mode fibers**, P. D. Lazay, *SP597*, pp. 93-95 (Oct. 1980).

**Optical time domain reflectometry on single mode fibers using a Q-switched Nd:YAG laser**, D. L. Philen, *SP597*, pp. 97-100 (Oct. 1980).

**Interferometric technique for the determination of dispersion in a short length of single mode optical fiber**, W. D. Bomberger and J. J. Burke, *SP597*, pp. 101-104 (Oct. 1980).

**Industrialized system for the automated measurements of the**

optical properties of waveguide fibers, E. F. Murphy, R. W. Lapierre, and C. F. Laing, *SP597*, pp. 105-111 (Oct. 1980).

Wavelength meters for optical cable transmission systems, K. Sano, K. Okada, and T. Oki, *SP597*, pp. 113-117 (Oct. 1980).

Fiber measurement techniques in West Germany, J. Feldman, *SP597*, p. 119 (Oct. 1980).

The preparation of standards for "Optical fibers and cables" within the International Electrotechnical Commission, M. P. Smid, *SP597*, pp. 121-127 (Oct. 1980).

CCITT studies on optical fibers cables measurements, F. Bigi and G. Bonaventura, *SP597*, pp. 129-134 (Oct. 1980).

Waveguide fiber standards, R. E. Love, *SP597*, pp. 135-143 (Oct. 1980).

**SP598. Metric conversion in the construction industries—Technical issues and status**, H. J. Milton and S. A. Berry, *Nat. Bur. Stand. (U.S.), Spec. Publ. 598*, 145 pages (Oct. 1980) SN003-003-02265-4.

Key words: construction industries; dimensional coordination; metric bibliography; metric conversion timetable; metric decision; metric product sizes; metric system (SI).

This Special Publication was prepared at the request of the Metric Symposium Planning Committee of the National Institute of Building Sciences (NIBS). It is intended to provide information on technical issues and status of metric conversion in the United States construction industries. It will be made available to attendees at the NIBS Symposium on "Metric Conversion in the Construction Community" to be held December 2-3, 1980, in Chicago, IL. In addition, it will be available to other affected parties in the construction community.

The report contains information on planning for the metric change, current metric activities of professional and industry groups, technical implications in the construction industries, dimensional coordination, metric building products and services, research issues, and timing. It is intended to provide assistance for informed decisionmaking relative to metric conversion for the U.S. construction industries. Also included in the report is a bibliography of relevant construction industries' metric technical information.

## 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-NBS3, Section 9. Selected tables of atomic spectra. A: Atomic energy levels—Second edition. B: Multiplet tables. O v, C. E. Moore, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 3, Sec. 9, 21 pages (May 1980) SN003-003-02134-2.**

Key words: atomic energy levels, O v; atomic spectra, O v; multiplet table, O v; oxygen spectra, O v; spectrum O v; wavelengths, O v.

The present publication is the ninth section of a series being prepared in response to the need for a current revision of two sets of the author's tables containing data on atomic spectra as derived from analysis of optical spectra. As in the previous Sections, Part A contains the atomic energy levels and Part B the multiplet tables. Section 9 includes these data for O v. The form of the presentation is described in detail in the text to Section I.

**NSRDS-NBS63, Supplement 1 and 1980 Index. EPA/NIH mass spectral data base—Supplement 1, 1980 and 1980 cumulative indexes to EPA/NIH mass spectral data base, S. R. Heller and G. W. A. Milne, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 63, Supplement 1, and 1980 Index, 2151 pages (Dec. 1980) SN003-003-01987-9.**

Key words: analytical data; mass spectra; organic substances; verified spectra.

This Supplement to the EPA/NIH Mass Spectral Data Base (NSRDS-NBS 63) presents an additional collection of 8807 verified mass spectra of individual substances compiled from the EPA/NIH mass spectral file. The spectra are given in bar graph format over the full mass range. Each spectrum is accompanied by a Chemical Abstracts Index substance name, molecular formula, molecular weight, structural formula, and Chemical Abstracts Service Registry Number. A cumulative index has also been issued which provides access to the entire file of 34,363 mass spectra.

**NSRDS-NBS66, Part I. Ion energetics measurements. Part I. 1971-1973, H. M. Rosenstock, D. Sims, S. S. Schroyer, and W. J. Webb, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 66, Pt. I, 379 pages (Sept. 1980) SN003-003-02131-8.**

Key words: appearance potential; electron impact; electron spectroscopy; gaseous ion photoionization; ionization potential; spectroscopy.

The present publication tabulates measurement information on energetics of gaseous positive ions published in 1972 and 1973 along with some information from 1971. It is intended to supplement the information previously compiled and evaluated in "Energetics of Gaseous Ions." Approximately five thousand measurements are tabulated, drawn from over six hundred published papers.

**NSRDS-67. Table of recommended rate constants for chemical reactions occurring in combustion, F. Westley, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.)*, 67, 119 pages (Apr. 1980) SN003-003-02145-8.**

Key words: Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur.

A table of recommended rate constants for gas phase chemical reactions occurring in combustion 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 reactions occurring in the combustion, oxidation, and decomposition of aliphatic saturated or unsaturated C<sub>1</sub> to C<sub>10</sub> hydrocarbons, alcohols, aldehydes, ketones, thiols, ethers, peroxides, amines, amides and their free radicals, as well as the reactions of O, O<sub>2</sub>, H, H<sub>2</sub>, OH, H<sub>2</sub>O, H<sub>2</sub>O<sub>2</sub>, N, N<sub>2</sub>, NO, N<sub>2</sub>O, NO<sub>2</sub>, N<sub>2</sub>O<sub>4</sub>, N<sub>2</sub>O<sub>5</sub>, S, S<sub>2</sub>, SH, SO, SO<sub>2</sub>, SOH, NS, with each other. The table includes 169 first order reactions, 782 second order reactions, and 57 third order reactions. There are 1770 entries covering 1008 distinct chemical reactions. These recommendations have been taken from eleven evaluations and critical reviews published between 1970 and 1976. The papers examined by the evaluators extend from the nineteen fifties up to—and including—1975.

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.

**BSS121. Soil classification for construction practice in shallow trenching,** F. Y. Yokel, R. L. Tucker, and L. C. Reese, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 121*, 89 pages (Mar. 1980) SN003-003-02162-8.

Key words: braced excavations; construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; soil classification; soil pressure; soil testing; trenching.

Construction practices in trenching and data on potential causes of trenching accidents are reviewed. A study is made of the soil properties and site conditions that must be identified in order to determine the stability of shored and sloped excavations against cave-ins. Two possible alternate soil classification methods are recommended. The methods are simple enough to be used by construction foreman and at the same time use parameters which can be measured or identified without ambiguity. The classification methods are supplemented by appropriate field tests and correlated with allowable side slopes and lateral soil pressures on shoring.

**BSS122. A study of lumber used for bracing trenches in the United States,** L. I. Knab, F. Y. Yokel, W. L. Galligan, B. A. Bendtsen, and J. F. Senft, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 122*, 221 pages (Mar. 1980) SN003-003-02164-4.

Key words: construction lumber; construction safety; excavation; hardwood; lumber grading; shoring; softwood; timber engineering; trench bracing; trenching.

In certain areas of the United States, lumber is used extensively to brace trenches against collapse. The life and safety of the workers in these trenches therefore depends on the structural adequacy of the lumber bracing used. This report presents a study of the properties and characteristics of trenching lumber which are critical to its structural performance. Using these properties and characteristics, allowable stresses and use recommendations are proposed.

The National Bureau of Standards (NBS) conducted a field study of trenching lumber and found that either ungraded eastern species, primarily hardwood, or graded Douglas-fir is used. For graded Douglas-fir, allowable design stresses and other properties are established by existing standards. The eastern species, however, are ungraded and no accepted guidelines are used to assign allowable design stresses and other properties. The results of the field study indicate that 80 percent of the eastern species trenching lumber, when graded by existing softwood grading rules (Southern Pine Inspection Bureau Grading Rules, 1977 edition) is No. 2 grade or higher; 60 percent is No. 1 grade or higher. These percentages do not reflect the effects of wane (deficiency in cross-sectional area) and decay, which are additional problems. NBS therefore recommends that, for hardwood wales and struts, allowable stresses and other properties be based on a No. 2 minimum grade with appropriate provisions to control wane and decay.

Use recommendations were developed, which consider duration of load, mechanical damage to lumber, presence of bark, decay, insect attack, inspectability, exposure, and storage for various aspects of trenching lumber applications. These recom-

mendations reflect a severe trenching environment, possible reuse of structural members, and the need for structural integrity to protect life and property.

**BSS123. The effect of moisture on the thermal conductance of roofing systems,** L. I. Knab, D. R. Jenkins, and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 123*, 46 pages (Apr. 1980) SN003-003-02168-7.

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 the 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 the thermal conductance, depending on the type and thickness of the insulation.

**BSS124. Hurricane wind speeds in the United States,** M. E. Batts, M. R. Cordes, L. R. Russell, J. R. Shaver, and E. Simiu, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 124*, 50 pages (May 1980) SN003-003-02177-6.

Key words: building (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology).

A Monte Carlo simulation technique is used to obtain estimates of hurricane wind speeds in the Gulf and East Coasts of the United States. The paper describes the sources of data, the probabilistic models for the climatological characteristics of hurricanes, and the physical models for the hurricane wind speed field used in the estimations. Estimated values of fastest-mile hurricane wind speeds at 10 m above ground in open terrain at the coastline and at 200 km inland are given for various mean recurrence intervals. The estimated hurricane wind speeds were found to be best fitted by Weibull distributions with tail length parameters  $\gamma > 4$ . Estimates are given of various errors inherent in the estimated values of the hurricane wind speeds. Owing to uncertainties with respect to the applicability of the physical models used in this work to locations north of Cape Hatteras, estimated hurricane wind speeds given for these locations should be viewed with caution.

**BSS125. An economic model for passive solar designs in commercial environments,** J. W. Powell, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 125*, 146 pages (June 1980) SN003-003-02203-9.

Key words: benefit-cost analysis; building economics; commercial buildings; investment analysis; life-cycle cost analysis; passive solar energy; retrofit; revitalization; solar energy systems.



This report presents an economic model for evaluating passive solar designs in commercial environments. It discusses the literature on this topic and draws upon this literature to develop a general methodological framework. The model incorporates a life-cycle costing approach that focuses on the costs of purchase, installation, maintenance, repairs, replacement, and energy. It includes a detailed analysis of tax laws affecting the use of solar energy in commercial buildings. Possible methods of treating difficult-to-measure benefits and costs, such as effects of the passive solar design on resale value of the building and on lighting costs, rental income from the building, and on the use of commercial space are presented. The model is illustrated in two case examples of prototypical solar designs for low-rise commercial buildings in an urban setting. These designs were developed at NBS under the Solar Cities project. The two designs, a wall collector system and a street canopy, are evaluated for a neighborhood in Baltimore undergoing urban renewal. Results of the analyses indicate these designs may be economically feasible under a realistic range of economic conditions. Topics requiring further research are identified.

**BSS126. Geographical extrapolation of typical hourly weather data for energy calculation in buildings**, E. A. Arens, L. E. Flynn, D. N. Nall, and K. Ruberg, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 126*, 121 pages (Aug. 1980) SN003-003-02228-4.

**Key words:** building energy; computerized climate data.

Two techniques are developed and tested for creating composite and synthetic hourly weather data for a wide range of sites. The first technique selects real weather data segments from a source multiyear weather record, and links them into a composite synthetic year, in which the hourly values are unchanged from the source. The second technique adjusts the real hourly data values of the source to create a more completely synthetic year. The techniques may be applied individually or in combination. The resulting synthetic year or years can be used to provide data that is representative of long-term climate for building energy prediction either at the first-order station where the source hourly weather data were recorded, or at a nearby second-order station for which only summarized climate averages are available. Additionally, the adjustment technique can generate synthetic data to represent specific time periods at second-order stations for use in energy audits and experiments. The effectiveness of extrapolating weather data from one location to another is assessed, and the uses of the two techniques are described. The user-interactive Fortran programs, SELECT and ADJUST are appended.

**BSS127. Recommended technical provisions for construction practice in shoring and sloping of trenches and excavations**, F. Y. Yokel, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 127*, 84 pages (June 1980) SN003-003-02195-4.

**Key words:** braced excavation; construction; retaining structures; shoring; slope stability; soil classification; soil pressure; standards; trenching.

On the basis of studies conducted by the National Bureau of Standards technical provisions for the sloping and shoring of the banks of trenches and excavations are recommended. Included are a recommended standard practice for trenching which can be used by construction supervisors and compliance officers of the Occupational Safety and Health Administration, and proposed engineering guidelines for the design of shoring systems and other means to prevent mass movement of soil or rock in excavations.

**BSS128. Evaluation of electrical connections for branch circuit wiring**, W. J. Meese and R. W. Beausoliel, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 128*, 71 pages (Nov. 1980) SN003-003-02269-1.

**Key words:** contact resistance; electrical codes; fire safety; glowing electrical connections; house wiring; innovative electrical connections; performance testing.

Performance criteria and test procedures are presented for the evaluation of electrical connections in branch circuit wiring. Investigations and research undertaken to determine needed characteristics of innovative electrical connections are summarized. Design and installation strategies to lessen the chances of electrical connection failures are discussed. Inherent weaknesses are described for design and installation methods of common types of branch circuit wiring connections or terminations, which appear to make them vulnerable to loosening and overheating. There are technology improvements which demonstrate that innovative electrical connections can be developed which may be less costly when installed, and have less chance of becoming hazardous, than common conventional connections.

**BSS129. Cost estimation and cost variability in residential rehabilitation**, R. E. Chapman, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 129*, 120 pages (Nov 1980) SN003-003-02270-5.

**Key words:** applied economics; building codes; building economics; cost estimation; economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation.

This study analyzes four methods of estimating the costs of residential rehabilitation. Each method is critiqued with regard to its treatment of changes in the size of the renovation project, the productivity of labor, and the contractor's markup for overhead and profit. Cost comparisons and a discussion of the way in which the inherent riskiness of renovation activities may be assessed are also presented. A theoretical approach for dealing with cost variability which integrates the performance concept with established engineering economics techniques is also developed.

## 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 Services, Springfield, VA 22161. See page 17 for price list.

**FIPS PUB 6-3. Counties and county equivalents of the States of the United States and the District of Columbia, J. L. Walkowicz, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 6-3*, 39 pages (1980).**

**Key words:** ADP standards; computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; national government; representations and codes; standards; statistical data.

This publication provides names and codes for representing the counties and county equivalents of the 50 States and the District of Columbia for use in the interchange of formatted machine-sensible data. County equivalents include the parishes of Louisiana; the census areas and boroughs of Alaska; the consolidated government of Columbus, Georgia; the independent cities of Maryland, Missouri, Nevada, and Virginia; and that part of Yellowstone National Park in Montana. For the convenience of data systems that need county equivalent codes for certain outlying areas of the United States, Appendix C lists Bureau of the Census codes for Puerto Rico and the Virgin Islands.

**FIPS PUB 60-1. I/O channel interface, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 60-1*, 70 pages (1980).**

**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 connecting computer peripheral equipment as a part of automatic data processing (ADP) systems. This standard, together with a companion standard for power control, defines the hardware characteristics for the I/O channel level interface. In order to achieve full plug-to-plug interchangeability of peripheral components, device class specific operational specifications standards are also required for each class of peripheral device. These operational specifications standards will be proposed as Federal Information Processing Standards to accompany this standard as they are developed.

The Government's intent in employing this I/O Channel 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 interface for connecting computer peripheral equipment as a part of ADP systems.

**FIPS PUB 61. Channel level power control interface, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 61*, 17 pages (1979).**

**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.

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 62. Operational specifications for magnetic tape subsystems, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 62*, 39 pages (Feb. 1979).**

**Key words:** automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; operational specifications for magnetic tape subsystems.

This standard defines the peripheral device dependent operational interface specifications for connecting magnetic tape equipment as a part of automatic data processing (ADP) systems. It is to be used together with FIPS PUB 60, I/O Channel Interface, and FIPS PUB 61, Channel Level Power Control Interface. This standard, together with these two referenced standards, provides for full plug-to-plug interchangeability of magnetic tape equipment as part of ADP systems.

The Government's intent in employing this standard for Operational Specifications for Magnetic Tape Subsystems 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 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 interface for connecting magnetic tape peripheral equipment as a part of ADP systems.

**FIPS PUB 63. Operational specifications for rotating mass storage subsystems, W. E. Burr, G. Clark, J. Little, and T. Pyke, Standards Coordinators, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 63*, 86 pages (1980).**



Key words: command codes; disk drives; Federal Information Processing Standard; format track; operational specification; rotating mass storage subsystems; sense information; status byte.

This Federal Information Processing Standard specifies the command, status and sense codes associated with three classes of rotating mass storage subsystems designed to be employed with the I/O channel interface prescribed by FIPS 60-1. The three classes of rotating mass storage subsystems provided for are: Class A with 100 to 200 megabytes per logical device address; Class B with 317.5 megabytes per logical device address; Class C with 35 or 70 megabytes per logical device address. The provisions of this standard are effective on June 23, 1980.

**FIPS PUB 68. Minimal BASIC**, J. Cugini, NBS Liaison, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 68*, 4 pages (Sept. 1980).

Key words: BASIC; data processing; Federal Information Processing Standard; interactive programming; programming language; software; standards; time-sharing.

This FIPS PUB announces the adoption of the American National Standard for Minimal BASIC as a Federal Standard. The standard defines the syntax of the Minimal BASIC programming language and the semantics for its interpretation. It is to be used by implementors as the reference authority in developing high-level language processors and by other computer professionals. Minimal BASIC is recommended for fast creation of computer programs to solve small non-recurring problems, particularly in time-sharing environments, and for the casual programmer when ease of learning and use are most important.

**FIPS PUB 69. FORTRAN**, J. C. Boudreaux, NBS Liaison, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 69*, 4 pages (Sept. 1980).

Key words: data processing; Federal Information Processing Standard; FORTRAN; numeric methods; programming language; scientific computing engineering; software; standards.

This FIPS PUB announces the adoption of the American National Standard for FORTRAN as a Federal Standard. The standard defines the syntax of the FORTRAN programming language and the semantics for its interpretation. It is to be used by implementors and other computer professionals as the authoritative reference for developing FORTRAN language processors. FORTRAN is recommended for the solution of numeric, scientific, or engineering problems.

**FIPS PUB 70. Representation of geographic point locations for information interchange**, J. Walkowicz, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 70*, 17 pages (Oct. 1980).

Key words: coordinate system; elevation; Federal Information Processing Standard; geographic point location; latitude; Latitude and Longitude; longitude; mapping; State Plane Coordinate System; surveying; Universal Transverse Mercator (UTM).

This standard specifies a uniform format for representing geographic point location data in digital form for purposes of information interchange among data systems. The standard applies only to the three coordinate systems most widely used in the United States to define the position of a point that may be on, above, or below the earth's surface. These systems include: Latitude and Longitude, Universal Transverse Mercator (UTM), and State Plane Coordinate Systems; all three are mathematically interconvertible and are officially recognized by many mapping and surveying agencies of the Federal and state governments.

**FIPS PUB 71. Advanced data communication control procedures (ADCCP)**, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 71*, 4 pages (May 1980).

Key words: advanced data communication control procedures; ANSI X3.66; bit-oriented; code independence; data; data link control procedures; data transparency; interoperability; teleprocessing; transmission.

This FIPS PUB announces the adoption, with three exceptions, of the American National Standard X3.66-1979, Advanced Data Communication Control Procedures (ADCCP). This standard defines the data link control procedures to be used by automatic data processing (ADP) equipment and services employing bit-oriented synchronous data communications links. The procedures provide: transfer of information across a data link; minimal exposure to errors and to the loss or duplication of information; control functions relating to beginning, suspending, and terminating the flow of information across a link; and operation on any type of synchronous data transmission facility.

**FIPS PUB 72. Guidelines for the measurement of remote batch computer service**, T. E. Bell and M. D. Abrams, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 72*, 26 pages (May 1980).

Key words: analysis; computer; evaluation; Federal Information Processing Standards Publication; measurement; performance; remote batch; selection; service.

These guidelines are primarily directed to people who operate or consume remote batch computer service.

The evaluation of Remote Batch [Computer] Service (RBS) is dependent on several factors, including the nature of the service provided, the RBS equipment and its staffing, the criteria and metrics which are deemed applicable, and the measurement methodology. These guidelines present these factors in a unifying context which should introduce increased orderliness into management and selection of RBS.

**FIPS PUB 73. Guidelines for security of computer applications**, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 73*, 55 pages (June 1980).

Key words: ADP availability; ADP security; application system security; computer applications; computer reliability; computer security; data confidentiality; data integrity; data security; Federal Information Processing Standards Publication; security controls; system life cycle; system security.

Security decisions should be an integral part of the entire planning, development, and operation of a computer application. This guideline describes the technical and managerial decisions that should be made in order to assure that adequate controls are included in new and existing computer applications to protect them from natural and human-made hazards and to assure that critical functions are performed correctly and with no harmful side effects. The multifaceted nature of computer security is described, and differences in security objectives, sensitivity levels, and vulnerabilities that must be considered are identified. Fundamental security controls such as data validation, user identity verification, authorization, journaling, variance detection, and encryption are discussed as well as security-related decisions that should be made at each stage in the life cycle of a computer application. These include questions about security feasibility and risk assessment that should be asked during initial planning, decisions that should be made during the design, programming and testing phases, controls that should be enforced during the development process, and security provisions that should be enforced during the day-to-day operation of the system.

**FIPS PUB 76. Guideline for planning and using a data dictionary system**, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 76*, 15 pages (Aug. 1980).

Key words: computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; Federal Information Processing Standards Publication; software.

This guideline provides assistance to Federal ADP Management and technical staff in planning and using Data Dictionary Systems (DDS's). A DDS is a computer software system that is used to assist in organization-wide data management, without restriction to computer data. This document describes the capabilities of a DDS; addresses selection considerations; provides guidance for preimplementation planning, including such management issues as DDS policies and budgeting, data standardization and control, and coordination of the DDS contents. The document also presents initiation and operation considerations for using a DDS.

**FIPS PUB 77. Guideline for planning and management of database applications, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 77*, 50 pages (Sept. 1980).**

Key words: computer applications; computer programs; data administration; database management; database standards; data processing; data resource management; Federal Information Processing Standards Publication; file processing; software; software selection.

The Federal Government uses computers principally to process and maintain large collections of data, often called databases. Databases may be separate files on personnel, property, finances, etc., or they may be integrated collections of all such information for a bureau, agency, project, or Federal program. Database users and system administrators face difficult tasks and choices in effectively applying available software technology to their particular agency needs. They often choose a general purpose database management system (DBMS) as the primary software that will enhance application services and improve overall economy. But DBMS usage has special risks because of the technical complexity of these software packages and the scarcity of skilled support personnel, among other factors. This Guideline is a technical primer for Federal managers and applications analysts, to advise them of alternative software capabilities and recommended development practices for database applications. Specific guidelines address applications planning and management, and software selection.

**FIPS PUB 79. Magnetic tape labels and file structure for information interchange, J. Collica, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 79*, 9 pages (Oct. 1980).**

Key words: data interchange; Federal Information Processing Standards Publication; file structure; magnetic tapes; tape labels.

This publication announces the adoption of X3.27-1978, American National Standard Magnetic Tape Labels and File Structure for Information Interchange, as a Federal Standard. This standard establishes four levels of labeling, label formats, blocking structure, and tape-mark relationships on magnetically recorded tapes (volumes) so that these volumes can be used for information interchange.

This standard contains specifications for processing volumes that correspond to a level of this standard to ensure proper treatment and understanding of these volumes and their contents in information interchange. The implementation of these processing specifications is called the system. A system exists for each level.

## 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.



## 5.12 TECHNICAL NOTES

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.

**TN1017. Characterization of electrically small radiating sources by tests inside a transmission line cell**, I. Sreenivasia, D. C. Chang, and M. T. Ma, *Nat. Bur. Stand. (U.S.), Tech. Note 1017*, 68 pages (Feb. 1980) SN003-003-02157-1.

Key words: electrical dipole; electrically small radiators; magnetic dipole; TEM cell.

An electrically small radiating source of arbitrary nature may be modeled by an equivalent dipole system consisting of three orthogonal electric dipoles and three orthogonal magnetic dipoles, each excited with arbitrary phase. An experimental procedure for determining the emission characteristics of such an equivalent dipole system by tests inside a single-mode transmission line cell is described in this report, followed by some experimental results.

**TN1018. An assessment of the backscatter technique as a means for estimating loss in optical waveguides**, B. L. Danielson, *Nat. Bur. Stand. (U.S.), Tech. Note 1018*, 88 pages (Feb. 1980) SN003-003-02160-1.

Key words: backscattering; fiber attenuation; fiber loss; fiber scattering; optical time domain reflectometry; Rayleigh scattering.

This technical note addresses some of the problems associated with determining the accuracy of the backscatter technique as it is applied to the estimation of attenuation in optical waveguides. The basic theoretical assumptions involved in optical time domain reflectometry are reviewed; the effect on calculated loss values resulting from a departure from these assumptions is then examined. The approach taken is to employ computer modeling of the various scattering and other loss mechanisms using the bulk material properties of optical fibers. Computer responses permit a numerical comparison between the direct (insertion) method of measuring attenuation and several methods of estimating attenuation from analysis of backscatter data. Numerous examples are given of physical effects which can produce discrepancies in attenuation values calculated from backscatter signals. Also, some experimental comparisons are made between backscatter-derived and directly measured attenuation values in step and graded-index optical waveguides. Finally, the conditions necessary for good agreement between the direct and backscatter methods are discussed and suggestions for minimizing these errors are made.

**TN1019. Measurement of optical fiber bandwidth in the time domain**, D. L. Franzen and G. W. Day, *Nat. Bur. Stand. (U.S.), Tech. Note 1019*, 72 pages (Feb. 1980) SN003-003-02161-0.

Key words: bandwidth; laser diodes; material dispersion; mode scramblers; optical detectors; optical fibers; transfer function.

A system is described for determining optical fiber bandwidth from time domain information. A measurement gives the optical fiber transfer function (or frequency response) relating the output waveform to the input. An analysis is given of the variables affecting the measurement. This includes a discussion

of such input related topics as launching conditions, mode scramblers, and laser diode sources; output related topics include a discussion of optical detectors. Laser diodes are evaluated with respect to short pulse performance, near field emission, material dispersion limits, and other spectral behavior like chirping; detectors are evaluated with respect to time response, linearity, and uniformity. Overall system architecture, precision, and dynamic range are discussed. A number of bandwidth related topics are briefly presented and typical experimental results given. This includes examples of: mode mixing via microbending, profile compensation, profile dispersion, intramodal broadening, materials dispersion constants, relative magnitude-phase behavior, and Gaussian predictions of frequency response.

**TN1020. Calculation of fluorescent efficiency from experimental data by the Huygens principle**, Y. Beers, *Nat. Bur. Stand. (U.S.), Tech. Note 1020*, 36 pages (May 1980) SN003-003-02199-7.

Key words: absolute fluorescent efficiency; characteristic wave impedance; Huygens principle; index of refraction; optical loss constants.

This paper concerns the situation of a fluorescent semiconducting layer deposited upon a substrate. It is desired to compute the number of quanta of fluorescent radiation per quantum absorbed of the pump radiation. The principal topic which is discussed is the theory of the Huygens principle method which gives the intensity of the emitted light in terms of the power of an array of point sources in the semiconductor. The method used is a direct application of Huygens principle to the individual waves that are multiply reflected by the boundary surfaces. The results are given in terms of the constants of the materials, the dimensions, and three quantum numbers: (1) P, the number of two-way trips in the semiconductor; (2) Q, the number of round trips in the substrate; and (3) S, the number of two-way penetrations of the boundary between them. Because of approximations used, the method is mainly useful for radiation emerging nearly normal to the surfaces. For light within 10° to the normal the errors are not more than a few percent. The Huygens principle method is also developed for use with planar external sources, and this method is compared with the impedance methods. The calculations made with external sources are needed for determining the non-fluorescent optical constants of the materials.

**TN1021. Fourier transformation of the nonlinear VOR model to approximate linear form**, D. F. Vecchia, *Nat. Bur. Stand. (U.S.), Tech. Note 1021*, 32 pages (June 1980) SN003-003-02232-2.

Key words: Fourier coefficients; linear model; nonlinear model; phase spectrum transformation; spectrum; VOR aircraft navigation system; white noise.

This technical note describes a method for transforming a particular nonlinear regression model to a form which is approximately linear in the unknown parameters. The technique involves computation of the Fourier coefficients for a set of sample data and uses phase variables to estimate the parameters. The phase spectrum transformation is employed to obtain bearing angle estimates for a model associated with the Very-High-Frequency Omni-Directional Range (VOR) aircraft navigation system. The transformation provides a model linear in relevant phase parameters. Thus, estimation of VOR bearing angle utilizes existing statistical theory. Finally, it is shown that certain



generalizations of the VOR model also are reduced to approximate linear form by the phase spectrum transformation.

**TN1022. Sunspot cycle simulation using a narrowband Gaussian process,** J. A. Barnes, H. H. Sargent III, and P. V. Tryon, *Nat. Bur. Stand. (U.S.), Tech. Note 1022*, 24 pages (Sept. 1980) SN003-003-02255-1.

Key words: ARMA models; forecasts; Maunder minimum; models; simulation; statistics; sunspots.

The square of a narrowband Gaussian process is used to simulate sunspot cycles at computer speeds. The method is appealing because: (i) the model is extremely simple yet its physical basis, a simple resonance, is a widely occurring natural phenomenon, and (ii) the model recreates practically all of the features of the observed sunspot record. In particular, secular cycles and recurring extensive minima are characteristic of narrowband Gaussian processes. Additionally, the model lends itself to limited prediction of sunspot cycles.

**TN1023. A system for measuring the characteristics of high peak power detectors of pulsed CO<sub>2</sub> radiation,** P. A. Simpson, *Nat. Bur. Stand. (U.S.), Tech. Note 1023*, 44 pages (Sept. 1980) SN003-003-02256-0.

Key words: beam diameter; insertion loss; optical detectors; photon drag detector; pyroelectric detector; responsivity; single longitudinal mode pulse; TEA laser.

A system is described for determining the responsivity of detectors for high peak power CO<sub>2</sub> laser pulses. The insertion loss of feed-through detectors can also be measured. The basic approach involves a measurement of the excitation energy and detector output waveform, and is applicable only for pulse amplitudes where the detector output voltage is a linear function of the optical power. However, a method is described for extending measurements to power levels where the responsivity becomes nonlinear. The time response of the detectors is checked using short duration (10 ns) rectangular pulses to simulate an impulse. A method for measuring beam diameter is also detailed. An error analysis of the system is given.

**TN1024. Evaluation of three-terminal and four-terminal pair capacitors at high frequencies,** R. N. Jones, *Nat. Bur. Stand. (U.S.), Tech. Note 1024*, 20 pages (Sept. 1980) SN003-003-02242-0.

Key words: calibration; capacitance; four-terminal pair capacitance; immittance standards; inductance; residual series inductance; resonance techniques; three-terminal capacitance.

The low frequency (1 kHz) capacitance values of three-terminal and four-terminal pair air dielectric capacitors can be extrapolated to higher frequencies if the residual series inductance is known. A resonance method for evaluating the residual series inductance of these capacitor types, together with the extrapolation procedure, is described. For the region where the product of capacitance in farads and frequency in hertz is  $10^{-2}$  or less, uncertainties of one percent or less may be obtained.

**TN1025. Interactive Fortran IV computer programs for the thermodynamic and transport properties of selected cryogens (fluids pack),** R. D. McCarty, *Nat. Bur. Stand. (U.S.), Tech. Note 1025*, 112 pages (Oct. 1980) SN003-003-02266-7.

Key words: argon; computer programs; density; enthalpy; entropy; equation of state; heat capacity at constant pressure; heat capacity at constant volume; helium; hydrogen; methane; neon; nitrogen; oxygen; thermal conductivity; velocity of sound; viscosity.

The thermodynamic and transport properties of selected cryogens have been programmed into a series of computer routines. Input variables are any two of P,  $\rho$  or T in the single phase

regions and either P or T for the saturated liquid or vapor state. The output is pressure, density, temperature, entropy, enthalpy for all of the fluids and in most cases specific heat capacity and speed of sound. Viscosity and thermal conductivity are also given for most of the fluids. The programs are designed for access by remote terminal; however, they have been written in a modular form to allow the user to select either specific fluids or specific properties for particular needs.

The program includes properties for hydrogen, helium, neon, nitrogen, oxygen, argon, and methane. The programs include properties for gaseous and liquid states usually from the triple point to some upper limit of pressure and temperature which varies from fluid to fluid. Computer listings of the FORTRAN IV codings are presented. Copies of the programs may be obtained from either the Thermophysical Properties Division of the National Bureau of Standards at Boulder, Colorado, or from Walter Scott at the NASA-Johnson Space Center in Houston, Texas.

**TN1029. The thermodynamic properties of helium II from 0 K to the lambda transitions,** R. D. McCarty, *Nat. Bur. Stand. (U.S.), Tech. Note 1029*, 64 pages (Dec. 1980) SN003-003-02280-2.

Key words: computer program; deviation plots; equation of state; helium II; mathematical model; superfluid; thermodynamic properties.

The equation of state of He-II is modeled by an equation of state explicit in pressure as a function of density and temperature. The equation of state is divided into three regions of temperature 0 to .8 K; .8 to 1.2 K and 1.2 to the lambda temperature for which similar functional forms are used with different adjustable parameters. The combined functions are valid over the entire PT range of the superfluid and may be used for all classical thermodynamic properties. Comparisons between calculated and experimental data are presented. A computer program for calculation of thermodynamic properties (PVT, isochoric heat capacity, isobaric heat capacity, internal energy, enthalpy, entropy, and velocity of sound) is included.

**TN1112. User evaluation of crystal data products and services: Questionnaire analysis and impact,** J. K. Stalick, A. D. Mighell, and R. J. Boreni, *Nat. Bur. Stand. (U.S.), Tech. Note 1112*, 42 pages (June 1980) SN003-003-02201-2.

Key words: computer dissemination; crystal data; identification; materials analysis; materials design; NBS crystal data center; user evaluation.

A survey was made of the needs of the users of *Crystal Data Determinative Tables* and related products and services of the NBS Crystal Data Center. The results indicate a high frequency of use of *Crystal Data*, with particular application to materials analysis and design. The survey suggests a need for the development of a rapid and inexpensive method of unit-cell determination as well as education of the scientific community in the use of the single-crystal method for identification of unknown materials. More complete coverage and consolidation of entries are also suggested. The necessity for computer-based methods of data base dissemination is indicated, with particular importance for research applications.

**TN1113-1. Highway noise criteria study: Traffic noise data base,** D. R. Flynn, C. R. Voorhees, and S. L. Yaniv, *Nat. Bur. Stand. (U.S.), Tech. Note 1113-1*, 381 pages (Apr. 1980) SN003-003-02169-5.

Key words: acoustics; environmental pollution; highway noise; motor vehicle noise; noise; noise control; sound; traffic noise; transportation noise.

This report documents a traffic noise data base that was obtained as part of a large research program developed to identify and quantify the important physical parameters which



affect human response to time-varying traffic noise and to investigate various procedures for rating such noise so as to enable reliable predictions of subjective response to the noise. Fifteen-minute recordings of actual traffic noise were made at four microphone positions (7.5, 15, 30, and 60 m from the centerline of the near lane) at several times of the day at each of seven sites, five representing nominally constant-speed traffic and two representing stop-and-go intersection traffic. The 107 recordings that resulted were subjected to extensive analysis. The analysis procedures are described and tables and graphs are included which document, for each recording, the 1/3-octave band spectra and numerous noise descriptors computed from the time-histories of the A-weighted sound level. As a separate part of this study, recordings also were made of the noise from single-vehicle passbys and from simulated traffic consisting of controlled drive-bys of up to ten vehicles. These recordings also were extensively analyzed and the results of these analyses are given.

**TN1113-2. Highway noise criteria study: Outdoor/indoor noise isolation**, P. R. Donavan, D. R. Flynn, and S. L. Yaniv, *Nat. Bur. Stand. (U.S.), Tech. Note 1113-2*, 180 pages (Aug. 1980) SN003-003-02235-7.

Key words: acoustics; building acoustics; environmental pollution; noise control; noise isolation; sound.

This report documents a series of measurements of the outdoor-to-indoor noise isolation provided by nine houses in the Washington, DC, area. These measurements were carried out as part of a large research program developed to identify and quantify the important physical parameters which affect human response to time-varying traffic noise and to investigate various procedures for rating such noise so as to enable reliable predictions of subjective response to the noise. While a small truck was driven past each test house, simultaneous recordings were made of the sound level at three outdoor microphones and at four indoor microphones (three of which were positioned at representative listener positions). These recordings were analyzed to yield one-third octave band sound levels as functions of time and from these levels outdoor-to-indoor level differences were computed. Analyses are given of the influence of different experimental variables. It is found that microphone placement, both indoors and outdoors, is the major source of measurement uncertainty. The data from this study are in good agreement with sound isolation data reported in the literature for houses in colder climates.

**TN1114. Prospects for an OSHA/ETIP project to facilitate technological innovation**, M. A. Mulkey and R. G. Weiss, *Nat. Bur. Stand. (U.S.), Tech. Note 1114*, 49 pages (May 1980) SN003-003-02171-7.

Key words: administrative experimentation; evaluability assessment; evaluation; Experimental Technology Incentives Program; experimental variance; Occupational Safety and Health Administration; regulatory experimentation; regulatory policy; standards; technological innovation.

This document describes the results of research performed to identify and screen candidate interventions for administrative experimentation with the Occupational Safety and Health Administration (OSHA) of the Department of Labor. It is one product of the Regulatory Processes and Effects Project of the Center for Field Methods (ETIP). The broader project, described elsewhere, is analyzing the effects of changes in regulatory processes on industrial innovation. The report presents preliminary conclusions regarding the appropriateness of experimental variances as a possible means of facilitating the introduction of new technology by industry.

The first two chapters provide an introduction and a brief history of ETIP/OSHA work. Chapter III describes: the basic logic of expanding the use of OSHA's experimental variance

authority to facilitate innovation; types of variances; the variance application and review processes; and limitations on the use of experimental variances to facilitate innovation. Chapter IV describes alternative OSHA policy change processes. The fifth chapter discusses OSHA's role in the equipment market, and Chapter VI describes possible future work. It is recommended that future work, if any, not focus exclusively on variances but rather explore the full range of OSHA policies for updating standards and enforcement policies relative to new technology.

**TN1115. A report on the relevance of the Second Law of Thermodynamics to energy conservation**, D. Didion, D. Garvin, and J. Snell, *Nat. Bur. Stand. (U.S.), Tech. Note 1115*, 51 pages (Aug. 1980) SN003-003-02231-4.

Key words: availability analysis; energy; energy conservation; process efficiency; Second Law of Thermodynamics; system efficiency.

This is a study of the relevance to Federal energy conservation programs of the use of the concept of energy efficiency as being the ratio of the minimum available work necessary for accomplishing a given task to the available work in the actual fuel used to accomplish this task. Included within the study is a review of selected elements of thermodynamics and efficiency concepts, and identification of the technology pertinent to energy conservation programs. The study examines the potential benefits, if any, that would accrue from the application of Second Law of Thermodynamics principles to these technologies. Results indicate the positive value of the Second Law analytical techniques in the planning and design stages of system development, and the rather limited value of its use during the performance monitoring stage. Needs for advancing the acceptance and use of the Second Law analytical techniques are identified.

**TN1116. SHIELDOSE: A computer code for space-shielding radiation dose calculations**, S. Seltzer, *Nat. Bur. Stand. (U.S.), Tech. Note 1116*, 72 pages (May 1980) SN003-003-02172-5.

Key words: computer code; depth-dose data; electron bremsstrahlung; electrons; protons; space shielding.

A computer code, SHIELDOSE, has been developed for the calculation of absorbed dose as a function of depth in aluminum shielding material of spacecraft, given the electron and proton fluences encountered in orbit. Absorbed dose, for small volumes of the detector materials Al, H<sub>2</sub>O, Si, and SiO<sub>2</sub>, is evaluated in three geometries: (1) in a semi-infinite plane medium, (2) at the transmission surface of a finite-thickness slab, and (3) at the center of a solid sphere. Use of the code is described, and an extensive set of monoenergetic depth-dose data for the various detector materials and geometries is tabulated.

**TN1117. NBS Reactor: Summary of activities July 1978 to June 1979**, F. J. Shorten, Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 1117*, 236 pages (Apr. 1980) SN003-003-02170-9.

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 1978 through June 1979. 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 evaluations.

**TN1118. Stone consolidating materials—A status report**, J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 1118*, 52 pages (May 1980) SN003-003-02191-1.



Key words: conservation; consolidating materials; deterioration of stone; preservation; stone; stone consolidation.

Information on types of stone consolidating materials, their performances, and uses are critically reviewed. Processes responsible for the deterioration of stone and criteria for selecting stone consolidants are also reviewed. The main function of stone consolidants is to reestablish the cohesion between particles of deteriorated stone. In addition, a good consolidant should meet performance requirements concerning durability, depth of penetration, effect on stone porosity, effect on moisture transfer, compatibility with stone, and effect on appearance.

Stone consolidants can be divided into four main groups, according to their chemistry. These groups are inorganic materials, alkoxysilanes, synthetic organic polymers, and waxes. Epoxies, acrylics, and alkoxysilanes are currently the most commonly used consolidating materials. Certain waxes have been found to have excellent consolidating abilities. Waxes, however, tend to soften and to accumulate grime and dust. Inorganic materials and some organic polymers have a tendency to form shallow, brittle layers near the surface of stone. These treated layers often separate from the untreated stone. Alkoxysilanes have excellent penetrabilities and are considered by some stone conservators as the most promising consolidating materials. However, a universal consolidant does not exist and many factors must be considered in selecting a consolidant for a specific stone structure.

**TN1119. A thermoluminescence dosimetry system for use in a survey of high-energy bremsstrahlung dosimetry,** M. Ehrlich and C. G. Soares, *Nat. Bur. Stand. (U.S.), Tech. Note 1119*, 47 pages (May 1980) SN003-003-02180-6.

Key words: calibration; dosimetry; high-energy bremsstrahlung; operational characteristics; radiation therapy; recommendations; selection of thermoluminescence dosimetry system; survey; thermoluminescence; United States.

This is the final report covering the work performed under an interagency agreement between the National Bureau of Standards and the Bureau of Radiological Health during the fiscal years 1978 and 1979. A thermoluminescence dosimetry system suited for a survey of high-energy bremsstrahlung in U.S. radiation-therapy departments was selected and calibrated. The experiments leading to the choice of the recommended operational characteristics, including dosimeter handling, annealing and readout, dosimeter stability in the contemplated mode of operation, dosimeter response over the photon-energy range to be covered, irradiation geometry and irradiation level are treated in detail. Results are reported of a pilot study involving the shipment of a typical survey assembly (a plastic phantom loaded with a set of dosimeters) for irradiation in one U.S. therapy department and the overall uncertainty of the proposed survey procedure is discussed.

**TN1120. An approach to improved durability tests for building materials and components,** G. Frohnsdorff, L. W. Masters, and J. W. Martin, *Nat. Bur. Stand. (U.S.), Tech. Note 1120*, 35 pages (July 1980) SN003-003-02213-6.

Key words: accelerated aging tests; building components; building materials; durability; life testing; prediction; recommended practice; reliability service life.

Durability tests usually provide relative measures of the time building materials and components will perform their intended functions under the expected service conditions. This is not adequate to ensure the proper selection of new building materials and components because quantitative measures of long-term performance are needed. Although many tests have been developed to accelerate degradation processes of building materials, they are seldom fully adequate for reliably predicting long-term performance. In this paper, a recommended practice, ASTM E 632-78, which provides a framework for the development of

improved durability tests, is outlined. The application of the recommended practice, which does not specify an analysis procedure, is illustrated by examples from the literature using both deterministic and probabilistic approaches.

While probabilistic concepts have not been applied extensively to materials durability problems in the construction industry, these concepts offer new opportunities for obtaining improved quantitative predictions of the service life of building materials.

**TN1121. A Schottky diode bridge sampling gate,** A. G. Perrey and H. K. Schoenwetter, *Nat. Bur. Stand. (U.S.), Tech. Note 1121*, 18 pages (May 1980) SN003-003-02197-1.

Key words: diode bridge sampling gates; diode bridge switches; diode clipping circuits; diode shunt limiters; Schottky diode bridge; time controlled sampling.

A Schottky diode bridge and associated gating and delay circuits have been designed to facilitate the measurement of low level signals preceded by large signals without overdriving the measuring instrument. This measurement problem occurs in testing or evaluating operational amplifiers, digital-to-analog converters, sample/hold amplifiers and other similar active circuits.

**TN1122. Summary of on-line or interactive physico-chemical numerical data systems,** J. Hilsenrath, *Nat. Bur. Stand. (U.S.), Tech. Note 1122*, 24 pages (Oct. 1980) SN003-003-02259-4.

Key words: chemical data; data banks; data bases; data networks; interactive systems; numerical data bases; on-line data; physical data; spectroscopic data systems.

A brief description is given of 51 interactive physico-chemical numerical data systems, most of which are on-line on international computer networks. The systems are listed under five headings: those useful for identification of substances from spectroscopic data; those providing thermodynamic and transport properties of pure components and mixtures; those which perform metallurgical calculations and draw phase diagrams; systems producing complete tables of thermodynamic properties of individual substances; and those for chemical process simulation, optimization, and design. References to published descriptions of the systems, where they exist, are also given.

**TN1123. A computer data base system for indexing research papers,** L. J. Kaetzel, R. A. Glass, and G. R. Smith, *Nat. Bur. Stand. (U.S.), Tech. Note 1123*, 90 pages (Oct. 1980) SN003-003-02245-4.

Key words: data base; information retrieval; interactive processing.

The KGS data base system allows the indexing and retrieval of scientific research papers through the use of a minicomputer system in an interactive mode. Criteria are entered through the user's computer terminal which produces subsets of the data base in a report format as well as statistical summaries of data base elements.

**TN1125. Photometry and colorimetry of retroreflection: State-of-measurement-accuracy report,** K. L. Eckerle, *Nat. Bur. Stand. (U.S.), Tech. Note 1125*, 44 pages (July 1980) SN003-003-02208-0.

Key words: accuracy; chromaticity; coefficient of luminous intensity; intercomparisons; retroreflectance; retroreflector; specifications; test methods.

A survey of the literature on retroreflection has been conducted and information from this survey necessary for the understanding of the phenomenon of retroreflection is summarized. Items included are materials, measurement geometry, quantities to be measured, instrumentation, and methods of calibration. Recommendations are given to evaluate or to write specifications by discussing important parameters. A partial list of test methods and specifications is presented in tabular form. Some



prior research and intercomparisons are summarized including the results of a previously unpublished intercomparison using prismatic type retroreflectors. The state-of-measurement-accuracy is inferred from the information presented. A bibliography is included for those who would like to obtain more details.

**TN1126. Problems used in testing the efficiency and accuracy of the modified Gram-Schmidt least squares algorithm, R. H. Wampler, *Nat. Bur. Stand. (U.S.), Tech. Note 1126*, 83 pages (Aug. 1980) SN003-003-02221-7.**

**Key words:** algorithms; curve fitting; least squares; modified Gram-Schmidt; pseudoinverse; regression; statistics; test problems; test results.

In preparing "Algorithm 544: L2A and L2B, Weighted Least Squares Solutions by Modified Gram-Schmidt with Iterative Refinement" for publication in *ACM Transactions on Mathematical Software* (Vol. 5, 1979), the Fortran computer program was extensively tested. This note describes the various types of problems which were used to explore the efficiency and accuracy of this algorithm. The Fortran subprograms which performed the various tests are listed in an appendix. Also listed are the data used in executing the testing routines as well as typical output from several different types of problems. Among the testing routines is one which is suitable for handling general linear least squares problems. Here, the user has the option of scaling his raw data in order to mitigate the effects of ill-conditioning.

**TN1127. National Bureau of Standards mass calibration computer software, R. N. Varner and R. C. Raybold, *Nat. Bur. Stand. (U.S.), Tech. Note 1127*, 164 pages (July 1980) SN003-003-02209-8.**

**Key words:** calibration report; correction to mass measurements; error checking; FORTRAN program; least squares solution; mass calibration; mass measurement.

This report describes the FORTRAN computer program used to generate a comprehensive report covering the sequence of operations used to assign mass values to weights submitted to the National Bureau of Standards for calibration. The assignment of these values is accomplished by the method of least squares analysis of the observation of differences between test items and reference items having the same or nearly same density and nominal size. The calculations are defined and the various weighing method options are given. To assist the user, a detailed description of the input data, an input list of error messages, a listing of a sample test case and a listing of the output resulting from the use of the sample test case are given. To assist in the implementation of the computer program, a flow chart, a description of each subprogram, a cross-reference of labeled COMMON, a list of DOUBLE PRECISION variables, a list of EQUIVALENCED variables and other pertinent information is given.

**TN1128. An oxygen consumption technique for determining the contribution of interior wall finishes to room fires, D. L. Senenig, *Nat. Bur. Stand. (U.S.), Tech. Note 1128*, 87 pages (July 1980) SN003-003-02211-0.**

**Key words:** fire tests; flame spread; flashover; heat release rate; ignition; interior finish; oxygen depletion; room fires.

An oxygen consumption technique was developed for determining the total rate of heat production in a room fire. This was accomplished by measuring the volume flow rate and the oxygen concentration of the exhaust gases flowing through a collection hood. This method can be used with unknown combinations of burning materials including both interior finish and furnishing. By simultaneously measuring the rate of oxygen consumption and the rate of mass loss the effective heat of combustion of the wall linings were determined in a reduced-scale model room fire test. The average heat release rate per unit area of the wall linings was determined by recording the

area of involvement during the test and dividing this area into the total rate of heat production at that time. The enthalpy of the exhaust gases passing out of the doorway was determined with the aid of an array of thermocouples located at the entrance to the exhaust duct. By subtracting the enthalpy flow through the doorway from the total rate of heat production in the room, the heat losses through the bounding surfaces were determined. Reduced-scale and full-scale room fire tests and a bench test for heat release rate using the oxygen consumption technique are discussed in this report. Lateral flame spread rates on vertical surfaces measured in the model room fire tests and in a laboratory bench test are also described.

**TN1129. Use of infrared thermography for industrial heat balance calculations, K. G. Kreider and T. P. Sheahan, *Nat. Bur. Stand. (U.S.), Tech. Note 1129*, 38 pages (July 1980) SN003-003-02216-1.**

**Key words:** heat balance; industrial furnaces; infrared; thermography.

Infrared thermography has been used to estimate the radiant heat loss from a channel induction furnace containing molten iron. Using this infrared data, the surface temperature was mapped and the convective heat loss was calculated on the basis of a mixed forced and free-convection model. Additional calculations were performed to include the heat conducted away through a water jacket, and the heat lost by infiltration. The furnace energy input was 255 kW, all electrical. The sum of radiation, convection, conduction, and infiltration losses was 246 kW, but the water cooling alone had  $\pm 30$  kW associated with it. The radiative and convective losses (89 kW) were compared with the losses expected on the basis of the original design (107 kW), which is fair agreement. The value of infrared thermography for doing heat balances on industrial furnaces was assessed.

**TN1130. Recycled oil program: Phase I—Test procedures for recycled oil used as burner fuel, D. A. Becker and J. J. Comeford, *Nat. Bur. Stand. (U.S.), Tech. Note 1130*, 93 pages (Aug. 1980) SN003-003-02227-6.**

**Key words:** fuel oil; petroleum standards; petroleum test methods; recycled burner fuel oil; substantial equivalency; used oil; waste oil.

The Energy Policy and Conservation Act requires the National Bureau of Standards (NBS) to develop test procedures which can be used to establish the "substantial equivalency" of recycled oils with new oils. This report covers the first phase of the NBS program, and contains test procedures which may be used for establishing the substantial equivalency of recycled petroleum oils (including blends of recycled oils with new oils) to new oils for use as a burner fuel. Test procedures were selected and evaluated for their ability to reliably measure the property under test.

**TN1131. Field investigation of the performance of residential retrofit insulation, J. L. Weidt, R. J. Saxler, and W. J. Ros-siter, Jr., *Nat. Bur. Stand. (U.S.), Tech. Note 1131*, 67 pages (Sept. 1980) SN003-003-02243-8.**

**Key words:** conservation; energy; field survey; insulation; moisture content; residences; retrofit; thermal resistivity.

A study was conducted to obtain information on the performance of in-service insulations of the type commonly used in the United States to retrofit sidewalls of housing: urea-formaldehyde based foam, loose-fill cellulose, and loose-fill mineral fiber.

In the field phase of the study, observations were made on performance-related factors such as: the completeness of filling the cavity, the condition of the insulation and wall components, and evidence of moisture accumulation such as water stains on sheathing, studs and other wall components. Shrinkage was observed to have occurred for all urea-formaldehyde based foam

specimens. Where measurable, it was found to be within a range of 4 to 9 percent. For the six test houses containing loose-fill insulation which were opened at the top of the wall cavity, only one with cellulose contained a void of undetermined origin at the location.

Insulation specimens removed from the walls were tested to determine their density, thermal resistivity and moisture content. The pH and moisture absorption of the urea-formaldehyde based foam specimens were also determined. Results of the laboratory measurements are discussed and compared with data from other studies. Relationships between the moisture contents of the samples and their thermal resistivities were not found. Results indicated that the retrofitting of the inspected sidewalls was for the most part accomplished without adverse effect upon them.

**TN1132. Solar energy systems—Standards for cover plates for plate solar collectors**, E. J. Clark, W. E. Roberts, J. W. Grimes, and E. J. Embree, *Nat. Bur. Stand. (U.S.), Tech. Note 1132*, 162 pages (Dec. 1980) SN003-003-02277-2.

Key words: cover plate durability; cover plate materials; cover plate standards; standards; weathering of cover plates.

Laboratory studies were performed to obtain data needed for the development of standards to evaluate the performance and durability of cover plates for flat plate solar collectors used in solar heating and cooling systems. Ten cover plate materials were evaluated to assess their durability after exposure to heat aging, natural weathering and accelerated weathering. Laboratory tests included measurement of solar energy transmittance, linear dimensional stability, warpage and the effect of the dirt retention. The temperatures cover plate materials attain on solar collectors were determined by measurement and by computer simulations. A procedure was developed for the natural weathering exposure of cover plate materials at elevated temperatures which approximate stagnation conditions of solar collectors.

The results of the laboratory tests are presented and draft standards for evaluating cover plate materials for flat plate solar collectors are proposed.

**TN1134. Guidelines for the installation of solar components on low-sloped roofs**, R. G. Mathey and W. J. Rossiter, Jr., *Nat. Bur. Stand. (U.S.), Tech. Note 1134*, 81 pages (Nov. 1980) SN003-003-02261-6.

Key words: collector installation; field survey; guidelines; low-sloped roofs; roofing performance; solar collectors.

Guidelines were prepared for the installation of solar collectors and related equipment on low-sloped roofs of commercial and industrial type buildings. The guidelines are concerned primarily with the waterproofing integrity of the roofing system, access to the collectors and roofing, attachment of different types of collector support frames and safety. Technical information from the literature, building codes, roofing field surveys and acceptable roofing practice provided the basis for the guidelines. The guidelines include recommendations for the design of the solar installation with regard to roofing performance, workmanship during collector installation and maintenance of roofs with solar components.

A field survey was conducted to inspect the condition of low-sloped built-up roofing systems which were retrofitted with solar collector systems. Literature and field surveys were conducted to identify roofing problems attributed to solar equipment installation on roofs and the effect of the installation on roofing performance. The results of the literature and field surveys are presented. Applicable building codes and related documents were examined to obtain information concerning the effect of the installation of solar components on rooftop safety.

## 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 76-1157. A methodology for testing life-cycle performance of consumer products**, J. Cohen, 46 pages (Aug. 1976). Order from NTIS as PB80-134265.

Key words: consumer products; life-cycle performance; methodology; reliability; terminology; testing; useful life.

Life-cycle performance testing of consumer products attempts to predict a probable useful life and to assess the performance during that time duration. A methodology—working concepts, terminology, rules, and procedures—to help accomplish this aim is presented. A glossary and an annotated bibliography are included.

**NBSIR 78-1555-1. A system for fire safety evaluation of health care facilities**, H. E. Nelson and A. J. Shibe, 147 pages (May 1980). Order from NTIS as PB80-195795.

Key words: automatic sprinklers; building codes; building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; safety evaluation; smoke detection.

A quantitative evaluation system for grading health care facilities in terms of fire safety is described. The system can be used to determine how combinations of widely accepted fire safety equipment and building construction features may provide a level of safety equivalent to that required by the widely accepted Life Safety Code of the National Fire Protection Association. The system will provide flexibility to both the designer of new facilities and to the renovator of existing health care facilities. Three major concepts form the basis for code equivalency: a) Occupancy Risk—the number of people affected by a given fire, the level of fire they are likely to encounter and their ability to protect themselves; b) Building Safety Features—the ability of the building and its fire protection systems to provide measures of safety commensurate with the risk; c) Safety Redundancy—in-depth protection, through the simultaneous use of alternative safety methodologies such as containment, extinguishment, and people movement methodologies. The design of the complete fire safety system is intended to ensure that the failure of a single protection device or method will not result in a major failure of the entire system. In this system, equivalency is judged to exist when the total impact of the occupancy risk factors and the compensating building safety features produce a level of safety equal to or greater than that achieved by rigid conformance to the explicit requirements of the NFPA Life Safety Code. In this evaluation, safety performance is gauged both in terms of overall safety impact and depth of redundancy. This report supersedes NBS report number NBSIR 78-1555 published in November, 1978.

**NBSIR 78-1578. Investigation of construction failure of reinforced concrete cooling tower at Willow Island, West Virginia**, H. S. Lew, S. G. Fattal, J. R. Shaver, T. A. Reinhold, and B. J. Hunt, 195 pages (Nov. 1979). Order from NTIS as PB80-192883.

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 has been investigated. This investigation included onsite 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 indicates 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.

**NBSIR 78-1580. Flammability testing of solids under the Federal Hazardous Substances Act**, R. D. Peacock and M. P. Vaishnav, 92 pages (Apr. 1980). Order from NTIS as PB80-226632.

Key words: Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; shredded and slit films; solids; sparks; test methods.

The objective of the Federal Hazardous Substances Act is to protect the consumer from hazards that arise from a large variety of products. The Act and its regulations have several provisions pertaining to the measurement of the flammability of substances. Some are detailed and explicit; others provide only general guidelines.

This report presents the results of a program to provide improvements to particular provisions of the Act and includes test methods that may be used for the testing of various solid materials. An extensive review of the Federal Hazardous Substances Act, its predecessor, and the legislative history provides the basis for some specific recommendations for improvement or clarification. Experimental work performed for the improvement of test methods for shredded or slit films, powders, pastes, and granular substances, and for extremely flammable solids is discussed. This report is based on work sponsored by the Consumer Product Safety Commission and performed from 1974 through 1976.

**NBSIR 78-1583. Standardization and measurement services in Indonesia**, H. S. Peiser, N. J. Raufaste, R. C. Sangster, B. M. Gutterman, and P. M. Odar, 344 pages (Sept. 1979). Order from NTIS as PB80-166267.

Key words: calibration; development; Indonesia; industrialization; instrumentation; less developed country; metrology; standardization; Third World.

At the request of the Indonesian State Minister for Research and Technology, the National Bureau of Standards conducted a two-week survey of standardization and measurement systems in support of industrialization. Financial support was shared between the Agency for International Development and the Government of Indonesia. Coordination by the Lembaga Ilmu Pengetahuan Indonesia (Indonesian Institute of Sciences) and the U.S. National Research Council was provided. There were six topics of specialization: (1) Food and Food Safety, (2) Building and Construction, (3) Quality Control in Industry, (4) Safety



Standards, (5) Calibration, Instrumentation, and Metrology, and (6) Industrial Measurement Techniques. In the executive summary the appraisal of the existing systems for standardization and measurement is coupled with recommendations. A background section is followed by one with the Indonesian specialists' assessments of needs and opportunities. The itinerary details about 80 visits and discussions of team members, and there is a concluding section with general remarks. Indonesia has immense human and natural resources. With a capable infrastructure in standardization and measurement (among other requirements), development could become rapid and very successful.

**NBSIR 79-1625. Metrology for electromagnetic technology: A bibliography of NBS publications, R. A. Kamper, Ed., 42 pages (Jan. 1980). Order from NTIS as PB80-146129.**

**Key words:** cryoelectronics; electromagnetic metrology; lasers; microwaves; optical fibers; time domain metrology.

This bibliography lists the publications of the present personnel of the Electromagnetic Technology Division of NBS in the period from January 1970 through September 1979. A few earlier references that are directly related to the present work of the division are included.

**NBSIR 79-1711. Resource requirements and allocations in IRS' audit division, K. L. Hoffman, L. S. Joel, and M. H. Pearl, 80 pages (Feb. 1979). Order from NTIS as PB81-108870.**

**Key words:** audit; behavior; compliance; discriminant analysis; game theory; law enforcement; taxation; utility.

The Applied Mathematics Division of the National Bureau of Standards (NBS) was asked by the Internal Revenue Service under IRS order No. 7T2867 to "assess the validity and effectiveness of the IRS Audit Division's Long Range Plan's strategies and approaches to resource requirements and allocations." This report, which documents that assessment, (1) summarizes the examination and evaluation by NBS of IRS's current audit practices and plans for the future, and (2) presents our major conclusions and recommendations. In many cases the available information did not permit recommending specific methods with which to solve current problems. In such situations we sought to identify those areas in which we believe further research is needed and is most likely to lead to improvements over present practices.

**NBSIR 79-1724. Selecting rail properties for improvement: A plan for analysis, R. E. Schofer, J. F. Gilsinn, W. G. Hall, C. R. Johnson, J. M. McLynn, and R. H. Watkins, 91 pages (Oct. 1980). Order from NTIS as PB81-115941.**

**Key words:** benefit-cost analysis; combinatorial optimization; high-speed rail; mathematical models; modal split; network analysis.

Section 901-(6) of the Railroad Revitalization and Regulatory Reform Act of 1976 (PL 94-210) calls for a listing and prioritization of rail properties to be improved to permit high-speed operations. This report identifies key factors entering the choice of links for such upgrading, and formulates an analytical methodology (and implementation plan) to support the decision process.

**NBSIR 79-1783. Evaluation of energy-conserving modifications for water heaters, R. L. Palla, Jr., 52 pages (July 1979). Order from NTIS as PB80-133853.**

**Key words:** energy conservation; energy consumption; gas pilot; heat loss; insulation; modifications; recovery efficiency; residential; standby loss; test procedures; water heaters.

The effects of various energy-conserving modifications on water heating energy consumption were evaluated based on laboratory tests. Nine storage-type residential water heaters, representative of standard and "energy-saving" electric, gas, and

oil fueled models currently on the market, were obtained for testing. Federally-promulgated water heater test procedures were used to measure the energy consumption of each unit before and after modifications. Energy-conserving modifications and corresponding projected reductions in energy consumption included: reduced thermostat settings (10 °C), 12 percent savings for standard electric, gas, and oil fueled water heaters (where appliance performance does not degrade below an acceptable level, and water heater capacity is still sufficient to meet hot water needs); and improved insulation, 9 percent savings for all water heater fuel types. Also considered for gas-fired units were reduced pilot input rate from 220 W to 60 W (750 Btu/h to 200 Btu/h), less than 2 percent savings; use of thermal dampers, 3 percent savings; use of intermittent ignition, 5 percent savings; and use of intermittent ignition and mechanical flue dampers, 11 to 16 percent savings. Modifications to energy-saving models resulted in somewhat smaller reductions. Multiple modifications were found to offer energy savings slightly less than the sum of the individual savings.

**NBSIR 79-1787. MIUS feasibility—Five exploratory studies, R. J. Mitchell, 158 pages (Jan. 1980). Order from NTIS as PB80-154719.**

**Key words:** energy conservation; environmental impact; feasibility study; integrated utilities; MIUS; on-site utilities.

This report highlights the collaborative efforts of the National Bureau of Standards, the National Aeronautics and Space Administration and their contractors in the analysis of a Modular Integrated Utility System (MIUS) and conventional utilities for five separate housing projects. The collaborative efforts consist of three separate tasks: 1. Comparative Environmental Analysis; 2. Comparative Energy Analysis; 3. Utility System Design and Cost Analysis.

**NBSIR 79-1908. Solar energy systems: Test methods for collector insulations, M. Godette, J. Lee, and J. Fearn, 39 pages (Oct. 1979). Order from NTIS as PB80-132038.**

**Key words:** accelerated aging; collector insulation; insulation; solar collector; standard insulation test methods.

A preliminary study was performed to evaluate potential procedures for screening the insulation used in solar collectors. Both ASTM standard test methods and newly developed non-standard procedures were used to evaluate twenty-one insulation materials. The insulation parameters measured in this study were selected on the basis of how and to what extent they were affected by the unique environmental conditions within solar collectors. Results of the laboratory tests are discussed and those procedures which offer a potential for screening insulations used in solar collectors are presented. It is intended that these procedures fulfill the first step in the development of a standard set of test methods for evaluating insulations for solar collectors.

**NBSIR 79-1919. Evaluation of a proposed ASTM standard guide to assess the compatibility of metal-heat transfer liquid pairs in solar heating and cooling systems, P. W. Brown and J. W. Grimes II, 45 pages (Nov. 1979). Order from NTIS as PB80-161748.**

**Key words:** corrosion; elevated temperature; heat transfer; liquid flow rate; solar-heat transfer liquid containment; stagnation.

This study was undertaken as part of a round-robin evaluation of a proposed American Society for Testing and Materials (ASTM) testing methodology entitled, "Standard Guide for Laboratory Screening of Metallic Containment Materials for Use with Liquids in Solar Heating and Cooling Systems." This study was undertaken solely to evaluate the procedural aspects of each test method and the results of this study are not intended to provide an assessment of the suitability of any of the



metals evaluated for use in solar heating and cooling systems. It was determined that the tests described in this Standard Practice can be carried out as a basis for evaluating metal-heat transfer liquid pair interactions under conditions simulative of various modes of solar containment system operation.

**NBSIR 79-1920. A collection of test problems for discrete linear  $L_1$  data fitting**, D. R. Shier, S. J. Neupauer, and P. B. Saunders, 142 pages (Nov. 1979). Order from NTIS as PB80-148281, microfiche only.

Key words: algorithm testing; approximation; curve fitting; least absolute deviation; polynomial approximation; spline fitting; test data; test problems.

This document assembles 27 test problems representing a variety of examples in which least absolute deviation (or  $L_1$ ) data fitting has been used. The problems were collected from the literature, from the authors of several  $L_1$  approximation codes, and from examples encountered in practice. Optimal  $L_1$  solutions to these problems (objective function value and solution vector) have been obtained using a double-precision computer code designed for checking the Kuhn-Tucker conditions and for performing an accurate reinversion of the optimal basis. Special problem characteristics such as alternative optima, degeneracy, and rank loss are also noted. This set of test problems has proven useful in evaluating and improving the performance of  $L_1$  codes as well as in suggesting types of problem structures that might be mimicked by problem generators.

**NBSIR 79-1921. A guide to papers citing antitrust cases involving standards or certification**, C. C. Rawie, 21 pages (Dec. 1979). Order from NTIS as PB80-133960.

Key words: antitrust; certification; competition; economics of standards; law; standards.

Since at least 1912, standards and certifications for products ranging from lumber to milk cans have been at issue in antitrust cases. Studying these cases may provide information about the economic effects of standards and certifications based on standards—in particular, their impacts on competition and innovation. This paper describes several articles and reports which examine the antitrust history of standards. It is intended as a research tool to help economists and others decide which (if any) antitrust cases they should study to learn more about the economic effects of standards.

**NBSIR 79-1922. An interlaboratory evaluation of the ASTM E 84-77a tunnel test modified by the Consumer Product Safety Commission for cellulosic loose fill insulation**, J. R. Lawson, 36 pages (Nov. 1979). Order from NTIS as PB80-128317.

Key words: cellulosic insulation; flame spread; interlaboratory evaluation; precision; test methods; tunnel test.

An interlaboratory evaluation was conducted to determine precision estimates for repeatability and reproducibility of the American Society for Testing and Materials (ASTM) E 84-77a tunnel test as modified by the Consumer Product Safety Commission for cellulosic loose fill insulation. Six laboratories participated in this study by running tunnel tests on eight cellulosic loose fill materials. Each laboratory was surveyed during the project to examine its conformance with the critical details of the test apparatus and procedure. The results of the survey showed that none of the tunnels completely conformed with the specifications of the modified ASTM E 84-77a standard.

The within-laboratory coefficients of variation for repeatability for the six fire-retardant treated cellulosic insulations ranged from 11 to 23 percent with an average of 16 percent. The between-laboratory coefficients of variation for reproducibility for the same materials ranged from 31 to 41 percent with an average of 35 percent. There would be little assurance that different laboratories would be able to distinguish between insu-

lations which do and which do not comply with the CPSC mandatory level ( $FSC \leq 25$ ) on a consistent basis.

**NBSIR 79-1925. Equal apparent conspicuity contours with five-bar grating stimuli**, G. T. Yonemura, E. J. Rinalducci, R. L. Tibbott, and L. A. Fogelgren, 38 pages (May 1980). Order from NTIS as PB80-199292.

Key words: conspicuity; contrast; energy conservation; illumination; illumination levels; lighting; suprathreshold seeing; visibility; vision.

The report discusses the results of laboratory studies on equal conspicuity (contrast) contours using as the test stimuli five-bar grating patterns, with the results of other experiments in this series conducted by NBS. These results are in agreement with the earlier studies. Basic groundwork is provided for additional experiments and analysis which will form a practical basis for recommending energy-conserving design illumination levels that conform to real-world office activities.

**NBSIR 79-1929. A computerized approach for identifying cost-effective fire safety retrofits in health care facilities**, R. E. Chapman, W. G. Hall, and P. T. Chen, 125 pages (Jan. 1980). Order from NTIS as PB80-194798.

Key words: applied economics; building codes; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; optimization; renovation.

This study focuses on how a computerized version of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards can be used to determine equivalence to the Life Safety Code in the least costly manner. This study presents a programmer-oriented discussion of the mathematical, economic and engineering considerations that went into the development of the linear programming algorithm for identifying cost-effective retrofits. Programmer-oriented topics treated in this report include: a discussion of user options; program documentation; format statements; flow charts; sample computer runs; and a complete listing of the computer program.

**NBSIR 79-1930. Interlaboratory evaluation of the cyclone settled density test for cellulosic loose fill insulation**, J. R. Lawson, 20 pages (Dec. 1979). Order from NTIS as PB80-138175.

Key words: cellulosic thermal insulation; cyclone settled density test; precision estimates.

The cyclone settled density test for cellulosic loose fill insulation was evaluated in an interlaboratory test program. Seven laboratories tested seven cellulosic loose fill insulations manufactured for the home insulation market. The participating laboratories were surveyed to evaluate the test apparatus and test methodology used at each location. It was concluded that none of the apparatus used in the program completely met the prescribed dimensional requirements for the test. However, statistical analysis of the test results showed that the repeatability coefficient of variation ranged from 2.3 to 3.7 percent with a median of 2.9 percent, and the reproducibility coefficient of variation ranged from 4.4 to 9.9 percent with a median of 8.4 percent. The median difference in density for the materials was 28 percent when blown density was compared to settled density. This study indicated that there is reasonable assurance that test results on the same material obtained at one laboratory can be reproduced in one of the other laboratories.

**NBSIR 79-1931. Fire experiments and flash point criteria for solar heat transfer liquids**, B. T. Lee and W. D. Walton, 41 pages (Nov. 1979). Order from NTIS as PB80-140536.

Key words: fire prevention; fire tests; flammability; flash point; heat transfer fluids; insulation; leakage; solar collectors; solar energy.



To help provide a rational basis for developing flammability criteria for heat transfer fluids used in solar energy collection systems, fire tests were performed using simulated accident scenarios involving spills, flowing leaks, spray leaks, and soaked insulation. These experiments indicated that the flash point temperatures, as measured with the Pensky-Martens closed cup apparatus, are close to the minimum temperatures at which pools of the fluids will support a flame when they are exposed to a small pilot igniting flame in a room. The heat release from moderate sized burning pools of these liquids is sufficient to cause flashover in a room.

Interim flash point criteria of at least 28 deg C (50 deg F) greater than the maximum operating temperature and not more than 111 deg C (200 deg F) below the maximum no-flow temperature are proposed to reduce the risk of fire in the use of solar heat transfer liquids.

**NBSIR 79-1932. NBS serial holdings 1979, J. C. Tucker, Ed., 299 pages (Nov. 1979). Order from NTIS as PB80-132525.**

**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 4 collections specializing in fire research, computer information, standards, and diffusion in metals are represented.

**NBSIR 79-1935. Proceedings, Federal Workshop on Excavation Safety, September 19 and 20, 1978, L. A. Salomone and F. Y. Yokel, 117 pages (Dec. 1979). Order from NTIS as PB80-130511.**

**Key words:** acceptable work practices; excavation; geotechnical engineering; safety; shoring; soil classification; trench; workshop.

A two-day workshop was held at the Department of Labor in Washington, DC, on Sept. 19-20, 1978 to obtain opinions from knowledgeable people on tentative conclusions and recommendations of a NBS Study on excavation safety. The workshop agenda included a series of presentations on Tuesday, Sept. 19, 1978, and a series of group discussions on Wednesday, Sept. 20, 1978. The topic areas covered in the group discussions were: 1) Soil Classification; 2) Acceptable Measures to Protect Workers Against Death by Caving of Banks in Trenches and Excavations; and, 3) Role of the Professional Engineer and Engineering Guidelines.

This report summarizes and synthesizes opinions expressed in these group discussions and presents comments provided by correspondence after the two-day workshop.

**NBSIR 79-1936. An analysis of the responses from an Associated General Contractors of America (AGC) Survey of trenching and shoring practices, L. A. Salomone and F. Y. Yokel, 61 pages (Jan. 1980). Order from NTIS as PB80-140817.**

**Key words:** construction practices; construction safety; excavation; shoring; trenching.

Results of an Associated General Contractors of America (AGC) survey of present practice in excavation, trenching and shoring and of the impact of the OSHA Regulations for Excavation, Trenching and Shoring as perceived by a selected number of the membership are presented. The survey consisted of forty-seven (47) questions. A response of about fifty percent resulted in twenty-three (23) questionnaires being completed and returned to AGC. Although the twenty-three responses did not merit a rigorous statistical analysis, the data are useful in making some general statements about trenching and excavation operations.

**NBSIR 79-1937. Review of current codes and standards for scaffolds, S. G. Fattal, C. L. Mullen, H. S. Lew, and B. J. Hunt, 70 pages (Apr. 1980). Order from NTIS as PB80-184369.**

**Key words:** codes and standards; construction safety; design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces.

This report presents a critical review of the provisions in existing codes and standards for the design, erection, operation and maintenance of scaffolds used in construction work and other applications. The requirements in these documents were examined from the standpoint of clarity, consistency and completeness. Ambiguities arising from conflicting requirements or from provisions that led to more than one interpretation, and lack of consideration of major safety-related structural, environmental and human factors are highlighted. In addition, the adequacy of, and the rationale behind, the prescribed provisions are examined. These are supplemented by a specific application appearing in Appendix B. Appendix A illustrates common types of scaffolding systems that have been addressed by at least one of the codes or standards examined. The findings of this study serve to identify principal areas of needed research to improve present scaffolding practices.

**NBSIR 79-1939. Zinc oxide varistors for lightning arrester service, R. I. Scace, 23 pages (Jan. 1980). Order from NTIS as PB80-144645.**

**Key words:** electrically conducting ceramics; electrical transmission; lightning arresters; nonlinear resistors; semiconductors; surge arresters; varistors; voltage-variable resistors; zinc oxide.

The application of zinc oxide (ZnO) varistors to high-power surge arresters for electrical transmission lines is considered, with particular attention to the special measurement problems posed by the application and by the unique properties of these varistors. The development of ZnO varistors and the present theory of ZnO varistor action are discussed. Consideration is given to the need for further elaboration of the theory.

**NBSIR 79-1943. Properties and interactions of oral structures and restorative materials, J. M. Cassel, J. A. Tesk, G. M. Brauer, J. M. Antonucci, J. E. McKinney, W. P. Whitlock, and G. B. McKenna, 125 pages (Dec. 1979). Order from NTIS as PB80-132020.**

**Key words:** alloy; base metal; casting; composite; cyanoacrylate; dental alloy; initiator; rator; resin; wear.

Promising new polymerization shrinkage-reducing dental resins that have been synthesized include prepolymer fluorinated polymethacrylate monomer (ave. MW = 10,320); diurea dimethacrylate; and methacryloxyethyl-l-adamantylcarboxylate, a tricyclic saturated monofunctional monomer. Initial experiments to gain greater durability using a rubber toughening approach with BIS-GMA indicates a less brittle but tougher matrix can be achieved. Acetylthiourea and ascorbic acid have been shown to be promising non-amine type of accelerators for the BIS-GMA system while new highly reactive amine types such as N,N-dimethyl-p-t-butylaniline, gave cured denture base materials with excellent color stability and may solve current problems in achieving and matching shades in such materials. Research to develop adhesive restorative materials indicates that urethane methacrylates with residual isocyanate groups yield less adhesion than is achievable with 2-cyanoacrylate esters. Pin-on-disc wear data indicated sintered hydroxyapatite pins may be useful substitutes for tooth enamel. A plan to evaluate fatigue as a contributing wear mechanism calls for pre-fatiguing materials before determining the laboratory wear resistance.

Dimensional change data that results from thermal cycling of different porcelains indicate considerable variation, some of which appears relatable to the crystalline forms that are present.



Be appears to lower corrosion resistance in crown and bridge Ni-Cr alloys subjected to anodic polarization measurement following casting, or casting and fire-cycling, to simulate porcelain bake on.

**NBSIR 79-1948. Optimizing weatherization investments in low-income housing: Economic guidelines and forecasts.** R. E. Chapman, R. W. Crenshaw, K. A. Barnes, and P. T. Chen, 155 pages (Feb. 1980). Order from NTIS as PB80-162142.

**Key words:** benefit-cost analysis; building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization.

This study establishes a framework for systematically analyzing the economic viability of alternative methods of weatherizing low-income housing. These methods include but are not limited to insulation, weatherstripping and caulking, and installation of storm windows and doors. The economic framework is illustrated through the development of a series of forecasts (economic guidelines) which show the optimal level of weatherization for low-income residences in 15 cities across the nation. These economic guidelines are designed to assist the Community Services Administration in carrying out its Weatherization Demonstration Program. In particular, they are designed to achieve a more balanced level of weatherization per dollar spent. The optimal level of weatherization is balanced in the sense that for a given weatherization budget no increases in net savings (total savings minus total costs) can be achieved by trading one method for another.

**NBSIR 79-1950. Measurements on insulating materials at cryogenic temperatures.** W. E. Anderson and R. S. Davis, 164 pages (Jan. 1980). Order from NTIS as PB80-134596.

**Key words:** capacitance; cryogenic; dielectric constant; dielectric properties; dissipation factor; electrical transmission; partial discharges; polymers; precision electric measurements; pulse-height analysis; superconducting transmission.

This final report describes the results of a four-year effort to study the high voltage dielectric behavior of various materials at cryogenic temperatures. Dissipation factors at 60 Hz were measured for polymer tapes and epoxy samples at 4.2 K, atmospheric pressure. Multi-layer polymer samples in coaxial geometries at temperatures from 7 to 10 K and helium pressures up to 1.5 megapascals were also studied. The measurements were performed at stresses up to 40 MV/m. Since partial discharges were a major source of losses at the higher stresses and their presence was possibly detrimental to the integrity of the insulation, instrumentation was developed and implemented to study these discharges under conditions found in proposed ac superconducting power-transmission lines.

**NBSIR 79-1951. Energy test method development for electric heat pump water heaters.** C. A. Wan, 86 pages (Jan. 1980). Order from NTIS as PB80-145212.

**Key words:** energy consumption; energy measurements; heat pump; laboratory tests; modifications test procedures; water heaters.

Modifications are proposed for the current U.S. Department of Energy test procedures for water heaters in order to make them applicable to electric heat pump water heaters. The modifications are in the areas of definitions and technical procedures. The latter includes the test conditions, test procedures and measurements, and calculations. Reasons for making these modifications and laboratory test data are provided to support the modifications in the technical procedures.

**NBSIR 79-1953. Simulated precipitation reference materials, III.** E. R. Deardorff, T. C. Rains, and W. F. Koch, 25 pages (Sept. 1980). Order from NTIS as PB80-227044.

**Key words:** chemical analysis; rainwater analysis; reference materials.

This report describes the preparation of a third series of reference materials for the chemical analysis of natural precipitation samples. These materials were prepared by the National Bureau of Standards (NBS), under the joint sponsorship of the Environmental Protection Agency (EPA), and the U.S. Geological Survey (USGS), and will be used as a means of intercalibrating atmospheric monitoring stations. These materials consist of high and low concentrates which upon dilution simulate the range of anion and cation concentrations typically found in natural rainwater. Two separate reference samples which are to be used undiluted are provided for evaluation of acidity measurements. The analytical methods used to establish the composition of the samples are also described.

**NBSIR 79-1954. Development of the flooring radiant panel test as a standard test method.** C. H. Adams and S. Davis, 57 pages (Mar. 1980). Order from NTIS as PB80-180938.

**Key words:** critical radiant flux; fire safety; flame spread; flammability; floor coverings; flooring radiant panel test; test method.

This report deals with the standardization phase of the Flooring Radiant Panel Test. It describes work done to develop the test as a standard for measuring one of the major factors contributing to the potential fire hazard of floor covering systems used in corridors and exitways.

The investigation involved major interlaboratory test programs and focused on: 1) establishing realistic test conditions; 2) defining and minimizing variability; 3) drafting a complete and concise test procedure; and 4) demonstrating the soundness of the method.

Required flux profile instrumentation calibration procedures were developed and proven. "Critical Radiant Flux" data obtained on representative floor covering systems showed the rank ordering of important products such as man-made and natural fiber carpets, vinyl asbestos tile, and hardwood flooring. Acceptable repeatabilities of about 20% (within-laboratory variability) and reproducibility of about 35% (between-laboratory variability) were demonstrated in two major NBS/MMFPA/CRI interlaboratory carpet system test programs. Fourteen laboratories participated in these full factorial statistically designed experiments with each laboratory testing eighteen carpet materials.

**NBSIR 79-1955. Analysis of scaffolding accident records and related employee casualties.** S. G. Fattal, C. L. Mullen, B. J. Hunt, and H. S. Lew, 56 pages (Jan. 1980). Order from NTIS as PB80-161466.

**Key words:** accidents; accident statistics; construction regulations; construction safety; employee casualties; environmental hazards; human factors; occupational safety; scaffold failures; scaffolds.

This report analyzes the causes of scaffold accidents involving employee casualties based on existing records of such incidents. Where possible, the causes are identified with system failures, environmental factors or human factors. System failures are further subdivided into categories to pinpoint the exact nature of the event that triggered the accident. The study provides an insight into the major safety-related aspects of scaffolding practices and points out the types of remedial measures that should be instituted to mitigate the frequency and consequences of scaffolding incidents. Simultaneously, it identifies critical research needs to develop the technical basis for the improvement of the safety aspects of scaffolding practices.



**NBSIR 79-1956. NVLAP glossary of terms for laboratory accreditation, product certification and standardization**, D. B. Thomas, 26 pages (Jan. 1980). Order from NTIS as PB80-147556.

Key words: accreditation; compliance testing; laboratory criteria; product certification; proficiency testing; quality control; standardization; testing laboratory.

This glossary provides definitions of terms commonly used in many laboratory accreditation programs, specifically the Department of Commerce National Voluntary Laboratory Accreditation Program (NVLAP), as well as product certification and standardization programs. The successful development and administration of these programs require a clear understanding of the terms frequently used in describing laboratory criteria, evaluation methodology, proficiency testing, compliance testing, quality control and standardization.

Some of the definitions were derived from those presented in ASQC, ASTM, ANSI, TAPPI and ISO/CERTICO documents with some of the wording (but not the meaning) altered to emphasize a principle. A bibliography listing the sources of some of the definitions is included.

**NBSIR 79-1957. Analysis of code related responses from the solar demonstration program**, J. Greenberg, 153 pages (Jan. 1980). Order from NTIS as PB80-153968, microfiche only.

Key words: building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy.

This report was prepared jointly for the Department of Housing and Urban Development (HUD) and the Department of Energy (DoE) under activities carried out by the National Bureau of Standards (NBS) relative to the National Solar Heating and Cooling Demonstration Programs. This report documents and analyzes the building regulatory information gathered during the course of the Residential Solar Demonstration Program from inception of the program through September 30, 1978. The report is based primarily on data collected by HUD contractor personnel and are data which have been transmitted to NBS for inclusion in the NBS Solar Data Base. Although not all builders and local code officials participating in the demonstration program were interviewed for this study, the total number of participants interviewed was of sufficient size to postulate trends and draw reasonable conclusions regarding the building regulatory aspects of the program. The report concludes that existing codes do not present a barrier to the installation and acceptance of solar systems; however, code officials need additional training and better back-up material to properly evaluate solar systems.

**NBSIR 79-1959. Standardization in France**, I. M. Martinez, 65 pages (Feb. 1980). Order from NTIS as PB80-162126.

Key words: AFNOR; antitrust; certification; France; French standards system; government policy; product; standards systems.

This report provides an overview of the voluntary standards system in France. The author, a former employee of AFNOR—the official French standardization organization, calls on her firsthand experience to discuss the following aspects of the French standard system: (1) Organization, (2) French Standards, (3) Standards Development, (4) Certification, (5) Government Use of Standards, (6) The Role of Consumers and Labor in Standardization, and (7) France's Participation in International Standards Activities.

**NBSIR 80-1629. Development of standards for superconductors. Annual report FY 79**, F. R. Fickett and A. F. Clark, 45 pages (Dec. 1979). Order from NTIS as PB80-175417.

Key words: critical current; critical temperature; losses; magnetic property; standards; superconductor.

Practical superconductors are complex materials and the determination of the parameters required for designing with them is a difficult task. Many approaches are possible for determining a given parameter and the results depend critically on which one is chosen. The goal of this program is to arrive at a set of useful voluntary standards for measurements on modern practical superconductors that will be acceptable to both manufacturers and users. Agreement on a set of standard definitions for the various parameters is also necessary. This report describes the status of the program and includes a brief historical introduction. The need for standards in this area is described in detail with particular attention paid to the need for consensus among all interested parties and our techniques for achieving it. Results from the experimental research by NBS and a review of the wire manufacturers' programs are presented.

**NBSIR 80-1633. Materials studies for superconducting machinery coil composites**, J. W. Ekin, M. B. Kasen, D. T. Read, R. E. Schramm, R. L. Tobler, and A. F. Clark, 162 pages (Nov. 1979). Order from NTIS as PB80-212202.

Key words: critical current; fiberglass/epoxy composite; mechanical properties; niobium-tin; niobium-titanium; strain; superconducting coil composite; superconducting wire.

The physical properties of a superconducting coil composite are studied to accurately predict the coil behavior under operating conditions. Emphasized in this third interim report are studies on the effect of stress and strain on the critical current of superconducting wires. The report also includes data on several fiberglass/epoxy support structures for the coil and its dewar. Preliminary results are also given for the effect of stress on small superconducting composite rings used to model the full sized coil behavior. A summary of the program results to date is included.

**NBSIR 80-1961. Simplified heating and cooling energy analysis calculations for residential applications**, T. Kusuda and T. Saitoh, 137 pages (July 1980). Order from NTIS as PB80-213986.

Key words: energy analysis calculation; energy retrofit; home audit; thermal time constant.

In order to shorten the lengthy computational labor and cost common to most existing hourly simulation computer programs, a simplified energy calculation procedure was developed for the evaluation of energy conservation effectiveness of home retrofitting. The procedure utilizes monthly normal weather parameters such as temperature, humidity, wind data, and solar radiation, in lieu of the traditional degree-day procedure.

The thermal time constant was used to account for the effect of building thermal mass on seasonal heat transfer performance. In addition to standard retrofit procedures such as addition of thermal insulation, use of storm windows, and sealing of cracks, included in the procedure are the energy conservation effects due to the use of solar collectors, hot water tank insulation, and insulation around the heat distribution systems such as ducts and pipes.

**NBSIR 80-1964. Recommended guidelines for safety inspection of construction of concrete cooling towers**, H. S. Lew, S. G. Fattal, and B. J. Hunt, 36 pages (Feb. 1980). Order from NTIS as PB80-170525.

Key words: concrete; construction; cooling tower; formwork; hoisting system; regulations; safety; standards.

As a result of the natural draft cooling tower construction disaster at Willow Island, West Virginia, the National Bureau of Standards (NBS) reviewed existing Occupational Safety and Health Administration (OSHA) construction safety and health



regulations and developed guidelines for use by the OSHA compliance officers for safety evaluation of reinforced concrete shell cooling tower construction.

The guidelines furnished are based on existing OSHA regulations, but highlight their application to this type of construction by pointing out critical construction operations, their safety aspects, and needed compliance inspection procedures. Major regulatory provisions affecting the basic construction plans, safety aspects of design criteria and responsibilities, record keeping, and inspections are summarized. Special attention is given to construction loadings, construction sequences, hoisting systems, and personnel safety training.

Detailed identification is made of items relating to concrete inspection, concrete control, formwork operations, construction loadings, hoisting systems, and construction safety planning.

**NBSIR 80-1965. Fire and life safety for the handicapped, B. M. Levin, Ed., 154 pages (Feb. 1980). Order from NTIS as PB80-144173.**

**Key words:** building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge.

On November 26-29, 1979, the National Bureau of Standards hosted a Conference on Fire Safety for the Handicapped where 80 experts discussed the problems of the handicapped in fire emergencies, safety procedures, and hardware that upgrades their safety. The major work of the Conference was conducted by seven panels that met in parallel: overview, alarm systems, refuge, egress, self-protection, management actions, and emergency service actions.

Six workshops were held in preparation for the Conference during August and September 1979 in the area of life safety for the handicapped in emergencies. The workshops were: codes and standards, emergency preparedness planning, building design, education, consumer interests, and products. Each of the 13 panels and workshops prepared a report containing background information and the recommendations of the panels. This document contains the 13 reports, the speeches at plenary sessions and supplementary comments by some of the participants.

**NBSIR 80-1967. The calibration of angle blocks by intercomparison, C. P. Reeve, 26 pages (Apr. 1980). Order from NTIS as PB80-182132.**

**Key words:** angle block; autocollimator; calibration; flatness; intercomparison; random error; squareness; standard deviation; systematic error; uncertainty.

One service performed by the National Bureau of Standards is the calibration of angle blocks. Test blocks normally come in sets of 16 nominal sizes from 1" to 45°. Their angular values are calibrated by intercomparison with NBS master angle blocks and other test blocks of the same nominal size. Each test block is also measured for its maximum out-of-flatness and out-of-squareness. Statistical tests are performed in order to maintain control over the short-term and long-term variability of the measurement process.

A complete description of the measurement process is given with special attention paid to the mathematical model for the measurements and the least squares estimation of the angular values. The method for determining the standard deviations of the short-term and long-term errors is also given.

**NBSIR 80-1968. Determination of the calorific value of refuse-derived-fuels by large-bomb calorimetry summary of the 1978 fiscal year results, D. R. Kirklin, E. S. Domalski, and D. J. Mitchell, 37 pages (Jan. 1980). Order from NTIS as PB80-154818.**

**Key words:** bomb calorimetry; gross calorific values; refuse-derived-fuels; sample characterization; sample processing effects; 25 gram capacity bomb calorimeter.

An oxygen bomb calorimeter which can accommodate a 25 gram sample of refuse or a refuse-derived-fuel (RDF) has been designed and constructed at the National Bureau of Standards for the purpose of studying the effects of sample processing on the measured calorific value of such material. This large calorimeter is an enlarged and modified version of a conventional-size calorimeter also in use at NBS. The large calorimeter can handle samples ten times larger than the conventional-size calorimeter and therefore can be used to investigate RDF samples with either minimal or no processing. Calorimetric results are presented for calorific value measurements carried out on d(densified)-RDF in both calorimetric systems. Moisture- and ash-free (MAF) calorific values were obtained in the large calorimeter from six randomly chosen unprocessed RDF samples and had a mean value of 24.99 MJ·kg<sup>-1</sup> (10 742 Btu·lb<sup>-1</sup>). Another randomly-chosen sample of unprocessed RDF was subjected to extensive processing to obtain a "homogeneous" analysis sample for use in the conventional-size calorimeter. Individual measurements in the conventional size calorimeter on each of ten "homogeneous" sub-samples gave a mean calorific value of 24.99 MJ·kg<sup>-1</sup> (10 743 Btu·lb<sup>-1</sup>). The result of this investigation indicate that the calorific value of d-RDF is unaffected by the sample processing technique used at NBS.

**NBSIR 80-1969. Consultation visit to the Honduras Department of Engineering and Standardization, H. S. Peiser, 54 pages (Feb. 1980). Order from NTIS as PB80-162134.**

**Key words:** Agency for International Development; development assistance; Honduras; legal metrology; metrication; metrology; quality assurance; standardization; test laboratories; weights and measures laws.

The Government of Honduras, with support from the Agency for International Development, asked the National Bureau of Standards to provide consultation on an increased concern with standardization and measurement services. In this report, H. Steffen Peiser describes his brief visit to Tegucigalpa and his constructive discussions with governmental, industrial, and university authorities. Honduras has very considerable unexploited natural resources and a developing industrial manufacturing base in need of standardization, especially for quality control, to enter world markets. Honduras needs a new Weights and Measures Law and metrology and test laboratories, as well as some assistance for training technicians. Closer cooperation with regional standardization organizations is advocated. Domestically, measurement control in retail markets needs to be developed. Although officially Honduras is metric, the change to metric units has not been widely accepted by the public. Peiser believes that the new programs would be highly cost effective for the economy.

**NBSIR 80-1974. Lead chromate pigments—A literature survey on environmental and toxic effects, M. A. Post and P. G. Campbell, 43 pages (Feb. 1980). Order from NTIS as PB80-160666.**

**Key words:** air pollution; chromate ore; environmental effects; lead chromate pigments; storm water runoff; toxicity; water pollution.

In connection with an evaluation of the performance of possible alternative yellow pigments, a literature search was made on the toxicity and environmental effects of lead chromate pigments. The literature reveals that workers in chromate plants in the U.S., Europe and Japan have had a high incidence of lung cancer as well as other respiratory ailments. Further, reports on the biologic interactions of chromium show that chromium in its hexavalent state (chromate, dichromate) penetrates body membranes such as skin and the walls of red blood cells and is subsequently reduced to the trivalent state and complexed with



organic molecules. While the carcinogen in the chromate manufacturing process has not been identified, animal experiments have shown that calcium chromate can produce cancer in rats. Information is presented on sources of chromium in air and water pollution. Also, the pollution aspects of lead and chromium in storm water runoff and as street contaminants are reviewed.

**NBSIR 80-1976. Numerical solution of linear difference equations**, D. W. Lozier, 169 pages (Mar. 1980). Order from NTIS as PB80-169980.

**Key words:** factorization methods; linear difference equations; linear recurrence relations; Miller's algorithm; numerical stability; Olver's algorithm.

Consider a given linear difference equation  $\sum_{s=0}^l a_s y(r+s) = g(r)$  where  $l \geq 2$  and  $r = 0, 1, 2, \dots$ . Suppose  $y$  is a solution of this equation and  $u, v$  are solutions of the homogeneous form of this equation such that  $u(r)/v(r) \rightarrow 0$ ,  $y(r)/v(r) \rightarrow 0$ ,  $u(r)/y(r) \rightarrow 0$ . Under these circumstances algorithms for the computation of  $y$  based on forward or backward recurrence, such as the Miller algorithm, are numerically unstable.

Stable algorithms, such as the method of Olver, have been based on approximating  $y(r)$  by the solutions of a certain sequence of boundary value problems. Specifically  $y_n(r)$  is a solution that coincides with  $y(r)$  over some initial range of  $r$ , say  $r = i, i+1, \dots, i+j-1$ , and satisfies  $y_n(r) = 0$  for  $r = n, n+1, \dots, n+1-j-1$ . Here  $j$  is an integer whose value depends on the asymptotic behavior of the chosen solution  $y(r)$  and  $n$  is an arbitrary large integer. Boundary value problems of this type are shown to be equivalent to two initial value problems of order  $j$  and  $1-j$  by factorization of the difference operator. The solution of the problem of order  $j$  is obtained by forward recurrence; the solution of the other problem is obtained by backward recurrence.

The algorithm is specified completely for a broad class of operators including, for example, every constant-coefficient operator. Convergence of  $y_n(r)$  to  $y(r)$  as  $n \rightarrow \infty$  for fixed  $r$  is proved and an expansion of the truncation error is derived. Numerical stability is demonstrated. The method is tested by numerical examples involving fourth-order equations with variable coefficients.

**NBSIR 80-1977. Forecasting lead paint abatement costs: A computerized approach**, R. E. Chapman and K. A. Barnes, 88 pages (Mar. 1980). Order from NTIS as PB80-162886.

**Key words:** applied economics; building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning.

This report describes a computerized procedure for estimating the cost of eliminating the lead-based paint hazard from buildings. This procedure is based on the results of an extensive field test program in which lead-based paint hazard abatement activities were carried out in approximately 200 dwelling units. The computerized cost estimation procedure which emerged is particularly useful because it takes into consideration both variations in the conditions of the dwelling unit as well as in the prices for labor and materials. As a result, it permits the least costly abatement technique to be identified under a wide variety of circumstances. In addition, when contract cost estimates are desired, the computer program groups dwelling units together into contracts in such a way that the sum of the expected bid prices is minimized.

This report is intended to serve as a user's manual for staff members concerned with the problem of estimating lead-based paint abatement costs. Specific cases with respect to the preparation of cost estimates for individual dwelling units or of budget estimates for program managers, policy makers, or other decision makers, are treated.

**NBSIR 80-1979. Modeling of standards: Technical aids for their formulation, expression, and use**, R. N. Wright, S. J. Fennes, and J. R. Harris, 17 pages (Mar. 1980). Order from NTIS as PB80-203581.

**Key words:** building standards; classification; decision tables; information networks; modeling; standards; standards-writers; systems analysis.

Standards are the primary communication and control mechanism used to describe building practices and products in communications between the various participants in the building process. Most prior research related to building standards has been concerned with understanding and improving the performance of building products. This work, in contrast, is concerned with improving the organization, expression and interpretation of the information contained in a standard. Techniques are described for objective and rigorous representation of the meaning of a standard. These allow it to be tested for aspects of clarity, completeness, consistency and correctness. Furthermore, the techniques allow alternative organizations and expressions to fit the needs of various users with assurance that meanings remain unchanged and that users will readily find and understand all provisions even in a new or unfamiliar standard.

**NBSIR 80-1980. Data requirements and thermal performance evaluation procedures for solar heating and cooling systems**, E. R. Streed, Ed., 85 pages (Aug. 1979). Order from NTIS as PB80-120173.

**Key words:** heating and cooling performance; solar energy system; thermal performance evaluation.

This document provides standardized nomenclature and procedures to serve as a guide to monitor and evaluate research or demonstration type solar hot water or heated and/or cooled systems, components and buildings. Performance factors, data requirements, measurement parameters and data analysis methods are described for typical solar energy systems. The document has resulted from the review and comments submitted by representatives of countries participating in Task 1. Material developed by the United States for use in the National Solar Heating and Cooling Demonstration Program and published as NBSIR 76-1137, was used as the primary reference. The contact persons for each country participating in Task 1 are listed in Appendix A.

**NBSIR 80-1982. BFIRE/Version 2: Documentation of program modifications**, F. I. Stahl, 113 pages (Mar. 1980). Order from NTIS as PB80-169949.

**Key words:** architectural research; building fires; computer-aided design; environmental psychology; fire research; fire safety; human behavior in fires; modeling technique; programming; simulation of human behavior.

Several shortcomings of BFIRE/Version 1 are discussed. Chief among these are the program's inability to simulate rescue activities during fire events, and to simulate direct interactions between occupant behavior and toxic qualities of smoke filled environments. This report documents a revised program, BFIRE/Version 2, which contains new subroutines developed to mitigate these problems. These subroutines are grouped into two modules: (1) a "smoke" module designed to simulate the experience of inhabiting a smoke filled environment, and (2) a "rescue" module intended to permit the rescue of physically immobile occupants. Additional improvements incorporated into BFIRE/Version 2 include more efficient file management and data input facilities, and expanded output capabilities.

**NBSIR 80-1983. Defect characterization and dimensioning of cracks in welds by the ultrasonic diffraction method**, S. Golan, 26 pages (Mar. 1980). Order from NTIS as PB80-161755.



Key words: compressional (P) modes; cracks; defect characterization; dimensioning; one-transducer technique; shear (S) mode; ultrasonic diffraction; welds.

The possibility of applying an ultrasonic diffraction method for dimensioning of crack-like defects in welds was investigated. A feasibility study was carried out and optimum test conditions were established using a series of test specimens with narrow slits. A series of welded specimens with in-weld cracks were tested. The possibility of using a quantitative diffraction technique for nondestructive examination of pipeline welds in field conditions is discussed.

**NBSIR 80-1984. Static pressures produced by room fires, J. B. Fang, 30 pages (Mar. 1980). Order from NTIS as PB80-162803.**

Key words: building fires; fire tests; flow measurement; furniture; interior finishes; residential buildings; room fires; static pressure.

The distributions and time-varying nature of the static pressures developed due to fires in residential recreation rooms were determined for a range of combustible load densities and different types of interior lining materials. The vertical pressure differentials with respect to the ambient static pressure for various fire sizes are satisfactorily correlated by a hydrostatic perfect gas model based on temperature measurements in enclosures and an orifice flow model, and the calculated doorway inflow and outflow gas velocities are in good agreement with the measured values. The pressure differentials are found to reflect the locations of the neutral plane at the doorway and the thermal discontinuity within the fire room reasonably well, and their magnitudes depend on the average upper gas temperature. Rates of mass flow in and out of the room calculated from the ceiling and the floor pressure differentials agree fairly well with those derived from the doorway gas velocity data.

**NBSIR 80-1987. A mathematical model for use in evaluating and developing impact test methods for protective headgear, R. E. Berger, 78 pages (Mar. 1980). Order from NTIS as PB80-164957.**

Key words: drop test parameter; head injury; helmet; injury criteria; mathematical model; test methods.

A lumped parameter mathematical model was developed to connect injury parameters in real life head impact environments to output parameters of test methods for evaluating protective headgear. Analytical/experimental schemes were developed for mathematically representing the parameters that characterize each of the three distinct elements of the model: the head or headform, the impact surface, the helmet. A comparison of the model output to experimental results showed a satisfactory agreement. The model was shown to be useful in determining test method pass/fail criteria which correspond to the threshold of injury in the real life situation.

**NBSIR 80-1988. A study of work practices employed to protect workers in trenches, J. Hinze and N. J. Carino, 124 pages (Mar. 1980). Order from NTIS as PB80-167497.**

Key words: construction safety; construction standards; excavation; safety regulations; shoring; trenching.

Results of a field study of trenching practices, safety related problems in trenching, and the effect of the Occupational Health and Safety Administration (OSHA) regulations for excavation, trenching and shoring are presented. The data were gathered from over 100 interviews with contractors and foremen in various regions of the country and from the answers to questionnaires sent by contractors' associations to their membership. The data indicate: 1) the technical aspects of trenching work, 2) the industry's opinion of the current OSHA regulations, and 3) factors affecting safety performance in trenching work.

**NBSIR 80-1989. A study of handcuff improvements, J. E. Harris, 25 pages (Apr. 1980). Order from NTIS as PB80-181365.**

Key words: handcuff; lock security.

Designs for improving the security of present day ratchet and pawl metallic handcuffs are presented. Two methods utilizing a new lock feature were developed that significantly improve the lock. In addition, several other potential handcuff improvements are discussed in this report.

**NBSIR 80-1990. Probabilities of vertical overlap: A sensitivity analysis, H. K. Hung, J. F. Gilsinn, and K. L. Hoffman, 72 pages (Mar. 1980). Order from NTIS as PB80-161151.**

Key words: air safety; collision probability; probability distribution; sensitivity analysis; separation standard; vertical error; vertical overlap.

Because of the potential increase in traffic at FL 290 and above, both current and alternative vertical separation standards are being reviewed. A plan to collect data on the vertical navigational performance of aircraft is also contemplated. This report documents a sensitivity analysis carried out to assess how different assumptions about the probability distribution of "total vertical error" affect the probability of vertical overlap. The four factors affecting the probability of vertical overlap which are examined in this study are: the functional form of the vertical-error distribution function; the standard deviation of this probability distribution; the vertical dimensions of the aircraft; and the vertical separation standard. Probabilities of vertical overlap were computed over a range of possibilities for each of these four factors in order to discern the effect of each factor. A final section discusses the findings of this study and draws some conclusions.

**NBSIR 80-1991. Materials for fuel cells, L. H. Bennett, C. K. Chiang, M. I. Cohen, A. L. Dragoo, A. D. Franklin, and A. J. McAlister, 89 pages (Mar. 1980). Order from NTIS as PB80-182355.**

Key words: catalyst; cerium dioxide; electrocatalysis; fuel cells; impedance; solid electrolyte; tungsten carbide.

Transition metal-metalloid compounds involving V, Mo, Ta, and Nb with P, Si and N were examined as potential electrocatalysts in hot concentrated phosphoric acid. MoP, WP, MoSi<sub>2</sub>, Mo<sub>2</sub>N/MoN, and W<sub>2</sub>N/WN were found to be stable in the absence of cathodic potentials. The W<sub>2</sub>N/WN was non-conducting. MoSi<sub>2</sub> and Mo<sub>2</sub>N/MoN were both inactive as catalysts and unstable under cathodic potentials. MoP and WP corroded at about 0.2 volts RHE. Only WP showed even mild activity as a hydrogen oxidation catalyst.

The electrochemical properties of Mo<sub>x</sub>W<sub>1-x</sub>C electrodes were studied in some detail, and found to be independent of x near 0.7. The electrochemical behavior is very similar to that of WC, with about the same activity and the same indifference to CO poisoning.

Experiments are outlined for studying a possible "spillover" effect from Pt to Mo<sub>1-x</sub>W<sub>x</sub>C and transition metal borides as supports, and for using a Raman spectroscopic technique for characterizing the electrochemical interface of transition metal-metalloid compound electrodes.

The preparation and characterization of high-density (99.6 to 99.8% of theoretical) Y<sub>2</sub>O<sub>3</sub>-doped CeO<sub>2</sub> ceramics is described. The material exhibits very sharp, single-phase, x-ray diffraction peaks, indicating good compositional homogeneity. The influence of various preparation methods on the sintering characteristics of powders of these materials is described. Chemical analytical techniques are given.

The electrical properties of inhomogeneities, presumably grain-boundaries, in the Y<sub>2</sub>O<sub>3</sub>-doped CeO<sub>2</sub> ceramics were very different for materials prepared from powders produced by mixing the oxides from those found when the powders were



prepared by coprecipitation. A higher resistance and a much higher capacitance were found in the latter case.

The temperature dependence of the inhomogeneity contribution to the overall resistance in the  $Y_2O_3$ -doped  $CeO_2$  is somewhat different from that of the internal grain or crystal contribution, and since they are in series, the larger resistance dominates. At low temperatures it is the crystal contribution. Hence an Arrhenius plot of the dc conductivity exhibits a break, as often seen in the literature on these materials. Only the portion at temperatures above the break, on this view, represents the true properties of the substance itself.

In the course of 4-probe dc conductivity measurements on some  $Y_2O_3$ -doped  $CeO_2$  materials a slow voltage transient was observed under constant-current conditions. This transient appears to involve a solid state diffusion process.

Modifications to our automated electrochemical measurement system are described that allow 1) an increase of the mass data storage available to the system, so that the results of a number of repetitive runs can be stored and later examined and compared; 2) an increase in the maximum sensitivity when data are being acquired at high speed, as in pulse mode operation; and 3) the use of a complete driver system in the software to coordinate all its aspects, and also the use of Fast Fourier Transform techniques during pulse mode operations. These modifications are described in detail.

**NBSIR 80-1992. Development of flammability criteria for transformer dielectric fluids**, R. G. Gann, 55 pages (Mar. 1980). Order from NTIS as PB80-163777.

Key words: fire; fluids; pool fires; transformers.

With the recent ban on the use of polychlorinated biphenyls, it has become necessary to examine the fire safety requirements for electrical insulating fluids. The hazards are delineated and the magnitude of the transformer fire problem assessed. The current fire code and standard test methods are shown to be inadequate. Approaches to fluid fire performance testing are presented, as is a basis for evaluating the economic impact of alternative fire safety strategies. The report concludes with recommendations for further work.

**NBSIR 80-1993. Economic analysis of improved efficiency for central air conditioners**, S. R. Petersen, G. E. Kelly, and D. A. Didion, 55 pages (June 1980). Order from NTIS as PB80-209885.

Key words: central air conditioners; economic analysis; incremental savings; life-cycle costs; minimum efficiency standards; minimum energy-efficiency levels.

The development of minimum performance standards for central air is required by the National Energy Act of 1978 and is the responsibility of the Department of Energy (DOE). This report attempts to assist DOE in this endeavor by providing an analysis of the life-cycle savings and costs associated with improvements in the energy efficiency of central air conditioners. It develops a rational methodology that can be used in setting minimum standards which are economically and technically justified and makes recommendations which the authors feel meet these criteria for both split and package central air conditioners.

**NBSIR 80-1994. Household appliance usage data**, A. D. Davies, R. V. Kelly, A. C. Lewis, C. D. Lovett, and T. J. Wang, 137 pages (Mar. 1980). Order from NTIS as PB81-114068.

Key words: appliances; conservation; costs; energy; EPCA; residential; usage.

The Energy Policy and Conservation Act (EPCA) requires the development of test procedures for the measurement of the energy efficiencies and the computation of Estimated Annual Operating Costs (EAOC's) of consumer products covered by the EPCA. These products are refrigerators, refrigerator-freezers, dishwashers, clothes dryers, water heaters, room air condi-

tioners, home heating equipment, television sets, kitchen ranges and ovens, clothes washers, humidifiers, dehumidifiers, central air conditioners and furnaces.

Each test procedure contains one or more factors that are determined by the consumer and include such items as uses per year, outdoor and indoor environment, household operating practices and ground water temperature. This report is a compilation of the sources and background for the consumer usage factors contained in the current test procedures. Uncertainties in these factors are discussed, and for selected base cases, the corresponding uncertainties in EAOC's are computed. A substantial bibliography is included.

The purpose of the report is to provide perspective in selecting usage factors for future study and refinement. The items found to be most in need of refinement were factors bearing on temperature and humidity control and on water heating, both on national and regional bases.

**NBSIR 80-1999. Models for the migration of additives in polyolefins**, L. E. Smith, S. S. Chang, F. L. McCrackin, I. C. Sanchez, and G. A. Senich, 137 pages (Aug. 1980). Order from NTIS as PB80-220288.

Key words: additives; diffusion; food additives; indirect additives; migration; models; regulations.

In addition to continuing our experimental and theoretical program as previously described during the past quarter we have considered methods of organization and classification which could facilitate the understanding and use of our program outputs. We have also considered a number of specific technical questions that have been raised by FDA staff. Our program has focused initially on the class of polymers best described as polyolefins. These polymers represent the majority of plastics used in packaging applications and we feel that models of migration developed for the principal members of the class will be applicable to most members with only minor modifications. The technical requirement that the polymers be equilibrium fluids rather than glasses can be established by a glass transition temperature well below the use temperature or by evidence of some crystallinity at use temperatures. Using these criteria, a preliminary classification of polymers based on chemical structure has been developed. We have found a formal decision tree to be a useful device to focus attention on the specific technical decisions involved in making regulatory judgments on indirect additive questions. A simple example of such a decision tree is given. The general form of this tree is, of course, independent of the polymer-migrant system involved but the functional forms used in the calculations of partition coefficients and diffusion constants are specific for the class of polymer involved. The determination of the appropriate functions for decisions is a principal objective of our work along with an assessment of the experimental data and methods needed as inputs.

**NBSIR 80-2000. Development of test structures for characterization of the fabrication and performance of radiation-hardened charge-coupled device (CCD) imagers: Annual report, December 1, 1978 to November 30, 1979**, G. P. Carver and S. Rubin, 22 pages (Mar. 1980). Order from NTIS as PB80-160708.

Key words: CCD; electrical test structure; gated diode; integrated gated-diode electrometer; integrated test structure; leakage current; test structure.

This project is to evaluate new test structures and test methods useful for the characterization of radiation-hardened CCD imagers. During the period covered by this report, consultation was provided to The Charles Stark Draper Laboratory, Inc. (CSDL) and to CSDL contractors on the implementation of test structures developed during the previous year of this project. In addition, the results of measurements on buried channel gated diodes and buried layer metal-oxide-semiconductor field-effect transistor (MOSFET) direct-current (dc) profilers are reported.



Further advances in the development of the integrated gated-diode electrometer are also reported.

**NBSIR 80-2001. Economics of the product certification industry: Some research needs,** C. Chapman Rawie, 75 pages (Mar. 1980). Order from NTIS as PB80-160716.

**Key words:** accreditation of testing laboratories; certification; certification industry; economics; government policy; product certification; standardization research needs; standards.

A number of private organizations certify products for safety and other qualities. With the increase in safety regulation, product liability suits, and interest in encouraging the use of new technologies through certification, certification is likely to become more and more important as a way to show conformance with voluntary or regulatory standards. There have been a number of Federal and State government activities related to product certification. However, the potential impact of past and proposed government actions is not clear. One reason may be that there has been insufficient study of the economics of the product certification industry. This paper asserts that such study is needed as a basis for setting government policy and raises issues that should be addressed concerning structure and performance of the product certification industry.

**NBSIR 80-2002. Method of testing, rating and estimating the heating seasonal performance of heat pumps,** W. H. Parken, G. E. Kelly, and D. A. Didion, 65 pages (Apr. 1980). Order from NTIS as PB80-185622.

**Key words:** central air conditioners; central heating equipment; heating seasonal performance; heat pumps; rating procedure; residential heating; seasonal performance; test method.

Test and rating procedures are presented for electrically-driven residential air-to-air heat pumps operating in the heating mode. The procedures are designed to include the effects of part-load (cyclic) operation, variations in outdoor temperature, and frost formation on the heating performance. Using the test procedure results, a calculation procedure is presented for estimating the heating seasonal performance (HSPF) and cost of operation of residential heat pump units.

**NBSIR 80-2004. The measurement of the smoke leakage of door assemblies during standard fire exposures,** L. Y. Cooper, 71 pages (June 1980). Order from NTIS as PB80-214000.

**Key words:** building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods.

A basis for relating overall intrabuilding smoke migration dynamics to high temperature, door assembly smoke leakage measurements is formulated. The results of applying the tentative, high temperature, ISO 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 method is limited in its utility in the sense that fire scenarios in high-rise buildings may not be adequately simulated. Consistent with the above-mentioned experimental results, troublesome theoretical problems with the test method and its procedures are identified. These lead to a conclusion that the test method as written is generally unreliable. An alternate test concept which removes the above-mentioned DP 5925 Part 3 limitation and all of its problems is described and its development is advocated.

**NBSIR 80-2005. Computer science & technology: Investigation of technology-based improvement of the ERIC system,** S. Treu, 120 pages (May 1980). Order from NTIS as PB81-167645.

**Key words:** communications technology; computer networks; computer technology; data entry; distributed processing;

Education Resources Information Center (ERIC); information systems; intelligent terminals; mass storage technology; microfiche; micrographics; optical character recognition.

Results of a one-year, NIE-sponsored study to identify potential technology-based improvements in the operation, access, and utilization of the Educational Resources Information Center (ERIC) are described. Both current problem areas and future possibilities are considered with regard to the dichotomy: system components and the total system. Emphasis is on characterizing the component functions of data input and data output as well as the total system operation in terms of applicable criteria (data type, volume, purpose, performance). Technological alternatives are then discussed with reference to those criteria. The report concludes with a structured summary of observations, recommendations, and possible follow-up studies.

**NBSIR 80-2006. Semiconductor technology program—Progress briefs,** W. M. Bullis, Ed., 16 pages (Apr. 1980). Order from NTIS as PB80-191521.

**Key words:** electronics; integrated circuits; measurement technology; microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; silicon.

This report provides information on the current status of NBS work on measurement technology for semiconductor materials, process control, and devices. Results of both in-house and contract research are covered. Highlighted activities include: modeling of diffusion processes, analysis of spreading resistance measurements, and studies of resonance ionization spectroscopy, resistivity-dopant density relationships in *p*-type silicon, infrared detector materials, photoresist sensitometry, power transistor switching characteristics, and gross leak testing and application of an electrical alignment test structure. Brief descriptions of selected on-going projects are included, and recent publications and publications in press are listed. The report is not meant to be exhaustive; contacts for obtaining further information are listed.

**NBSIR 80-2008. Physical testing of polymers for use in circulatory assist devices,** R. W. Penn, G. B. McKenna, and F. A. Khoury, 61 pages (Mar. 1980). Order from NTIS as PB80-164650.

**Key words:** biomaterials; blood pump materials; butyl rubber; elastomers; polyolefin rubber; segmented polyurethane; time dependent failure; urethane-silicone copolymer.

The mechanical durability of an elastomer is a critical factor in its suitability for blood pump applications. In such applications, an elastomeric bladder is expected to undergo cyclic stress or strain histories at a frequency of approximately 1 Hz for periods of several years. Test methodologies for characterizing the mechanical durability of such materials do not exist.

In this report, we describe a test methodology which we have developed for the characterization of the durability of elastomers which are candidate materials for blood pump applications. This framework is based upon a cumulative damage rule which we have used to describe the time dependent failure of glassy and semicrystalline polymers. Within this framework, we are in the process of studying the durability of a polyolefin rubber, a urethane-silicone copolymer elastomer and a segmented polyurethane elastomer which are candidate materials for blood pump applications. We have also prepared a standard butyl rubber to use for inter laboratory comparisons with other labs working on this contract.

The cumulative damage framework suggests that the testing protocol be designed to examine four aspects of material failure: (1) failure under static loads, (2) failure under dynamic loads, (3) frequency dependence of dynamic failure, (4) statistics of failure. We report on our results to date on the uniaxial and equibiaxial failure of the blood pump elastomers using a testing protocol which includes the above four points.



NBSIR 80-2009. **Abstract & Index Collection—National Bureau of Standards Library**, D. Cunningham, 64 pages (Jan. 1980). Order from NTIS as 80-169329.

Key words: abstracting and indexing services; abstracts; indexes; National Bureau of Standards.

An alphabetical arrangement of abstracts and indexes available at the National Bureau of Standards (NBS) Library is listed by most current title of the publication. Other information includes description of the abstract or index, library holdings, principal sources, publisher or association, corresponding data base and the classification number. A general subject index follows the main text of the report.

NBSIR 80-2010. **Analysis of construction conditions affecting the structural response of the cooling tower at Willow Island, West Virginia**, H. S. Lew and S. G. Fattal, 48 pages (July 1980). Order from NTIS as PB80-222631.

Key words: collapse; concrete; concrete strength; construction; construction loads; cooling tower; dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell.

The initial investigation of the Willow Island cooling tower collapse (NBSIR 78-1578) established that the most probable cause of the collapse was the imposition of construction loads on the tower before the concrete had gained adequate strength. The analysis presented herein responds to questions outside the scope of that investigation which considered only actual conditions existing at the time of the collapse. The present investigation shows that failure would initiate in lift 28 if the concrete strength in that lift is 1000 psi (6.9 MPa) or less, and to maintain a safety factor of 2.0, the concrete strength in that lift should be 4000 psi (27.6 MPa). This study also reveals that even if an additional bolt had been introduced between each exterior jumpform beam and the tower, the stresses would not have been relieved enough to prevent failure of lift 28. Finally, it is shown, that if the ground anchor point of the static line had been kept at the location occupied just prior to its last move to a location near the center of the tower, the stresses in the shell due to construction loads would have been relieved to the extent that failure of lift 28 would probably not have occurred.

NBSIR 80-2012. **Measuring the rate of corrosion of reinforcing steel in concrete**, E. Escalante, S. Ito, and M. Cohen, 44 pages (Mar. 1980). Order from NTIS as PB80-170848.

Key words: bridge deck corrosion; corrosion in concrete; corrosion of steel; polarization technique; rebar corrosion.

The progress on a research program directed at developing a nondestructive method for measuring the corrosion of steel in concrete as related to bridge deck deterioration is reported. Several polarization techniques for measuring the corrosion rate of steel in concrete are correlated to actual weight loss measured gravimetrically. The design of a prototype automated mini-computer system for measuring the corrosion of steel in concrete is also described. Included are the results of a laboratory basic study on the effect of pH,  $\text{Cl}^-$ ,  $\text{O}_2$ , and moisture on initiating and maintaining corrosion in mortar.

NBSIR 80-2014. **Safe environments—Anthropometric, biomechanical, and activity considerations**, C. E. Jones and J. V. Fechter, 155 pages (June 1980). Order from NTIS as PB80-199128.

Key words: accidents; anthropometry; biomechanics; disability; disability organizations; home safety; household activities; household design; mobility aids; room use.

This report has been prepared for the National Bureau of Standards' Center for Fire Research as part of their support to the Office of Human Development Services of the U.S. Department of Health, Education, and Welfare. The major objective of this report is to summarize data describing the physical charac-

teristics of "normal" and disabled people as actual or potential residents of "normal" homes, the space through which they move, their limits of bodily action, the causes of their injuries, and the factors influencing their use of residential time. The data have been obtained almost entirely from published literature. Specific and general evaluations of the applicability of the data to normal home activities are presented.

NBSIR 80-2015. **Economics applied to standards: A guide to the literature**, S. F. Weber and B. C. Cassard, 92 pages (Apr. 1980). Order from NTIS as PB80-186034.

Key words: benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; economics; evaluation; literature search; regulation; standardization; standards.

This report provides a guide to the available literature on the application of economics to the analysis of standards and standardization. One hundred eighty-nine relevant articles, reports, and books were found and organized into four major categories of interest: (1) General methods of economic evaluation; (2) Economics useful for standards analysis; (3) Evaluation of specific developed standards; and (4) Economics applied to the development of standards. The significant findings within each of these categories are briefly discussed in the text. The annotations which accompany the bibliographical entries provide more detailed information. The text includes a discussion of the approach followed in the literature search. An author index is also provided.

NBSIR 80-2016. **The economics of consumer product information**, R. Dardis, 56 pages (May 1980). Order from NTIS as PB80-181001.

Key words: benefits; consumer; information; label; product; testing.

The major objective of this study was to examine the economic principles underlying the provision and acquisition of consumer product information. The direct and indirect benefits from product information and the economics of consumer information acquisition comprise the first part of the study. The existence of the consumer information gap within the past two decades is investigated in the second part of the study. Reasons for information failures in the marketplace are then examined leading to a discussion of various methods for increasing the level of consumer product information. The analysis should provide an understanding of reasons for information failures in the marketplace and problems faced by policy makers in attempting to correct market deficiencies.

NBSIR 80-2017. **State standards, plans and programs for energy conservation of consumer products**, S. J. Chumas, Ed., 69 pages (Apr. 1980). Order from NTIS as PB80-182850.

Key words: energy conservation measures for consumer products; Energy Extension Service (EES) program; regulations; standards; State energy conservation office contact personnel; State energy conservation plans and programs.

States are responding to Federal requirements to develop procedures for public energy conservation measures and plans. This document furnishes evidence or absence of state energy conservation legislation, regulations, voluntary standards, plans, and programs for consumer products. It also identifies the states that are participating in the pilot Energy Extension Service (EES). The survey was based on seven questions asked of each state. This document contains the state responses to the inquiry and a bibliography of the materials submitted in response to the survey.

NBSIR 80-2019. **Technical specifications of a proposed Federal Information Processing Standard on the modes of operation for the Data Encryption Standard**, M. J. O'Brien, 41 pages (Apr. 1980). Order from NTIS as PB80-183189.



**Key words:** computer security; cryptography; data security; DES; encryption; modes of operation.

This paper contains a draft of the technical information describing some of the modes of operation for the Federal Data Encryption Standard (DES). A DES mode of operation is a technique, external to the cryptographic algorithm, for incorporating the DES into a cryptographic system. Four modes of operation are described: the electronic codebook (ECB) mode, the cipher block chaining (CBC) mode, the cipher feedback (CFB) mode, and the authentication-only mode.

**NBSIR 80-2021. Report to AID on an NBS/AID workshop on standardization and measurement services, H. S. Peiser, C. C. Raley, and P. M. Odar, Eds., 66 pages (Apr. 1980). Order from NTIS as PB80-181829.**

**Key words:** AID; assistance; developing economies; foreign relations; industrializing nations; international relations; LDC's; measurement services; standardization.

From October 3-21, 1978, a Workshop was held at the National Bureau of Standards, Gaithersburg, and at selected universities, research institutes, standards developing organizations, test centers, and industrial companies, under the sponsorship of AID. The object of the Workshop was to give standards officials of industrializing nations insight into the standards and measurement systems of the United States and the role of the National Bureau of Standards, so that these officials might consider what parts of the U.S. system might usefully be adapted to conditions in their home countries. In addition, the participants had the opportunity of attending the National Conference of Standards Laboratories and a special seminar designed to assist the preparations for the U.N. Conference on Science and Technology for Development (UNCSTD). During the Workshop, papers were presented to exchange standardization experience from each participant's country. (These papers were previously published in NBS SP-543, the report on the UNCSTD seminar.) The presentations of the special evening speakers for the Workshop are featured in this report and also a special contribution by the representative from the Arab Organization for Standardization and Metrology. The other participants were from Argentina, Barbados, Brazil, Guyana, India, Indonesia, Jordan, Kenya, Korea, Pakistan, Panama, Saudi Arabia, Sudan, Tanzania, and Tunisia.

**NBSIR 80-2022. NBS/AID course on weights and measures services, H. S. Peiser, C. C. Raley, A. D. Tholen, and P. M. Odar, Eds., 84 pages (Apr. 1980). Order from NTIS as PB80-187206.**

**Key words:** AID; assistance; developing economies; foreign relations; industrializing nations; international relations; measures; weights; weights and measures.

During the period July 15-27, 1979, a course on weights and measures services was held by the National Bureau of Standards under the sponsorship of AID in Los Angeles, California; Seattle, Washington; and Portland, Oregon. The object of the course was to give weights and measures officials of industrializing nations insight into the weights and measures systems of the United States and the role of the National Bureau of Standards, so that these officials might consider what parts of the U.S. system might usefully be adapted to conditions in their home countries. An exchange of experience in each of the participant's countries was presented by delivered papers which are reproduced here. Countries represented included Egypt, Honduras, India, Liberia, Mexico, Nigeria, Sri Lanka, Sudan, Thailand, and Tunisia.

**NBSIR 80-2027. Measurement techniques for solar cells, Annual report: September 15, 1977 to December 14, 1978, D. E. Sawyer, H. K. Kessler, and H. A. Schafft, 69 pages (July 1980). Order from NTIS as PB80-223134.**

**Key words:** device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cell; solar cell measurements; solar cell stability.

This is a report of work in a program on solar cell measurement technique development and other services which was performed at NBS on September 15, 1977 to December 14, 1978. The objectives of the program are to assist the DOE thin film photovoltaic effort by developing solar cell device and material measurement techniques using the NBS-developed laser flying-spot scanner, by assisting DOE in organizing and hosting appropriate workshops and symposia, and by providing general consultation and liaison service.

A technique was developed which employs forward biasing during laser scanning of the solar cell to reveal defects including cracks, metallization breaks, and regions of metallization not in ohmic contact with the underlying semiconductor. The technique also has provided information useful to cell designers. The experimental results obtained are consistent with predictions made by a first-order theory developed in-house, and by subsequent mathematical modeling performed by the University of Southern California under subcontract. Single-crystal silicon artifacts have been designed to couple laser scanning measurements with mathematical analyses to define quantitatively the capabilities of the laser scanner techniques to detect cell defects and spatial nonuniformities of cell performance.

The laser scanner was designed originally to analyze integrated circuit devices. A number of scanner modifications were made and ancillary apparatus was developed to adapt the scanner for examining solar cells. These modifications include an increase in the specimen area that can be scanned without specimen repositioning, the use of a more efficient means of electronically coupling scanned cells to the display electronics, and the construction of a high-intensity source for light-biasing cells during scanning.

A workshop on Stability of (Thin Film) Solar Cells and Materials was held May 1-3, 1978 at NBS, Gaithersburg, MD. Plans were initiated for a workshop on photovoltaic material and device measurements scheduled to be held in the Washington, D.C. area in the spring of 1979.

**NBSIR 80-2028. Information and guidelines for a proposed laboratory accreditation and product certification program for photovoltaic energy conversion systems, D. B. Thomas, 45 pages (Aug. 1980). Order from NTIS as PB80-217615.**

**Key words:** energy conversion; laboratory accreditation; photovoltaics; product certification; solar collectors; solar energy.

This report provides information and guidelines for use in preparing and implementing a laboratory evaluation and product certificate program for photovoltaic products, as required in the Department of Energy's work plan for the National Photovoltaic Energy Program.

The report presents an overview of the advantages and disadvantages of laboratory accreditation and product certification including economic factors that should be considered for such programs. Detailed information is also provided on the two national programs for accrediting laboratories, the Department of Commerce National Voluntary Laboratory Accreditation Program (NVLAP) and the American Association for Laboratory Accreditation (AALA). Information on the California and Florida state programs for laboratory accreditation and product certification of solar collector systems is given as examples of programs that have been in operation for several years. The organization of these programs and the experience gained by the program administrators may be useful in designing and implementing a program for photovoltaics. Also, accreditation and certification programs which are operated by other Federal and State agencies or professional and trade associations are listed for reference purposes.



A number of steps are presented which need to be taken before any laboratory accreditation and product certification program for photovoltaics can be initiated. These steps include the selection of the photovoltaic products to be certified and the selection of pertinent performance criteria, levels of performance, and test methodology. Once these and other preparatory steps have been taken, a procedure is described to actually implement an appropriate program for photovoltaics.

**NBSIR 80-2029. The thermochemical properties of the uranium-halogen containing compounds.** V. B. Parker, 172 pages (July 1980). Order from NTIS as PB80-204605.

**Key words:** data evaluation; enthalpy; entropy; Gibbs energy; heat capacity; thermochemical tables; uranium-halogen containing compounds.

A detailed analysis and evaluation of the thermochemistry of the uranium-halogen containing compounds is presented, with a tabular summary of the thermochemical properties given. The properties given, where data are available, are in the enthalpy of formation,  $\Delta H_f^\circ$ , Gibbs energy of formation,  $\Delta G_f^\circ$ , entropy,  $S^\circ$ , heat capacity,  $C_p^\circ$ , all at temperature 298.15 K, and the enthalpy of formation at K 0,  $\Delta H_f^\circ$ , and the enthalpy difference,  $H^\circ(298) - H^\circ(0)$ . The values are consistent with the CODATA Key Values for thermodynamics.

The analysis of the uranium-halogen containing compounds includes some vapor pressure equations and  $C_p$  equations. Some thermal functions which are not readily available in the accessible open literature are presented in the Appendix for compounds that required their use.

The tabular summary of  $\Delta H_f^\circ$ ,  $\Delta G_f^\circ$ , includes the values for those uranium compounds which were necessary for this evaluation.

**NBSIR 80-2032. Kinetic and photochemical data for atmospheric chemistry reactions of the nitrogen oxides.** R. F. Hampson, Jr., 94 pages (May 1980). Order from NTIS as PB80-198799.

**Key words:** atmospheric chemistry; chemical kinetics; data evaluation; nitrogen oxides; photoabsorption cross section; photochemistry; quantum yield; rate coefficient.

This report contains 24 individual data sheets for thermal and photochemical reactions of importance in the atmospheric chemistry of the nitrogen oxides. For each reaction the available experimental data are summarized and critically evaluated, and a preferred value of the rate coefficient is given. The selection of the preferred value is discussed and an estimate of its accuracy is given. For the photochemical process the data are summarized, and preferred values for the photoabsorption cross section and primary quantum yields are given. These data sheets were prepared by the author for the evaluation by the CODATA Task Group on Chemical Kinetics to be published in the Journal of Physical and Chemical Reference Data.

**NBSIR 80-2038. Psychological deterrents to nuclear theft: An updated literature review and bibliography.** G. W. Lapinsky, Jr., and C. Goodman, 46 pages (June 1980). Order from NTIS as PB80-197080.

**Key words:** cognitive processes; nuclear weapon theft; perceptual processes; psychological deterrence; security systems; sensory processes.

A review of the unclassified literature dealing with psychological deterrents was conducted for the Defense Nuclear Agency (DNA). The review indicates that while human psychological processes (sensory, perceptual, and cognitive) can be manipulated by various means, definitive empirical data are lacking which directly relate to deterring nuclear weapon theft. Behavioral impact research should be undertaken by DNA to ascertain the deterrence values of the many techniques identified.

**NBSIR 80-2039. A metallurgical evaluation of two AAR M128 steel tank car head plates used in switchyard impact test.** Report No. 10, J. G. Early and C. G. Interrante, 66 pages (May 1980). Order from NTIS as PB81-179483.

**Key words:** AAR M128 steel; Charpy V-notch; head plates; impact properties; nil-ductility transition temperatures; railroad tank cars; switchyard impact tests; tensile properties.

The National Bureau of Standards was requested by the Federal Railroad Administration to correlate the mechanical properties and metallurgical characteristics of two steel head plate samples taken from tank cars (GATX 93412 & UTLX 38498) subjected to switchyard impact tests. This metallurgical evaluation included determining whether the samples conformed with the appropriate specifications and to determine the impact test behavior of both plate samples. The results of check chemical analyses and ambient-temperature tensile tests indicated that both plates met the chemical, tensile strength, and tensile ductility requirements of AAR M128 steel. The results of metallographic analyses of both plates revealed extensive banding with alternate layers of ferrite and pearlite, typical of carbon-manganese steel in the hot-rolled condition. The GATX sample also contained a microstructural anomaly near the inside plate surface, possible related to prior thermo/mechanical processing of the plate. The nil-ductility transition temperatures were determined to be -20 F and -40 F for the GATX and UTLX plates, respectively, similar to the lowest values reported for a group of tank car plate samples. The results of Charpy V-notch tests established that the transition temperatures of these two plates are similar to one another, and are among the lowest of those measured for all other tank car plates tested at NBS. The comparatively low impact transition temperatures for both plates are related to the high manganese-to-carbon ratio and relatively fine ferrite grain size observed in the microstructures.

**NBSIR 80-2040. Recommended practice for measuring life-cycle costs of buildings and building systems.** R. T. Ruegg, S. R. Petersen, and H. E. Marshall, 76 pages (June 1980). Order from NTIS as PB80-203649.

**Key words:** benefit-cost analysis; building economics; buildings; building systems standard; cost; discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice.

Rising prices of labor, material, and particularly energy have forced builders, architects, engineers, building owners and operators, and code writers to identify building designs and building systems that will be cost effective in the long run. This report describes how to measure the life-cycle costs of buildings and building systems. Life-cycle cost analysis, when applied to building decisions, provides an economic evaluation of the net dollar effect, over time, of purchasing, constructing/installing, maintaining, operating, repairing, and replacing buildings or building systems. This recommended practice for making life-cycle cost evaluations will assist the private and public building communities in making cost-effective decisions.

**NBSIR 80-2041. Fluid friction losses in two sets of black steel pipe of recent manufacture.** J. R. Whetstone, 44 pages (May 1980). Order from NTIS as PB80-181811.

**Key words:** friction factor; Hazen-Williams coefficient.

Two sets of black steel pipes have been tested at the National Bureau of Standards (NBS) to determine their frictional loss characteristics. Twenty foot lengths of pipe furnished by the American Iron and Steel Institute ranging from one to three inches nominal pipe size were tested using water in the primary flow measurement facilities at NBS. These facilities use static gravimetric techniques with precision timing to determine flow rates to within  $\pm 13\%$  based upon three standard deviations. Pipe pressure losses were measured using water and mercury



manometers for pipe flow velocities ranging from 4 to 16 feet per second. Frictional loss characteristics of each pipe characterized using the conventional Hazen-Williams formulation at each flowrate.

**NBSIR 80-2045 (DOE). Analysis of erosion-related failure information from coal gasification systems, A. W. Ruff, 39 pages (Mar. 1980). Order from NTIS as PB80-208051.**

**Key words:** cyclones; energy; erosion; metals; pumps; valves; wear.

Failure information reports concerning erosion that are contained in the NBS-DOE Failure Information Center have been analyzed for the purpose of identifying critical and common factors associated with erosion in coal gasification applications. Emphasis was placed on the components most frequently identified in erosion failure reports—piping, valves, pumps, cyclones—and on three of the principal processes. Recommendations are presented on a minimum set of erosion-related information needed to analyze erosion behavior. A brief review of solid particle erosion and several bibliographic references are also included.

**NBSIR 80-2047. Application of fracture mechanics in assuring against fatigue failure of ceramic components, J. E. Ritter, Jr., S. M. Wiederhorn, N. J. Tighe, and E. R. Fuller, Jr., 33 pages (June 1980). Order from NTIS as PB80-213549.**

**Key words:** dynamic fatigue; fracture mechanics; lifetime prediction; proof testing; stress corrosion; subcritical crack growth.

This paper will review the application of fracture mechanics theory to the prevention of delayed failure of ceramics. Three successful applications of this theory of assuring the mechanical reliability of ceramics are discussed in order to demonstrate the viability of the theory for purposes of engineering design. Finally, a description is presented of practical limitations of the theory with regard to heat engine application. Methods of overcoming these limitations through modification of test procedures, and application of statistical theory are then presented.

**NBSIR 80-2049. Emergency egress from mobile homes: Anthropometric and ergonomic considerations, V. J. Pezoldt, 46 pages (May 1980). Order from NTIS as PB80-187321.**

**Key words:** anthropometry; emergency egress; escape behavior; HUD; mobile home; safety; standard; window.

This report summarizes a two task effort which is part of the National Bureau of Standards evaluation of the Federal Mobile Home Construction and Safety Standard. The first task consists of a review of relevant anthropometric data from which egress requirements might be drawn. The second task is an empirical study of egress designed to generate data which can assist HUD in evaluating the existing size requirements for egress devices. The degree to which the requirements in the current standard for location and operating characteristics of egress device latches and other operating mechanisms are acceptable varies for different segments of the population at risk. The limited applicable anthropometric data suggests that the requirements are sufficient for the most part, for average, healthy, normally ambulatory adults. The minimum opening size requirements were also shown to be acceptable for average healthy adults under most conditions tested. However, devices which meet the maximum sill height allowed by the standard were shown to be extremely difficult to negotiate or unusable by a significant portion of the experimental test subjects. Implications of the present egress requirements for escape by handicapped or otherwise impaired individuals are discussed.

**NBSIR 80-2051. NBS/AID/PCSIR survey on standardization and measurement services in Pakistan, H. S. Peiser, T. M.**

**Manakas, and P. M. Odar, Eds., 115 pages (June 1980). Order from NTIS as PB80-199441.**

**Key words:** Agency for International Development; development assistance; industrialization; less developed countries; measurement technology; Pakistan; standardization.

Following similar projects conducted by the National Bureau of Standards in other countries, the Ministry of Science and Technology of Pakistan and under it the Pakistan Council of Scientific and Industrial Research invited NBS to organize a six-man international team of experts in selected topics of metrology to advise on the adequacy and needs for standards and measurement services and to comment upon the plan to establish a new laboratory in Islamabad which would be the primary national standards body under the title of National Physical and Standards Laboratory. This Survey was undertaken with shared funding and guidance from the Government of Pakistan and the U.S. Agency for International Development. The team was composed of specialists from Korea, Sri Lanka, and the United Kingdom, joined by three NBS staff members, and visited industrial, academic, and governmental establishments (Section IV). They were accompanied by a strong Pakistani counterpart team with highest level representation from the PCSIR laboratories under the continuous personal direction of Dr. Abdul Ghani, the PCSIR Chairman. The team strongly endorsed the NPSL plan, having found every indication that a national focal point for good measurements appeared as a critical need for Pakistan's development. A summarizing letter of conclusions and recommendations is reproduced with other recommendations and relative remarks by visiting team members (Section III). For readers not familiar with Pakistan, Sections V and VI give some background on science and technology in Pakistan.

**NBSIR 80-2052. Energy budget procedures and performance criteria for energy conserving building illumination systems, A. T. Hattenburg, J. L. Heldenbrand, D. K. Ross, R. G. Stein, and W. Tao, 121 pages (May 1980). Order from NTIS as PB80-184229.**

**Key words:** building illumination systems; energy budget; energy conservation; energy performance criteria; illumination; lighting; power budget.

This report covers subsystem energy budget development procedures and performance criteria for building illumination which were developed by a consultant team of practitioners experienced in building illumination systems. A general procedure is described wherein the energy required for efficient illumination of a building is examined and corresponding power and annual energy budget guidelines are developed.

This methodology is applied to three classes of building—offices, schools, and residences—to illustrate the method. Representative power and energy budgets are developed.

The model performance criteria and illumination energy budget methodology are recommended as the basis for development of national consensus standards, covering the principal classes of new buildings designed primarily for human occupancy.

**NBSIR 80-2057. The NBS semiconductor technology program and VLSI, W. M. Bullis and R. I. Scace, 10 pages (June 1980). Order from NTIS as PB80-185531.**

**Key words:** Department of Commerce; integrated circuits; metrology for semiconductors; National Bureau of Standards; photomasking; resistivity; second breakdown; semiconductors; test structures; thermal resistance; very large scale integration; VLSI; wire bonds.

The Semiconductor Technology Program at NBS is described briefly; several examples of past successful programs and their significance are given. The work is planned to be expanded significantly beginning in FY 1981. An outline of the present



plans for this expansion to cover the problems of very large scale integration (VLSI) is presented.

Note: This material represents four pages of 30 in a chapter covering the role of the U.S. Government in VLSI development. The book is to include 20 other chapters from authors in both industry and universities, and is provisionally titled "Microstructure Science and Technology/VLSI".

**NBSIR 80-2058 (ONR). Studies of microscopic aspects of wear processes in metals,** A. W. Ruff and P. J. Blau, 79 pages (June 1980). Order from NTIS as PB80-208077.

Key words: copper; electron microscopy; friction; metals; plastic deformation; steel; surfaces; wear; wear debris.

Wear experiments have been conducted in copper alloys and steels under dry sliding conditions in order to study the microscopic aspects of wear and the mechanisms involved. Two experimental wear test systems have been developed: a linear sliding tester and a block-on-ring computer controlled tester. Preliminary findings have compared the wear rates of three different steels, one a high strength-low alloy "dual phase" steel, and two copper-aluminum alloys. Worn surface and subsurface morphologies have been studied using optical and scanning electron microscopy. Wear debris particles have been recovered from the tests and compared in morphological characteristics between the materials. Mechanical properties measurements of two of the steels were carried out to determine strain hardening characteristics for comparison with wear behavior. Micro-hardness measurements have also been made. Initial wear rate and friction transients for tests in laboratory air and argon have been examined to study processes involved in the early stages of sliding.

**NBSIR 80-2060. Drafting test methods for photovoltaic systems,** W. F. Lankford and H. A. Schafft, 19 pages (June 1980). Order from NTIS as PB80-205693.

Key words: consensus standards; measurement technology; photovoltaic energy conversion; photovoltaics; solar cells; test method preparation.

General guidance and a step-by-step procedure are provided as aids in the development of initial drafts of test methods for photovoltaic energy components and systems. It is intended that these drafts will be referred to the appropriate technical committees of organizations writing voluntary consensus standards. This approach is designed to facilitate the expeditious development of consensus test method standards for photovoltaic systems. The procedure is therefore designed to be compatible with the requirements of existing standards organizations.

**NBSIR 80-2061. Measurement techniques for high power semiconductor materials and devices: Annual report, October 1, 1978 to September 30, 1979,** F. F. Oettinger and R. D. Larabee, Eds., 62 pages (Aug. 1980). Order from NTIS as PB80-217623.

Key words: dc transmission; deep-level measurements; energy conservation; measurement methods; neutron transmutation doped silicon; power-device grade silicon; resistivity variations; silicon; spreading resistance measurements; thermally stimulated measurements; thyristor materials measurements; thyristor measurements; zinc oxide varistors.

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. It responds to national needs arising from the rapidly increasing demands for electricity and the present crisis in meeting long-term energy demands. Emphasis is on the development of measurement methods for materials for thyristors and rectifier diodes.

The major tasks under this project are (1) to evaluate procedures for the effective utilization of deep-level measurements to detect and characterize defects which reduce lifetime or contribute to leakage current in power-device-grade silicon, (2) to coordinate standardization activities of preferred procedures for specimen preparation for spreading resistance measurements on thyristor-grade silicon and structures, (3) to determine technical impediments to a more effective utilization of neutron transmutation doped silicon for thyristor production, and (4) to determine the measurement and analysis needs to aid in the application of zinc oxide varistor technology for the manufacture of high voltage limiters for lightning arrester application.

**NBSIR 80-2065. Microprocessor applications and building control systems to achieve energy conservation,** Y. M. L. Chang and J. Y. Shih, 47 pages (July 1980). Order from NTIS as PB80-207848.

Key words: building automation; building controls; building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers.

A well insulated building may be considered a thermally efficient building. However, the systems and controls within the building must also be energy efficient in order to conserve energy. Thus, building controls is an important subject in energy conservation. In recent years, building control engineers have been developing energy conserving control methodologies. The availability of microprocessors and minicomputers has made it possible to apply many control strategies requiring extensive computations. Since a large segment of energy is consumed in buildings, the enhancement of control methodologies will help achieve national energy goals. This report is mainly to investigate the capabilities of microprocessors in building control applications so that requirements to expedite these applications may be developed. Microprocessor applications in both conventional control systems and in local-loop energy conservation devices are examined. In addition, special applications of microprocessors in buildings are explored. The development of microprocessor technology is also discussed.

**NBSIR 80-2068. Review of current calculation procedures for building energy analysis,** T. Kusuda, 61 pages (July 1980). Order from NTIS as PB80-219819.

Key words: calculation procedures; computer simulation; energy analysis; energy conservation.

Existing calculation procedures for building energy analysis, both computer-based and manual, were surveyed by questionnaires to determine the extent to which they were used and their technical content. It was found that most of the Nation's building energy consumption analyses are done by computerized simulation of HVAC system and equipment performance. This report provides brief descriptions of some energy analysis procedures which merit further study. It also identifies items not covered in the existing procedures which need to be developed for the improvement of energy calculation technology.

**NBSIR 80-2070. Second international seminar on human behavior in fire emergencies: October 29-November 1, 1978—Proceedings of seminar,** B. M. Levin and R. L. Paulsen, Eds., 298 pages (June 1980). Order from NTIS as PB80-204738.

Key words: communications; evacuation; fire alarms; fire safety; human behavior; human factors; panic; safety; smoke; symbols.

The safety of building occupants in fire emergencies depends on both the fire protection features of the building and the actions of the occupants. Until recently fire protection experts have relied mainly on experience and intuition regarding the capabilities and actions of building occupants in the develop-



ment of fire protection systems and training programs. Research projects underway can assist the fire protection experts by providing them with needed information to supplement their experience and intuition. This report contains summaries of some of the recent research in this field as reported at an international seminar on the subject. It also contains the invited papers presented at the seminar on the topic of panic.

**NBSIR 80-2071. Breakdown between bare electrodes with an oil-paper interface, E. F. Kelley and R. E. Hebner, Jr., 33 pages (June 1980). Order from NTIS as PB80-226699.**

**Key words:** breakdown; electrical breakdown; impulse testing; interfacial breakdown; oil-paper interfaces; transformer oil.

This report describes experimental measurements of the location of electrical breakdown in a composite insulating system. For these measurements a paper sample was mounted so that it connected the two electrodes. Electrode structures ranging from plane-plane to sphere-sphere were used. The electrode-paper system was tested in oil in an attempt to determine the properties of an oil-paper interface.

The data indicated that in a carefully prepared system the breakdown will not necessarily occur at the interface. In addition, it was found that the breakdown voltages were not significantly lower for those breakdowns which occurred at the interface than for those which did not.

It was noted that if the paper interface was not dried or if many gaseous voids were left in or on the paper, the breakdown will regularly occur at the interface and at a lower voltage.

**NBSIR 80-2072. X-Cal—A calibration system for electrical measurement devices used with diagnostic x-ray units, R. H. McKnight and R. E. Hebner, Jr., 75 pages (June 1980). Order from NTIS as PB80-197478.**

**Key words:** calibration; diagnostic x-rays; electrical measurements; health; radiation; radiation safety; safety; x rays.

The X-CAL high-voltage-divider calibration system was designed to calibrate the direct and alternating voltage measurement capabilities of commercial high voltage dividers used to characterize diagnostic x-ray units. In addition, there is capability for determining the frequency response of these dividers and for the calibration of the filament current and anode current measurement features of specific commercially-available devices. The calibration system combines in a single unit a range of capabilities which allows calibration of a device under test to be accomplished with a minimum of set up time. This report gives a description of the motivation for, the operation of and the design details of the X-CAL system. It lists the specified accuracies and the ranges of applicable parameters of the various subsystems, describes the five different calibrations which can be performed using the X-CAL system, discusses techniques used in the original calibration of the X-CAL system itself, and contains the basic circuit diagrams for the system.

**NBSIR 80-2073. Guidelines for exchangeable APT data packages, B. M. Smith, 17 pages (June 1980). Order from NTIS as PB80-208630.**

**Key words:** APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming.

A method of APT programming and postprocessor design is described which permits more efficient data preparation for numerical control (NC) machine tools and then allows this data to be quickly and easily exchanged among different NC machines. A rigorous specification is made of the APT postprocessor language based upon new ANSI standards for APT and is coupled with a comprehensive definition of the machining functions which should result from the use of each APT language statement. Individual postprocessors are modified to process

each statement in the same manner. Thus, the original intent of the part programmer is always satisfied. A 23% increase in NC manufacturing efficiency is projected. The approach is demonstrated in production by processing a single APT data package on three different milling-drilling type machine tools. This Final Report details the approach taken and the benefits measured.

**NBSIR 80-2073.2. Guidelines for exchangeable APT data packages. APT part programmer's manual, B. M. Smith, 24 pages (June 1980). Order from NTIS as AD-A092929.**

**Key words:** APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming.

A method of APT programming and postprocessor design has been developed which permits more efficient data preparation for numerical control (NC) machine tools and then allows this data to be quickly and easily exchanged among different NC machines. This is accomplished through rigorous specification of the APT post-processor language based upon new ANSI standards for APT plus a comprehensive definition of the machining functions which should result from the use of each APT language statement. Individual post-processors are modified to process each statement in the same manner. The concept was successfully demonstrated in production by processing a single APT data package on three different milling-drilling type machine tools. A 23% increase in NC manufacturing efficiency is projected. This document describes the APT post-processor language used, including the syntax and semantics of each statement. It also defines the default conditions under which the post-processor and machine tool operator accomplish the desired function in the absence of the automatic feature.

**NBSIR 80-2073.3. Guidelines for exchangeable APT data packages. APT postprocessor specifications, B. M. Smith, 15 pages (June 1980). Order from NTIS as AD-A092933.**

**Key words:** APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming; software specifications.

A method of APT programming and postprocessor design has been developed which permits more efficient data preparation for numerical control (NC) machine tools and then allows this data to be quickly and easily exchanged among different NC machines. This is accomplished through rigorous specification of the APT postprocessor language based upon new ANSI standards for APT plus a comprehensive definition of the machining functions which should result from the use of each APT language statement. Individual postprocessors are modified to process each statement in the same manner. This document sets forth minimum specifications for the procurement of APT Post-processors consistent with the standardized postprocessing language concept. It is expected that these specifications will be used in future machine tool procurements. The concept was successfully demonstrated in production by processing a single APT data package on three different milling-drilling type machine tools. A 23% increase in NC manufacturing efficiency is projected.

**NBSIR 80-2075. In situ oxidation of  $Y_2O_3$ -doped  $Si_3N_4$ , N. J. Tighe, K. Kuroda, T. E. Mitchell, and A. H. Heuer, 11 pages (Aug. 1980). Order from NTIS as PB80-218191.**

**Key words:** ceramic; high voltage electron microscopy; *in situ*; oxidation; silicon nitride; yttria-doped silicon nitride.

Specimens of  $Y_2O_3$ -doped  $Si_3N_4$  were oxidized in an environmental cell in a 600 kV electron microscope. This ceramic oxidizes passively at temperatures greater than 1000 °C but oxidizes catastrophically at ~750 °C. The *in situ* experiments showed that oxidation occurs by nucleation and growth of  $SiO_2$  and  $Si_2N_2O$  on the  $\beta Si_3N_4$  surfaces and by volatilization of W



inclusions. The paper discusses the HVEM methodology and the oxidation results.

**NBSIR 80-2076. Expanded NBSLD output for analysis of thermal performance of building envelope components, S. R. Petersen and J. P. Barnett, 103 pages (July 1980). Order from NTIS as PB80-224330.**

**Key words:** building design; computer analysis; energy conservation; HVAC loads; thermal insulation; thermal performance.

The NBS Load Determination Program (NBSLD) for the calculation of space heating and cooling loads in buildings is a potentially useful tool for the improved thermal design of building envelopes. However, its usefulness is limited because only the net heating and cooling loads are determined. In order to design building envelopes which are to be, from inception, more energy efficient than existing buildings, the thermal performance of the individual envelope elements (e.g., walls, windows, ceilings and floors) must be known and the interrelationships among these components understood. NBSLD-XO is an expanded output version of NBSLD which provides this data on an hourly, daily, monthly and/or annual basis. This report outlines the NBSLD-XO program, format, and output and provides several examples of its use based on a prototypical single-family residential building. A considerable amount of information about the thermal performance of the various envelope elements and their interrelationships is provided as exemplary of the use of the NBSLD-XO computer program.

**NBSIR 80-2077. Development of recommended test method for toxicological assessment of inhaled combustion products, M. M. Birky, M. Paabo, B. C. Levin, S. E. Womble, and D. Malek, 63 pages (Sept. 1980). Order from NTIS as PB81-110884.**

**Key words:** combustion; fatality ( $LC_{50}$ ); hydrogen cyanide; incapacitation; inhalation; test method; toxicology.

The objective of the project supported by PRC was to develop a test method for measuring the toxicity of combustion products from polymeric materials including cellular plastics. The development of such a test procedure was considered an essential first step to determine the hazard to life when cellular plastics are involved in fire.

As a result of this work, a test procedure was developed. It consists of 3 major elements; (1) combustion system, (2) chemical analysis system and (3) animal exposure system. Two biological endpoints obtained from the exposure are: (1) incapacitation in 30 minute exposure period, and (2) lethality in 30 minutes plus 14 days post exposure.

The test apparatus has been evaluated to determine mixing rates and loss of reactive chemicals in the exposure chamber. In addition, a statistical evaluation of the experimental results demonstrated that order of incapacitation was independent of animal location.

Evaluation of a limited number of different materials that produce different toxicological syndromes has demonstrated the utility of all 3 endpoints. Two natural polymers (wood and wool) and 2 synthetic materials (modacrylic and PTFE) have been studied in detail. In addition, preliminary data have been obtained on a flexible polyurethane foam (CM-21).

**NBSIR 80-2078. The NBS gage block calibration process using a measurement assurance program, C. D. Tucker, 9 pages (June 1980). Order from NTIS as PB80-200132.**

**Key words:** check standard; gage blocks; measurement assurance; random errors; standard deviation; systematic errors; uncertainty.

The calibration method for gage blocks, employing a measurement assurance program, is described for the user of an NBS calibration report. The various parameters and their significance to the calibration process are discussed.

**NBSIR 80-2079. An economic analysis of efficiency improvements to residential gas- and oil-fired central heating equipment, S. R. Petersen and G. E. Kelly, 55 pages (July 1980). Order from NTIS as PB80-212749.**

**Key words:** boilers; central heating equipment; economic analysis; furnaces; incremental savings; life-cycle costs; minimum efficiency levels; minimum efficiency standards.

Minimum performance standards for new residential gas- and oil-fired furnaces and boilers will be promulgated by the Department of Energy in the early 1980's. These standards will implicitly require that a number of design modifications be made to improve the seasonal efficiency of many basic furnace/boiler configurations. This report examines the potential improvement in seasonal efficiency due to a number of such modifications, as well as their life-cycle cost effectiveness. Included in the analysis are intermittent ignition devices (for gas-fired equipment), improved heat exchangers, stack dampers, external venting (with preheated air), and improved blower motor efficiencies (for forced-air furnaces). NBS DEPAF simulation data, the DOE/NBS furnace and boiler test procedures, current estimates of modification costs, and a wide range of annual heating requirements and fuel costs are used in the analysis. Minimum efficiency criteria for new furnaces and boilers are developed, based on the estimated performance of current configurations representative of lower efficiency models, upgraded with those energy-saving modifications which are generally cost effective and can be implemented without serious disruption in the industry.

**NBSIR 80-2082. NBS: Materials measurements, J. R. Manning, 117 pages (July 1980). Order from NTIS as PB80-223159.**

**Key words:** Auger measurements on liquids; convection; gallium; heat capacity; lead-tin alloys; magnetic field effect; phase diagram; potassium-iron-silicon oxides; solidification; surface tension; thermodynamic properties.

The report describes NBS work for NASA in support of NASA's Materials Processing in Space Program covering the period April 2, 1979 to April 1, 1980.

The results obtained are given in detailed summaries in the body of the report. Briefly, in Task 1—Surface Tensions and Their Variations with Temperature and Impurities—measurements in an Auger spectrometer of surface impurity concentrations on liquid gallium showed that the principle impurities were oxygen and carbon. The impurities showed a tendency to collect into plates or clumps. In Task 2—Solutal Convection During Directional Solidification—in Pb-rich Pb-Sn off-eutectic alloys, macrosegregation caused by solutal convection was not reduced by vertical or horizontal fields of 0.1T, but downward solidification (liquid below solid) virtually eliminated macrosegregation in small (~3 mm) diameter samples. In Task 3—A Thermochemical Study of Corrosive Reactions in Oxide Materials—phase assemblages of selected compositions on the joins  $K[Fe_{0.5}Si_{0.5}]$   $O_2$ - $SiO_2$  and  $KFeO_2$ - $SiO_2$  were determined over a large range of oxygen partial pressures and the temperature range 800 °C to 1400 °C. In Task 4—Thermodynamic Properties of Refractory Materials at High Temperatures—use of pyroelectric detectors to determine the radiant heat loss from spherical samples as cooling occurs in free-cooling experiments is being investigated.

**NBSIR 80-2083. Development of in-situ techniques for the detection and measurements of corrosion of copper concentric neutrals in underground environments, J. Kruger, U. Bertocci, E. Escalante, and J. L. Mullen, 136 pages (June 1980). Order from NTIS as PB81-101800.**

**Key words:** corrosion; corrosion noise; electrochemistry; polarization techniques; underground corrosion.

This is a final report on the Development of In-Situ Techniques for the Detection and Measurement of Corrosion of



Copper Concentric Neutrals in Underground Environments which collects all of the papers written for the project. The titles of the papers included are: 1) Final Technical Report on the Development of In-Situ Techniques—Underground Environments; 2) Electrochemical and Corrosion Studies on Copper Concentric Neutral Wires; 3) Laboratory Corrosion Studies on Tinned Copper Concentric Neutral Wires; 4) Corrosion Induced by an Alternating Voltage. A Comparison between Theoretical Predictions and Experimental Results; 5) Detection and Analysis of Electrochemical Noise for Corrosion Studies; 6) Applications of a Low-Noise Potentiostat in Electrochemical Measurements; 7) A Low-Noise Potentiostat for the Study of Small Amplitude Signals in Electrochemistry; 8) Corrosion Enhancement Due to Large Voltage Modulations. Frequency Analysis of the Response of Electrodes Under Charge-Transfer Control; 9) Studies of Passive Film Breakdown by Detection and Analysis of Electrochemical Noise; 10) A Field Study on the Corrosion of Concentric Neutral Cable; 11) AC Induced Corrosion. The Effect of an Alternating Voltage on Electrodes Under Charge-Transfer Control.

**NBSIR 80-2085. Fire performance of loose fill cellulosic insulation in residential occupancies—A progress report, L. A. Issen, 52 pages (Aug. 1980). Order from NTIS as PB80-224835.**

Key words: activation energy; borax; boric acid; cellulose; critical radiant flux; fire; fire retardants; fire tests; loose fill insulation; smoldering ignition; thermal analysis; thermal insulation.

The smoldering and flame spread properties of cellulosic loose fill insulation were examined as a function of retardant type, particle size, and concentration to provide a basis for the development of improved fire test methods. A series of laboratory insulations was prepared whose fire performance covered an extended range of critical radiant flux in the attic floor radiant panel test and weight loss in the cigarette smoldering test. These materials were evaluated in a recessed light fixture test in a simulated attic configuration. Borax and boric acid were effective in raising the critical radiant flux (CRF) in the attic floor radiant panel test, but borax alone, in the cigarette smolder test, increased the smoldering potential of loose fill cellulosic insulation. The divided box test for smoldering propagation appears to be a more realistic test than the present test for smoldering ignition.

In the cigarette smoldering test, inclusion of 10% borax increased the boric acid requirement for passing from 7.5% to 20%. In the attic floor radiant panel test, the finer the grind, the less boric acid required to meet Federal Specification HH-I-515D. This varied from less than 10% for vapor applied boric acid to over 35% for granular boric acid. Above the 25% level the presence of borax did not significantly affect the CRF level. Passing the recessed light fixture test required a minimum of 30% impalpable boric acid, or 40% to 50% intermediate grind boric acid.

In order to determine fundamental parameters which could be used to characterize smoldering ignition potential, a number of test methods have been investigated which can be used to determine the pre-exponential factor and the activation energy of ignition reaction. These include the Bowes and Townshend hot plate, thermo-gravimetric analysis (TGA), and the adiabatic furnace.

**NBSIR 80-2086. An assessment of an experiment in accelerating the development of nuclear standards, J. P. Woodward and S. D. Garrity, 153 pages (June 1980). Order from NTIS as PB80-202104.**

Key words: administrative experimentation; evaluation; Experimental Technology Incentives Program; nuclear regulatory standards; regulatory experimentation.

As part of its program on regulatory experimentation, the Experimental Technology Incentives Program conducted a

project with the Nuclear Regulatory Commission on accelerating the standards development process. This report assesses the execution and outcomes of the project with a specific focus on whether further work is needed on the project and on how to improve future experimental designs. The report includes sections on agency and project background, project initiation, project plans, what actually happened, what was learned about the standards development process, and factors to consider in the design of other experiments.

**NBSIR 80-2087. Testing flat-plate water-heating solar collectors in accordance with the BSE and ASHRAE procedures, J. P. Jenkins and J. E. Hill, 82 pages (Aug. 1980). Order from NTIS as PB81-104770.**

Key words: instantaneous efficiency; optical efficiency; solar collectors; thermal losses; thermal performance testing.

Five solar collectors were tested according to the BSE and ASHRAE test procedures and the results compared. All five collectors tested were modular, flat-plate, and water-heating, and included single- and double-glazed designs with and without selectively-coated absorbers. In both procedures, collector efficiency curves are determined. 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's optical and thermal loss characteristics, respectively. During the indoor testing in this study, the environmental test conditions were controlled and regulated by use of specially-built environmental simulators to investigate the effect of wind and "sky" temperature on the thermal loss characteristics of the collectors. The simulators provided stable, uniform wind speeds in the range of 0 to 7.1 m/s across the collectors and "sky" temperatures above the collector ranging from  $t_a$  (ambient air temperature) to  $t_a - 19$  °K.

**NBSIR 80-2090. Estimating the heating seasonal operating cost of residential hybrid heat pump systems, including units retrofitted to oil, gas and electric furnaces, P. Domanski and G. E. Kelly, 43 pages (July 1980). Order from NTIS as PB80-223142.**

Key words: add-on heat pumps; furnaces; heat pumps; hybrid heat pumps; hybrid systems; rating procedure; seasonal cost of operation.

A method is presented for estimating the heating seasonal operating cost of a residential, hybrid heating system consisting of an electric heat pump and a warm-air furnace. The approach described is applicable to a heat pump/control system/gas or oil-fired furnace which is sold as a package or to a heat pump/control system which is intended to be added to an existing gas, oil or electric furnace. Recommendations are made regarding how such systems can be rated and the type of information that would assist consumers in comparing the operating cost of a hybrid heat pump system with that of a conventional heat pump or furnace. Different control strategies are accounted for and examples are presented (in the appendix) for estimating the heating seasonal operating cost of hybrid systems employing both single and two-speed compressors.

**NBSIR 80-2093. Analysis of computer-simulated thermal performance of the Norris Cotton Federal Office Building, W. B. May, Jr., and L. G. Spielvogel, 65 pages (Nov. 1980). Order from NTIS as PB81-131922.**

Key words: building models; building performance data; computer simulations; building; energy conservation in commercial buildings; heat pumps; validation of computer models, buildings.

Five computer-based simulations of the Norris Cotton Federal Office Building (NCFOB) in Manchester, New Hampshire, were performed using the Ross Meriwether Energy Systems



Analysis Program. The NCFOB is a medium-size office building, occupied in September 1976, designed to serve as a demonstration of and feasibility test for energy-conserving building features. The simulations included two simulations in accordance with the original design—with and without a solar system; a simulation of the building as actually operated; a simulation of the building with modifications to actual operation; and a simulation of an alternative building design. Results of the five simulations are compared with each other and with actual measured data at several levels of detail, including total energy consumption, consumption by fuel type, and heating and cooling requirements. Good agreement between the simulation and actual data is demonstrated, and consequences of design features are discussed.

**NBSIR 80-2097. Full-scale fire tests with automatic sprinklers in a patient room. Phase II, J. G. O'Neill, W. D. Hayes, Jr., and R. H. Zile, 91 pages (July 1980). Order from NTIS as PB80-224298.**

**Key words:** clothing wardrobes; health care facilities; hospitals; mattresses; smoke movement; sprinkler systems.

The Center for Fire Research conducted a series of full-scale fire tests in a patient room and corridor arrangement to examine the use of automatic sprinklers in patient rooms of health care facilities. This is a report of twenty-one (21) fire tests in which either mattresses with bedding or clothing wardrobes served as the burning items.

Test results indicated that actuation of both pendant and horizontal sidewall sprinklers in the patient room acted to cool and redistribute the combustion products in the patient room and in the corridor away from the flowing sprinkler. This phenomena resulted in total obscuration throughout the test area. It was demonstrated that the use of a fast response, (low thermal inertia) sprinkler resulted in significantly less smoke obscuration in the mattress and bedding fires.

Sprinkler spray distribution measurements were made to develop criteria for the position of privacy curtains with respect to the automatic sprinklers in the patient room. Recommended installation criteria are provided.

Analysis of the test results indicated that the combustible clothing wardrobe fire resulted in room flashover in a non-sprinklered test. In several tests with sprinklers, flashover did not occur, however, estimated hazardous thresholds for carbon monoxide were still exceeded in the test area. It was determined that the combustible construction of the wardrobe primarily contributed to the high concentrations of carbon monoxide.

**NBSIR 80-2099-1. Testing geothermal-well cements: Strength measurements following hydrothermal exposures, R. F. Krause, Jr., and E. R. Fuller, Jr., 15 pages (July 1980). Order from NTIS as PB80-219785.**

**Key words:** cement; compressive strength; geothermal well; hydrothermal exposure; splitting-tensile strength.

Laboratory data were obtained for the compressive and tensile strength of some candidate cements for geothermal wells after they were exposed to water at a temperature of 195 °C and a pressure of 17 to 21 MPa for various periods. Some of these cements were being considered for use in the remedial cementing of a hot-dry-rock well at Los Alamos Scientific Laboratory. The shear-bond strength to steel of the prime candidate for this remedial cementing was also examined. The methods used are preliminary to a standard property verification program, now being developed at the National Bureau of Standards.

**NBSIR 80-2099-2. Testing geothermal-well cements: Standard practice, R. F. Krause, Jr., and E. R. Fuller, Jr., 25 pages (July 1980). Order from NTIS as PB80-219801.**

**Key words:** compressive strength; exposure to geothermal fluids; geothermal-well cements; permeability to water; shear-bond strength to steel; splitting tensile strength.

The National Bureau of Standards is under contract with the U.S. Department of Energy to verify certain properties of cementing materials which are submitted as candidates for use in the finishing operations of geothermal wells. Specimens will be set-cured in molds under water for two days at elevated temperature and pressure. Subsequently, specimens will be exposed demolded to light and heavy simulated geothermal fluids for periods of one week or one month. Following each of these treatments, the following properties will be measured at room temperature and pressure: compressive strength, splitting tensile strength, shear-bond strength of the cement-steel interface, and cement permeability to water. Upon the basis of this survey of properties at room temperature, a priority of cementing materials will be established for further testing of select physical properties while the specimens are at elevated temperature and pressure.

**NBSIR 80-2099-3. Testing geothermal-well cements: High temperature, high pressure, and fluid handling facility, R. F. Krause, Jr., and E. R. Fuller, Jr., 12 pages (July 1980). Order from NTIS as PB80-219793.**

**Key words:** geothermal-well cements; high pressure vessel; high temperature furnace; permeability; shear-bond strength; simulated geothermal fluids.

Construction of a high temperature, high pressure, and fluid handling facility, which includes four pressure vessels of Hastelloy alloy C, has been completed. The facility allows set cements to be exposed to simulated geothermal fluids at pressures up to 60 MPa (8700 psi) and at temperatures up to 400 °C. Two of these pressure vessels are equipped for measuring either the shear-bond strength of the cement-steel interface or the cement permeability to water at elevated temperatures and pressures. In addition, there is a fifth pressure vessel of stainless steel 316 which can be used for set-curing cements in molds under water at pressures up to 21 MPa (3000 psi) and at temperatures up to 340 °C.

**NBSIR 80-2100. Thermal resistance measurements of a built-up roof system, S. J. Treado, 28 pages (Oct. 1980). Order from NTIS as PB81-140063.**

**Key words:** built-up roofs; measurement technology; moisture accumulation; nondestructive tests; thermal resistance.

This report describes factors which affect the thermal performance of built-up roof systems, and a technique for making in-place measurements of thermal resistance. This measurement technique utilizes a combination of infrared thermographic imaging, surface heat-flow meters, and surface thermopiles. The thermal resistance of the roof system is computed based on temperature differences across the roof and the measured heat flow through the roof.

A field test of the measurement procedure is detailed, along with an examination of the time period required to perform a roof thermal resistance measurement, as related to the thermal time lag for heat flow through the roof due to the effect of the thermal mass of the roof.

Roof thermal resistance determinations performed according to this measurement procedure are found to be very accurate, if measurements are performed over a sufficient time interval, the minimum interval being dependent upon the thermal mass of the roof system.

**NBSIR 80-2101 (Navy). Passive films, surface structure and stress corrosion and crevice corrosion susceptibility, J. Kruger, J. J. Ritter, J. J. Carroll, and A. J. Melmed, 50 pages (Aug. 1980). Order from NTIS as PB81-103368.**

**Key words:** chromate; electrochemistry; ellipsometry; field ion microscopy; hydrogen; inhibitors; iron; organic coatings; titanium-palladium alloys; vanadium.



**PART I:** A feasibility study has shown that qualitative-ellipsometry combined with electrochemical-pH and potential measurements comprise valuable techniques for the study of the corrosion of iron protected by an organic coating. A simulated painted metal system using cellulose nitrate over iron and immersed in dilute  $\text{Cl}^-$  medium showed a concomitant rise of subcoating pH to high values ( $\sim 14$ ) and a thickening of the metal oxide film. These processes could be modified by the presence of a chromate inhibitor under the coating.

**PART II:** Three titanium-palladium alloys, nominally containing 1, 2, and 3 at. % palladium were prepared and imaged in the field ion microscope at temperature less than 30 K. Although significant alloy inhomogeneities occurred in the wire preparations, the results indicated that the alloys offered no greater resistance to hydrogen/stress induced crack formation and development than unalloyed titanium under similar conditions.

Field ion micrographs of 99.9+ percent pure vanadium showed surfaces having significant short-range disorder, an effect that might be due to imageable impurities. Experiments demonstrated that improved surface order is gained in the top-most layers by exposing specimens to hydrogen imaging conditions at temperatures less than 30 K. This hydrogen treatment leaves the ordered vanadium surfaces free of defects.

**NBSIR 80-2105. Air leakage measurements of an unpartitioned mobile home.** S. Silberstein, 27 pages (Aug. 1980). Order from NTIS as PB80-226707.

Key words: air leakage measurements; environmental chamber; fan depressurization; mobile home; sulfur hexafluoride; tracer gas.

Air exchange rates,  $I(\text{h}^{-1})$ , of an unpartitioned mobile home were measured at various indoor-outdoor temperature differences,  $\Delta T(\text{K})$ , using  $\text{SF}_6$  tracer in an environmental chamber, and found to be lower than for conventional buildings but similar to other mobile homes. There was little scatter from the regression equation  $I = 0.0182 + 0.0118 |\Delta T|$ , with relative standard errors of the first and second coefficients of 62 and 2.5%, respectively.

A fan depressurization experiment was also performed, and yielded a flow coefficient of  $C = 1.64 \times 10^{-4} \text{ m}^3/\text{s} \cdot \text{Pa}^{0.65}$ , which is also comparable to that of a previously measured mobile home. It was further found that: (1) For  $I = 0.24 \text{ h}^{-1}$ , no  $\text{SF}_6$  could be detected in the environmental chamber even after five hours, but when  $I = 9 \text{ h}^{-1}$  for more than five minutes, the tracer gas method could not be used accurately in the environmental chamber even with exhaust fans operating; (2) The standard error is useful for monitoring whether sufficient concentration measurements were taken at each step; (3) An air bag sampling technique appeared as good as the conventional monitoring method for determining infiltration rate; (4) Reported intercepts of regression equations vary greatly from building to building, and it may be difficult to analyze the significance; (5) The possibility that  $I = 0 \text{ h}^{-1}$  at  $\Delta T = 0 \text{ K}$  cannot be excluded.

**NBSIR 80-2107. Mathematical modeling of fires.** R. S. Levine, 45 pages (Sept. 1980). Order from NTIS as PB81-110520.

Key words: fire; fire engineering; fire safety; mathematical modeling; modeling application.

This presentation has three technical parts, and ends with audience participation and recommendations. First, a brief discussion of fire growth in a compartment is presented, showing why we need full scale tests, or a mathematical model adequately simulating such growth. The second part of the talk describes what several Federal agencies and their grantees are doing to bring about the necessary engineering and mathematical capability for this modeling. The third part illustrates some problems that may be of interest to fire protection engineers that can be solved relatively simply by using fragments of the modeling capability now available.

Then a discussion was held with the audience to determine modeling needs. Should we provide a series of simple models, each applicable to a limited range of problems, or a major comprehensive model, accessible from a computer terminal, that will solve a very wide range of problems? The audience decided both were needed.

**NBSIR 80-2109. A basis for traceable NDE measurements.** D. G. Eitzen, H. Berger, and G. Birnbaum, 17 pages (Dec. 1980). Order from NTIS as PB81-145757.

Key words: acoustic emission; calibration; eddy currents; magnetic particles; nondestructive evaluation; radiography; traceability; ultrasonics; visual testing.

The National Bureau of Standards is beginning to provide a mechanism for traceability for a number of NDE measurement procedures, an activity that is expected to have a significant, positive impact on the reproducibility and accuracy of NDE measurements. Much of the NDE standards activity has been in ultrasonics and acoustic emission, these efforts leading to calibration services for ultrasonic reference blocks and ultrasonic and acoustic emission transducers. Additional NDE standards are also available or are being developed in radiography, eddy currents, magnetic particles, liquid penetrants and visual testing.

**NBSIR 80-2111-2. Review and refinement of ATC 3-06 tentative seismic provisions. Report of technical committee 2: Structural design.** J. R. Harris, 91 pages (Oct. 1980). Order from NTIS as PB81-111759.

Key words: building; building codes; building design; earthquakes; engineering; standards; structural engineering.

The TENTATIVE PROVISIONS FOR THE DEVELOPMENT OF SEISMIC REGULATIONS FOR BUILDINGS were developed by the Applied Technology Council to present, in one comprehensive document, current state-of-knowledge pertaining to seismic engineering of buildings. The TENTATIVE PROVISIONS are in the process of being assessed by the building community. This report is one of a series of reports that documents the deliberations of a group of professionals jointly selected by the Building Seismic Safety Council and the National Bureau of Standards and charged with reviewing the TENTATIVE PROVISIONS prior to the conduct of trial designs. The report contains the recommendations and records of the committee charged with review of the general structural design and analysis provisions. The committee made 27 recommendations for revisions to the TENTATIVE PROVISIONS and five additional recommendations concerning subsequent activities, such as the conduct of trial designs. These recommendations were made to the parent group, the Joint Committee on Review and Refinement, and their action on these recommendations is documented in a companion report.

**NBSIR 80-2111-9. Review and refinement of ATC 3-06 tentative seismic provisions. Report of technical committee 9: Regulatory use.** J. H. Pielert and P. W. Cooke, 70 pages (Oct. 1980). Order from NTIS as PB81-111742.

Key words: building; building codes; building design; disaster mitigation; earthquakes; engineering; standards.

The TENTATIVE PROVISIONS FOR THE DEVELOPMENT OF SEISMIC REGULATIONS FOR BUILDINGS were developed by the Applied Technology Council to present, in one comprehensive document, current state-of-knowledge pertaining to seismic engineering of buildings. The TENTATIVE PROVISIONS are in the process of being assessed by the building community. This report is one of a series of reports that documents the deliberations of a group of professionals jointly selected by the Building Seismic Safety Council and the National Bureau of Standards and charged with reviewing the TENTATIVE PROVISIONS prior to the conduct of trial designs. The report contains the recommendations and records of



the committee charged with review of the regulatory implementation and enforcement aspects of the provisions. The committee made two recommendations for revisions to the TENTATIVE PROVISIONS and five additional recommendations concerning subsequent activities, such as the conduct of trial designs. These recommendations were made to the parent group, the Joint Committee on Review and Refinement, and their action on these recommendations is documented in a companion report.

**NBSIR 80-2112. Explosion containment for underground coal mine equipment: A bibliography, C. A. Wan and E. Braun, 31 pages (Aug. 1980). Order from NTIS as PB80-224843.**

Key words: bibliography; coal mines; electrical equipment; enclosures; explosion; explosion containment; mine safety.

This is a bibliography of publications concerning explosion-proof enclosures with the emphasis on underground coal mine applications. A survey of the literature primarily in English speaking countries through 1974 is compiled. The compilation includes over 200 citations. An author and key word index is included for cross reference.

**NBSIR 80-2114. Fire research publications, 1979, N. H. Jason, 20 pages (Aug. 1980). Order from NTIS as PB81-103335.**

Key words: bibliographies; building fires; cable fires; compartment fires; decision analysis; fabric flammability; fire suppression; fire tests; flame research; smoke detectors; toxicity.

"Fire Research Publications, 1979" 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. PB284462; 1978 NBSIR 79-1745, NTIS Order No. PB-295395.

Only publications prepared by members of the Center for Fire Research (CFR), by other National Bureau of Standards (NBS) personnel or external laboratories under contract or grant from the CFR are cited. Articles published in NBS house organs also are cited.

**NBSIR 80-2115. Prospectus for data dictionary system standard, Application Systems Division, 20 pages (Sept. 1980). Order from NTIS as PB80-225204.**

Key words: computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; software.

A Data Dictionary System is an automated information system to assist in organization-wide data management, without restriction to computer data. This report describes NBS effort to develop a Federal Data Dictionary System standard. It discusses the scope and purpose of the standard, the intended audience, general issues being investigated, and the basic project approach.

**NBSIR 80-2116. Dimensional considerations in solar installations, H. J. Milton, 154 pages (Sept. 1980). Order from NTIS as PB81-106312.**

Key words: dimensions; flat plate collectors; preferred sizes; solar installations; standardization.

The Interim Report contains a study of dimensional considerations in solar installations using non-integrated flat plate collectors. Special attention is given to sizes of collectors and their constituent materials, to dimensions that affect the collector array, and to sizes for thermal storage tanks.

One of the aims of the investigation was to assess the scope for future standardization of collector sizes and their configurations, with the object to facilitate the processes of collector

design, production and distribution, system design, installation, operation, and maintenance. An additional aspect was to assess the potential impacts of a change to metric units and product sizes in U.S. industry.

The report deals principally with a listing and evaluation of dimensional data for 185 flat plate collectors in production and/or use in 1978, (141 liquid, 37 air, and 8 special types), produced by 152 manufacturers. Measured sizes cover a wide range of width/length combinations, but some preferred sizes can be observed. Solar water heaters have followed standardization patterns of hot water tank manufacturers. The report suggests that greater standardization of solar systems and components is feasible, and points to some benefits that would result. The report also contains recommendations for follow-up and future investigations.

The Interim Report is intended to provide an overview of trends in the industry in 1978/79, and not an evaluation of individual commercially available components.

**NBSIR 80-2117. Probabilistic assessment of tornado-borne missile speeds, E. Simiu and M. R. Cordes, 86 pages (Sept. 1980). Order from NTIS as PB81-128431.**

Key words: engineering; missiles; structural engineering; tornadoes; wind.

A procedure was developed for estimating speeds with which postulated missiles hit any given set of targets in a nuclear power plant or similar installation. Hit speeds corresponding to probabilities of occurrence of  $10^{-7}$  were calculated for a given nuclear power plant under various assumptions concerning the magnitude of the force opposing missile take-off, direction of tornado axis of translation, number and location of missiles, and size of target area. The results of the calculations are shown to depend upon the parameters:  $C_D A/m$ , where  $C_D$  = drag coefficient,  $A$  = projected area,  $m$  = mass of missiles, and the ratio,  $k$ , between the minimum aerodynamic force required to cause missile take-off, and the weight of the missile.

**NBSIR 80-2118. Tables of rate constants for gas phase chemical reactions of sulfur compounds (1971-1979), F. Westley, 60 pages (July 1980). Order from NTIS as PB81-105074.**

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, cyc-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 16 unimolecular, 187 bimolecular, and 11 termolecular reactions totalling 214 distinct chemical reactions. There are 348 distinct entries, distributed as follows: 26 for first order reactions, 294 for second order reactions and 28 for third order reactions. The kinetic data were compiled from 109 experimental papers and 6 critical reviews published between 1970 and 1979.

**NBSIR 80-2119. State-of-the-art summary of incentives for residential water conservation, J. Elder, 38 pages (Oct. 1980). Order from NTIS as PB81-115958.**

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 home-



owner 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. Fire development in residential basement rooms,** J. B. Fang and J. N. Breese, 98 pages (Oct. 1980). Order from NTIS as PB81-141509.

**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,  $3.3 \times 3.3 \times 2.4$  m and  $3.3 \times 4.9 \times 2.4$  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 80-2123. Need for economic information on standards used in regulatory programs: Problems and recommendations,** M. Breitenberg, 62 pages (Sept. 1980). Order from NTIS as PB81-115784.

**Key words:** economic impact of regulations; economic impact of standards; economic information on standards; Federal use of voluntary standards; procedural history; rationale; standardization.

A number of government regulatory agencies are increasing their use of standards developed by the private sector. Federal regulators are, however, being required to provide increasing justification for their regulations, especially information on their economic desirability. If regulators are to effectively use voluntary standards in their regulations rather than develop standards in-house, they will need the same types of economic information on the voluntary standards as they would have on their in-house standards. This paper describes the types of requirements and pressures that regulatory agencies are faced with in justifying their actions, and provides standards writers with guidelines on the types of economic information that may allow regulators to make greater use of voluntary standards.

**NBSIR 80-2124. Slag characterization: Viscosity of synthetic coal slag in steam,** W. S. Brower, J. L. Waring, and D. H. Blackburn, 33 pages (Oct. 1980). Order from NTIS as PB81-115990.

**Key words:** coal gasification; coal slag; high temperature; steam; viscosity.

A rotating cylinder apparatus has been designed and constructed for measuring the viscosity of molten slags under steam pressure in the range 15 to ~300 psi and up to about 1400 °C.

Two synthetic coal slags, one high in alkali and the other lower in alkali but higher in calcia were studied with this apparatus. In the high alkali slag, equilibrium was probably not achieved and the viscosity appeared to increase with time. In the low alkali slag, although the viscosity appeared to be increased with increasing steam pressure, the ambient and higher pressure curves appear to tend to coalesce with increasing temperature.

**NBSIR 80-2127. Fourth annual conference on fire research,** I. M. Martinez and S. M. Cherry, Eds., 159 pages (Oct. 1980). Order from NTIS as PB81-110447.

**Key words:** chemistry of fire; combustion products; detection; fire hazards; fire modeling; fire protection; fire research; fire suppression; human behavior in fires; physics of fire; toxicity of combustion products.

This report contains descriptions of the internal programs of the Center for Fire Research as well as extended abstracts of grants and contracts sponsored by the Center for Fire Research, National Bureau of Standards.

**NBSIR 80-2128. The NBS energy model assessment project: Summary and overview,** S. I. Gass, K. L. Hoffman, R. H. F. Jackson, L. S. Joel, and P. B. Saunders, 42 pages (Sept. 1980). Order from NTIS as PB81-105082.

**Key words:** assessment; documentation; energy; forecasting; mathematical models; sensitivity analysis.

This report is a summary of the activities and technical reports for the Energy Model Validation Procedure Development project undertaken by the Operations Research Division for the Department of Energy, using DOE's Midterm Oil and Gas Supply Modeling System (MOGSM) as a test vehicle. The reports cover: (1) assessment of the documentation of MOGSM; (2) analysis of (a) the model methodology, (b) characteristics of the input and other supporting data, (c) statistical procedures undergirding construction of the model, and (d) sensitivity of the outputs to variations in input; as well as (3) guidelines and recommendations for the role of these in model building and developing procedures for their evaluation.

**NBSIR 80-2129. Modeling for determination of temperatures of electrical cables within thermally insulated walls,** D. D. Evans, 29 pages (Oct. 1980). Order from NTIS as PB81-113847.

**Key words:** electric wiring; resistive heating; thermal insulation; thermal model; wiring system.

Models have been developed to predict the temperature rise caused by resistive heating of a current-carrying electric cable within an insulated wall cavity, with emphasis on simplified models to minimize computation time. Predictions are compared to measurements performed on an AWG-12 2-G NM cable installed in a laboratory wall space mock-up. Results of the two-dimensional model are within 15 percent of the measured temperatures. The heat sink effect of the wood studs within the wall on the temperature rise of the section of cable passing through them is demonstrated both with experiment and calculation.

**NBSIR 80-2130. A survey of field experience with smoke detectors in health care facilities,** R. W. Bukowski and S. M. Istvan, 37 pages (Oct. 1980). Order from NTIS as PB81-132276.

**Key words:** detector location; false alarms; health care facilities; hospitals; ionization detectors; maintenance; NFPA 101; nursing homes; photoelectric detectors; smoke detectors; surveys.

A survey of health care facilities in eight states was conducted to gather data on experience with smoke detection systems. Requested information included detector manufacturer and model number, number of detectors and time in service, detec-



tor locations, numbers of false and real alarms and the methods and frequency of cleaning and testing the detectors. The results of the survey indicate that about 70 percent of the detectors were ionization type, and 30 percent were of the photoelectric type. Fourteen percent of the total number of detectors were single-station, battery-operated, residential-type detectors, most of which were installed in health care facilities in only one of the eight states surveyed. Almost 80 percent of the detectors were installed in corridors and the average age of the detector installation was about five years. The detection systems were found to experience approximately 14 false alarms for each real fire detected with the highest false alarm rate occurring in detectors installed in laundry areas, storage areas, and kitchens. While over 88 percent of the systems were tested at least annually (55 percent tested monthly), almost half (45.7 percent) were never cleaned. Almost 11 percent of the installed systems were maintained under an outside service contract.

**NBSIR 80-2133. Data bases available at the National Bureau of Standards Library, D. Cunningham, 70 pages (Oct. 1980).** Order from NTIS as PB81-132870.

Key words: bibliographic data bases; computerized data bases; information storage and retrieval systems; libraries-automation; machine-readable bibliographic data.

An alphabetical listing of data bases available on-line at the National Bureau of Standards (NBS) Library is listed by either acronym or full title of the data base. Other additional information includes description of the data base, period of coverage, producer(s), corresponding hard copy, principal sources and vendors. A general subject and a cross reference index to the data bases is also supplied.

**NBSIR 80-2134. Fire performance of selected residential floor constructions under room burnout conditions, J. B. Fang, 80 pages (Dec. 1980).** Order from NTIS as PB81-144404.

Key words: fire endurance; fire tests; flame through; floors; furniture; interior finishes; joists; room fires; steel; wood.

A series of seven large-scale room burnout fire tests was conducted with a set of selected residential floor-ceiling assemblies to provide data on the performance of the assemblies; these will be compared with the results in future tests on the same constructions in a fire endurance furnace. Four wood-frame and three light gage steel-frame, load-bearing assemblies, each measuring  $3.7 \times 3.7$  m in size, were exposed from the underside to a fire environment produced from the burning of typical furniture and interior finish materials in a room. The fire resistance periods based on flame-through of floor assembly and structural failure of floor joists varied from 10 to 12 minutes for floors with unprotected wood joists and was 4 minutes or less for floors with unprotected steel joists. The addition of a 12.7 mm thick gypsum board ceiling as a protective layer increased the fire resistance time of the steel joisted floor assembly approximately 12 minutes.

**NBSIR 80-2140, Vol. 1. Fire safety of wood-burning appliances, Part 1: State of the art review and fire tests (Vol. 2 is included in this volume on microfiche), R. D. Peacock, E. Ruiz, and R. Torres-Pereira, 80 pages (Nov. 1980).** Order from NTIS as PB81-145823.

Key words: chimneys; fire models; fire safety; fire tests; flues; heating equipment; heat transfer; literature reviews; radiant energy; stoves; wood.

A series of 18 full-scale tests was conducted in an instrumented test room using five different wood-burning appliances. These tests were designed (1) to establish typical operating conditions including temperatures on the appliances, chimneys, and adjacent combustible surfaces; (2) to study the effects of a variety of combinations of appliance design, clearance to combustibles, and room construction on temperatures on adjacent

combustible surfaces; and (3) to compare these measured values with theoretical predictions of wall surface temperature. Additional tests were conducted to compare a standardized fuel source with typical oak logs.

A review of literature related to wood-heating safety included in this study revealed that current codes are based on data almost 40 years old. The results of these tests point out some areas where the codes should be modernized to accurately reflect the newer appliances and construction techniques.

**NBSIR 80-2143. An analysis of the effects of dynamic and static forces present in the NBS SI volt experiment, M. E. Cage, 218 pages (Sept. 1980).** Order from NTIS as PB81-115370.

Key words: absolute volt; balance equations of motion; D'Alembert's principle; metrology; precision balance; precision electrical measurement.

An analysis of the NBS SI volt experiment has been made first to obtain algebraic expressions for the electrical forces present on the suspended electrode of the electrometer. These forces, and the gravitational forces, are used in the Principle of Virtual Work and D'Alembert's Principle to obtain the second order, non-linear, inhomogeneous, coupled differential equations of motion for the balance. Exact, analytical solutions of these equations of motion are obtained using small angle approximations and perturbation methods. Estimates are then made of the uncertainties that might result in both the slope and path integral methods in order to determine what requirements must be satisfied to reduce the systematic and random errors of the force determination and the capacitance measurements to acceptable levels so that the SI volt can be determined to within a few ppm.

**NBSIR 80-2144. Residential solar data center—MIRADS user's guide, P. M. Christopher, M. Vogt, and D. Hall, 144 pages (Oct. 1980).** Order from NTIS as PB81-132268.

Key words: automatic data processing; computer retrieval; data base retrieval; residential buildings; solar data base; solar 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. Data contained in the solar data base are accessible online to users of the NBS Center Computer via remote terminals with a data base retrieval software package called MIRADS (Marshall Information Retrieval and Display System). This document is a self-teaching user's guide to the solar data base. It is complete with the basic MIRADS language rules, examples of use, and a step-by-step walk-through of a typical interactive session. Appendices contain all the data element names and coded values needed to use the solar data with MIRADS, as well as many examples of actual computer sessions.

**NBSIR 80-2149. GRIDNET, R. T. Moore, 75 pages (Oct. 1980).** Order from NTIS as PB81-144370.

Key words: communications networks; CROSSFIRE; link protocols; local survivability.

This report describes a highly reliable and survivable digital data communication system. It is based on the multiple interconnection of dual fiber optic loops, with up to about twenty data communications stations being served by each dual loop. The dual loop configuration is called CROSSFIRE. The interconnection of many of these to form a large network is called GRIDNET. The network is highly connected and many alternate routes are available for transmitting a message between two stations located at different points on the network. The intelligence required for the control of communications and the routing of traffic is distributed among a number of data communica-



tion nodes called gateway stations. Network survival is not dependent on the survival of any node or link, but requires instead that the network not be fragmented.

**NBSIR 80-2159. NBS Software Tools Database**, R. C. Houghton, Jr., and K. A. Oakley, Eds., 107 pages (Oct. 1980). Order from NTIS as PB81-124935.

Key words: dynamic analysis; programming aids; software development; software management; software tools; static analysis.

A listing of information on the software tools contained in the NBS Software Tools Database is provided for review.

**NBSIR 80-2161. A "reference building" approach to building energy performance standards for single-family residences**, S. R. Petersen and J. L. Heldenbrand, 39 pages (Oct. 1980). Order from NTIS as PB81-135642.

Key words: building design; building energy performance standards; building standards; component performance standards; energy conservation; housing.

The Department of Energy is currently developing building energy performance standards (BEPS) that are intended to significantly reduce the design energy requirements of new buildings. This report provides a modified approach to the DoE BEPS development program for residential buildings. The modified BEPS are not meant to replace component performance standards for new buildings but rather to augment them so that design tradeoffs can be made at the whole building level if they can be shown not to increase design energy requirements.

In the modified approach, equivalence must be demonstrated between the thermal performance of a proposed building design and a reference building design of the same type and size and in the same geographic location. A number of approved calculation methods could be used to demonstrate such equivalence. This modified approach to BEPS development is directly linked to reference component performance specifications for both shell and equipment through a reference building envelope configuration. This reference basis for the BEPS provides a great deal of information to the user about acceptable building designs, making the modified BEPS approach both more manageable and more flexible than the current DoE approach.

**NBSIR 80-2162. Technical activities 1980—Office of Nondestructive Evaluation**, H. Berger and L. Mordfin, Eds., 119 pages (Nov. 1980). Order from NTIS as PB81-132466.

Key words: acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; penetrants; radiography; ultrasonics.

A review of nondestructive evaluation programs at NBS, for FY1980 is presented in this annual report.

**NBSIR 80-2167. Weatherization investment costs for low-income housing**, S. F. Weber, M. J. Boehm, and B. C. Lippiatt, 84 pages (Nov. 1980). Order from NTIS as PB81-133829.

Key words: building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization.

This report presents the results of a project involving the collection and tabulation of field data on the costs of retrofitting low-income houses for energy conservation. This project is part of the Community Services Administration Weatherization Demonstration Program being carried out through the National Bureau of Standards. The program involves the installation and evaluation of a broad range of energy conservation techniques for over 200 single-family houses in 14 demonstration sites throughout the United States. The energy conservation techniques discussed in this report consist of a variety of architectural

modifications to building envelopes for the purpose of reducing heat losses due either to air infiltration or conduction. The methods used to collect and synthesize the field data on the major cost components of installing these techniques are described. An analysis of these costs is presented in the form of summary statistics including the weighted mean and standard deviation of the unit cost of installing each architectural option in each demonstration site. The significant intercity variation found in the mean unit cost of most techniques suggests that unique cost estimating procedures may be needed for each city. Possible sources of variation in the mean unit costs are discussed. Recommendations for further research include investigating the effect on cost that can be attributed to selected sources of variation.

## 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-79-171. Regulatory use of standards: The implications for standards writers,** P. J. Harter, 286 pages (Nov. 1979). Order from NTIS as PB80-120579.

Key words: administrative law; law; legal aspects of standards; regulation; safety regulation; standards organizations; voluntary standards.

The purposes of this report are: 1) to help standards-writing organizations prepare standards that are acceptable to regulatory agencies for use in regulations or as an alternative to regulation; and 2) to suggest how regulatory agencies might improve their relationships with private sector standards organizations. The report describes how standards are used in regulatory programs and discusses the requirements imposed on agencies by administrative law. From this analysis, it is possible to make some general suggestions—for example: organizations writing standards for possible regulatory use should prepare an accompanying rationale and procedural history. The report summarizes complaints of standards organizations about regulatory agencies, and suggests how agencies might improve their relationships with standards organizations.

**NBS-GCR-79-173. Cost effectiveness of marine fire protection programs,** K. R. Oppenheimer, R. S. Alger, S. B. Martin, P. C. McNamee, and F. L. Offensend (NBS contact: Nora Jason), 222 pages (Nov. 1978). Order from NTIS as PB80-185671.

Key words: cost benefit analysis; cost effectiveness; fire departments; fire losses; fire models; fire protection; marine transportation; merchant vessels; shipboard fires.

This report presents the results of a cost-effectiveness study of alternative marine fire protection programs. It includes an estimate of current and future marine fire losses and a comparison of the cost-effectiveness of programs designed to reduce these losses. The study, sponsored by the U.S. Department of Commerce, evaluates proposed legislation that would establish regional marine firefighting teams in port cities throughout the country. In the analysis, a wide range of alternatives are compared with the regional team approach; these alternative approaches include fire prevention and fire suppression, and in-

volve fire departments, the U.S. Coast Guard, merchant seamen, and fire protection equipment. To compare the cost-effectiveness of these marine fire protection programs several quantitative models are built—models of fire development, firefighting performance, and fire losses. These models compute the expected net savings of each alternative, where expected net savings is defined as the expected reduction in losses minus the expected cost of the program (relative to the status quo). The models relate firefighting performance in each type of ship fire to the extent of damage that occurs. They incorporate both historical data and consensus judgments of experts, and are tested and calibrated against past ship fire data. The alternatives are ranked by expected net savings and by incremental benefit-cost ratios. The optimal program turns out to be a combination of several of the individual alternatives.

**NBS-GCR-79-175. Linewidth measurement by diffraction pattern analysis,** H. L. Kasdan (NBS contact: Elaine Cohen), 159 pages (Apr. 1980). Order from NTIS as PB80-199342.

Key words: diffraction; diffraction pattern analysis; Fourier analysis; Fourier spectrum; linewidth; linewidth measurement; photomask.

Measurements on photomask linewidths of 1 to 10  $\mu\text{m}$  are made using a technique of diffraction pattern analysis. This technique consists of Fourier analyzing the diffraction pattern produced by coherent light of wavelength 632.8 nm diffracting from a 1- to 10- $\mu\text{m}$  wide photomask line. The technique is applied to both clear and opaque lines. Linewidth dimensions are obtained by numerical inversion of the measured Fourier diffraction spectrum to form the autocorrelation function and then statistically determining the x-axis intercept of this function. The effects of the variables of detector linearity, laser intensity variation and focusing on the measurement precision are investigated. The measurement linearity and repeatability are evaluated as functions of nominal linewidth dimensions, repeated focusing, and instrument aperture width for clear and opaque lines. The effects on the measured dimensions of a nonzero transmittance of the background for clear lines are calculated from theory.

Analyses show that the most critical instrument parameters are the uniformity and phase of the aperture illumination and the numerical aperture of the illuminating objective lens as well as the characteristics of the line or space being measured. Anomalies were observed in the autocorrelation function which suggest that additional analysis and instrument improvements are required to interpret accurately linewidths less than 2.5  $\mu\text{m}$ . The measurement repeatability was about two percent.

**NBS-GCR-79-180. Snow and ice accumulation around solar collector installations,** M. J. O'Rourke, 72 pages (Aug. 1979). Order from NTIS as PB80-127053.

Key words: building; ice; load; roof; roof load; snow; solar collector; structural engineering.

This report presents observations on and measurements of snow and ice on eight structures with flat plate solar collectors mounted on the roof. The data was collected from January through March of 1979 in areas of New York, New Hampshire and Connecticut in the general vicinity of Albany, New York. Half the installations had the collectors mounted flush with the roof surface, while the remainder had collectors mounted on racks at an angle to the roof. Contours of snow depth on the racks, snow densities, measurements of snow on the ground adjacent to the buildings, sketches and photographs of the roofs, and



comments of the owners of the installations are included in the report, in addition to a discussion of the state of the art of predicting snow accumulation on roofs of buildings. The effect of solar collectors on the design of roof structures for the support of snow loads is discussed and recommendations for future research are made.

**NBS-GCR-79-183. Smoke movement studies at the NIH Clinical Center, Integrated Systems, Inc., 101 Central Ave., Brunswick, MD 21716 (NBS contact: N. Jason), 97 pages (June 1978). Order from NTIS as PB80-123094.**

**Key words:** air movement; elevators; fire tests; hospitals; smoke; smoke movement; stairwells; tracers.

Air movement in the NIH Clinical Center was analyzed in order to evaluate possible smoke movement in the event of a real fire. The experimental techniques employed were pressure mapping and tracer gas tests. The tests were conducted under both summer and winter conditions which produce different air flow conditions. In addition, the location of the neutral planes in elevator shafts and stairwells changed significantly with the seasons.

**NBS-GCR-79-184. Solar collector fluid parameter study, W. W. Youngblood, W. Schultz, and R. Barber, 130 pages (July 1979). Order from NTIS as PB80-125891.**

**Key words:** efficiency; flow rate; heat transfer fluid; solar collector; thermal performance.

A series of instantaneous thermal performance tests were performed on four differently constructed, commercially available flat plate solar collectors with each of four commonly used heat transfer fluids. The tests were designed to illustrate the magnitude of fluid parameter effects on the thermal performance of flat plate solar collectors. The configurations were selected to provide a broad variety of flow condition. The heat transfer fluids used were as follows: (1) water; (2) an ethylene glycol (Prestone 11)—water solution (50 percent by weight); (3) a silicone based heat transfer fluid (SYLTHERM 444); and (4) a synthetic hydrocarbon (Therminol 44). Each collector was tested with flow rates in the range of approximately 0.010 to 0.047 kg/sec per square meter (7 to 35 lbm/hr.ft<sup>2</sup>) of net aperture area. The efficiency of the heat collection process for each test was correlated with the heat transfer fluid flow rate. The ASHRAE 93-77 recommended flow rate of 0.02 kg/sec-m<sup>2</sup> (14.7 lbm/hr.ft<sup>2</sup>) was used as a reference baseline. Results show a marked decrease in efficiency (5 to 8 percentage points) for all collectors tested when using the silicone oil and the synthetic hydrocarbon oil from the efficiency obtained when using water at the same flow rate. Decreases in efficiency of 2 to 4 percentage points were observed for all collectors tested when the Prestone-water solution was used compared to water at the same flow rate. The results indicate that a flat plate solar collector's thermal efficiency response to fluid parameter effects is a strong function of the absorber plate to fluid heat transfer path, and a weaker function of the collector's optical characteristics (i.e.,  $\tau\alpha$ ).

**NBS-GCR-79-185. Colorimetry of fluorescent specimens. A state-of-the-art report, F. W. Billmeyer, Jr., (NBS contact: Pam Jackson), 47 pages (Oct. 1979). Order from NTIS as PB80-165590.**

**Key words:** color; colorimetry; fluorescent; fluorescent specimens; measurement.

Accurate measurement of the color of fluorescent specimens, independent of instrument parameters, is very difficult because such materials absorb radiant power in one wavelength region (the excitation region) and emit power in a region of longer wavelengths (the emission region). There is a complicating overlapping wavelength region in which both excitation and emission take place. Measurement of the spectral radiance fac-

tors of fluorescent specimens, the quantity correlating with their visual appearance, requires the use of a spectrophotometer in which the specimen is irradiated by the exact source designed for the visual observations. Bidirectional illumination and viewing, normally 45°/0° must be used, since in the more common integrating-sphere arrangement the sample itself alters the irradiation away from that desired. Conformance to better color specifications requires irradiation by a source identical to CIE standard daylight illuminant D<sub>65</sub>, but existing instrument daylight simulators provide a widely discrepant range of results. Calculation methods are described allowing these results to be converted to those for D<sub>65</sub> by computation. Instrument modifications and accompanying material standards are proposed for direct measurements corresponding to D<sub>65</sub> irradiation. A proposed field test method and instrument are described. Recommendations for implementing these techniques are made for both short-term and long-term time frames.

**NBS-GCR-79-186. Life cycle cost workbook, J. W. Griffith (NBS contact: Nora Jason) 30 pages (Dec. 1979). Order from NTIS as PB80-128788.**

**Key words:** cash flow; economic analysis; fire safety; fire safety evaluation system; health care facilities; life cycle.

The workbook presents a methodology to compare total or relative (Life Cycle) cost of the alternative plans. It is designed to be useable by any person who has access to the necessary financial data and a rudimentary understanding of normal business financing and cost. The approach used is based on the completion of simple work sheets. All of the definitions and reference tables needed to execute the work sheets are included in the workbook. By use of this approach the health care provider, or other person responsible for making preliminary decisions among widely varying alternatives, can extend his information base beyond the traditional approach of first cost figures to consider the actual life cycle price.

**NBS-GCR-79-187. An examination and analysis of the dynamics of the human behavior in the fire incident at the Georgian Towers on January 9, 1979, J. L. Bryan and P. J. DiNunno (NBS contact: Nora Jason), 44 pages (Apr. 30, 1979). Order from NTIS as PB80-148596.**

**Key words:** apartments; building fires; doors; egress; evacuation; fire departments; fire fighters; fire investigations; mattresses; smoke.

This fire incident at the Georgian Towers Apartment Complex in Silver Spring, MD, on January 9, 1979 was initially detected by the occupant of apartment 214 when he was awakened with his mattress on fire. The occupant attempted to remove the mattress from the apartment and, being unsuccessful, ran down four levels to the desk receptionist to call the fire department. The fire department received the alarm at 0246. The corridor door to the apartment of fire origin had been left open and, with the arrival of the Silver Spring Fire Department at 0248, flashover had occurred in the apartment, and smoke had completely saturated the second floor corridor of both the "A" and "B" wings. The fire was extinguished with two 2-inch hose lines, one from the corridor and one from the balcony. Smoke permeated most of the building, being especially on the second, seventh, ninth and eleventh floors. A total fire department response of four alarms was required to assure the evacuation of over 250 occupants. Approximately 21 occupants required emergency medical treatment, 17 for smoke inhalation. The fire was confined to the apartment of origin and the immediately exposed second floor corridor area.

**NBS-GCR-79-189. Data requirements and thermal performance evaluation procedures for solar heating and cooling systems, E. R. Streed, Ed., 87 pages (Aug. 1979). Order from NTIS as PB80-120173.**



Key words: heating and cooling performance; solar energy system; thermal performance evaluation.

This document provides standardized nomenclature and procedures to serve as a guide to monitor and evaluate research or demonstration type solar hot water or heated and/or cooled systems, components and buildings. Performance factors, data requirements, measurement parameters and data analysis methods are described for typical solar energy systems. The document has resulted from the review and comments submitted by representatives of countries participating in Task 1. Material developed by the United States for use in the National Solar Heating and Cooling Demonstration Program and published as NBSIR 76-1137, was used as the primary reference. The contact persons for each country participating in Task 1 are listed in Appendix A.

**NBS-GCR-80-164. Design, cost and operating data for alternative energy systems for the Summit Plaza Complex, Jersey City, NJ, H. O. Nottingham and Associates, Inc. (NBS contact: Morris Nimmo), 315 pages (May 1979). Order from NTIS as PB80-183445.**

Key words: cogeneration; costs; economic analysis; energy consumption; HVAC systems; Total Energy systems.

This report develops basic design and operating data for a comparison of alternative methods of supplying heating, cooling and electric power to a residential/commercial complex. The community complex studied is the Summit Plaza Development located in Jersey City, NJ, which has been served since January, 1974, by a Total Energy (TE) plant. The Summit Plaza TE project is a demonstration effort of the U.S. Department of Housing and Urban Development (HUD) currently being administered by the National Bureau of Standards (NBS) for analysis of the performance and overall viability of the Total Energy facility.

Included in the scope of this study is the following: Analysis of the installed energy system; Conceptual design of alternate energy systems; Estimates of the capital costs of the existing system and each alternate system; Estimates of the operation and maintenance costs of the existing system and alternate systems; Simulation of the energy systems operating through a typical year to determine energy demands and consumptions.

The data in this report are incorporated into the Final Report being prepared by NBS for the HUD Total Energy Demonstration Project. The Final Report will compare the energy, economic, reliability, and environmental viability of each energy system.

**NBS-GCR-80-165. Detailed initial cost data for alternative energy systems for the Summit Plaza Complex, Jersey City, NJ, H. O. Nottingham and Associates, Inc. (NBS contact: Morris Nimmo), 142 pages (May 1979). Order from NTIS as PB80-183452.**

Key words: cogeneration; costs; economic analysis; HVAC systems; Total Energy system.

This report presents detailed estimates of the construction cost of 12 alternative energy systems which could supply heating, cooling and electrical services to the Summit Plaza Complex. Construction costs are developed for each system in the report by a quantity take-off for all major and minor equipment for each energy system including the individual electrical and mechanical components of the energy conversion equipment, site distribution, equipment, building terminal equipment etc.

The detailed data in the report is summarized in a related report in which the energy performance and costs for the energy system were developed: Design, Cost and Operating data for Alternative Energy Systems for the Summit Plaza Complex, Jersey City, NJ.

**NBS-GCR-80-191. An examination and analysis of the dynamics of the human behavior in the fire incident at the University**

**Nursing Home on April 13, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 39 pages (Jan. 1980). Order from NTIS as PB80-158157.**

Key words: death; doors; egress; evacuation; fire alarm systems; fire departments; fire fighters; flashover; nursing homes; nursing staff; patients; room fires; smoke detectors.

At approximately 0833 hours on April 13, 1979, the smoke detector located on the ceiling of the lounge area at the south end of the corridor of the South Section of B wing on the second floor activated in the University Nursing Home, 901 Arcola Avenue, Silver Spring, Maryland. This detector was activated by a flow of convected heat and dark smoke from the door of patient room 27, fifteen feet to the north. The activation of this smoke detector automatically initiated the activation of the local alarm system. The receptionist upon hearing the alarm notified the Montgomery County Emergency Operations Center. The nursing staff were able to close the doors to all the patient rooms in both the South and West Sections of B wing with the exception of the door to the room of fire origin, room 27. The room experienced flashover and the rapidly spreading heat and smoke forced the staff out of the area. The smoke barrier doors closed with the activation of the local alarm system and prevented the spread of smoke extensively to the West Section and in particular to A wing. Approximately 21 patients were removed from rooms in the South Section by the fire department, 7 of these down ladders. An additional 26 patients were evacuated from the West Section of B wing. Seventeen patients were transported to hospitals for medical treatment with eight staff members. Two of these patients subsequently died. The total fire department response involved three alarms. The fire was extinguished within 5 minutes of the arrival of the first engine and within 9 minutes of smoke detector activation.

**NBS-GCR-80-192. An examination and analysis of the dynamics of the human behavior in the fire incident at the National Institutes of Health Clinical Center on April 21, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 43 pages (Jan. 1980). Order from NTIS as PB80-177264.**

Key words: egress; evacuation; fire alarm systems; fire departments; fire fighters; hospitals; nursing staff; patients; smoke.

This fire incident at the National Institutes of Health Clinical Center on April 21, 1979, was detected by a pharmacy technician on the ninth floor, west pediatrics nursing unit with the visual observation of smoke in the solarium lounge at approximately 1502. The technician immediately notified the charge nurse. The local alarm system was activated, which automatically transmitted an alarm to the National Institutes of Health Fire Department. Four ambulatory patients and two visitors were evacuated by the nursing staff and one ambulatory patient was evacuated by maintenance personnel. Bethesda Fire Department personnel rescued one infant. The Clinical Center was evacuated from the fourteenth through the third floors of approximately 184 patients and 50 visitors primarily by staff and NIH personnel in approximately 55 minutes. A total of seven persons was hospitalized for medical observation or treatment: four fire department personnel, one police officer, one visitor and one patient. The initial response by the National Institutes of Health Fire Department consisted of one engine and one ambulance with 5 personnel. The fire was extinguished by Bethesda Fire Department personnel with one 2 inch hose line from the stand-pipe system in stairway 7, in approximately 20 minutes. The fire damage in this 26 year old fire resistive building was limited to the solarium lounge and the corridor of the 9 west nursing unit.

**NBS-GCR-80-193. An examination and analysis of the dynamics of the human behavior in the fire incident at Thurston Hall on April 19, 1979, J. L. Bryan, J. A. Milke, and P. J. DiNenno**



(NBS contact: Nora Jason), 44 pages (July 31, 1979). Order from NTIS as PB80-163017.

Key words: doors; dormitories; evacuation; fire departments; fire fatalities; fire fighters; flashover; ladders; room fires; smoke; students.

This fire incident occurred on the fifth floor of Mabel Nelson Thurston Hall, George Washington University, 1900 F Street, N.W., Washington, DC, on April 19, 1979. The fire incident was initially detected by a student who investigated an abnormal noise followed by smoke issuing from the corridor into the room 501, occupied by the student. The student opened the room door and observed that the corridor was involved in fire. Other students were awakened by abnormal noises or the smell of smoke. Many students attempted to evacuate through the corridor, while others waited for rescue in their rooms. Two students jumped and incurred serious injuries. The District of Columbia Fire Department arrived after flashover had occurred in the corridor of the fifth floor. Upon arrival, fire department personnel found students calling for help from their dormitory windows. Aerial ladders were raised by the truck companies on the North and East sides of the building, and students evacuated from the building. The fire in the fifth floor, north and west corridor and room 533 was extinguished with one 1-1/2 inch hose line off the standpipe system in the Northwest stairway. Smoke permeated the top half of the building, floors five through nine, which hindered prompt evacuation of the building. Eight hundred ninety-eight students and University staff residing in the building were evacuated. Approximately 37 occupants required emergency medical treatment; 15 occupants were admitted to hospitals.

**NBS-GCR-80-194. Personality theory and firesetting: An elaboration of a psychological model.** R. G. Vreeland and M. B. Waller (NBS contact: Nora Jason), 65 pages (Feb. 1980). Order from NTIS as PB80-161599.

Key words: antisocial behavior; arson; cognition; firesetters; human behavior; social environments; social learning theory.

This report attempts to develop a theoretical framework for understanding firesetting behavior in terms of social learning theory. An advantage of the social learning approach is that it provides a unified functional approach to classification, theory, and therapeutic change, and that there is some continuity between an understanding of firesetting and an understanding of the determinants of behavior in general. Three major aspects of the interaction between a person's behavior and the social environment are considered. (1) At the *behavioral level*, the individual's behavior acts upon and is acted upon by the environment, and aspects of the rearing environment which may lead to firesetting are considered. (2) *Vicarious processes* determine how behavior is influenced by other sources of information, including modeling and instructional influences. (3) *Cognitive processes* determine how a person selects, encodes, and evaluates incoming information about the social environment, and how behavioral sequences are determined in light of the person's expectations and abilities. These three components, which are considered basic processes in a person's successful adaptation to the environment, sometimes interact in ways which produce and maintain deviant behavior patterns, including firesetting. The implications of social learning theory for the treatment of firesetting in children and adults are discussed in detail. The present paper also provides a framework for future studies examining the social learning determinants of firesetting behavior.

**NBS-GCR-80-197. An investigation of factors affecting geographic cost differentials on military construction projects.** J. M. Johannes, P. D. Koch, and R. H. Rasche (NBS contact: Pam Jackson), 100 pages (Mar. 1980). Order from NTIS as PB80-160427.

Key words: building economics; construction; cost estimation; econometric models; economic analysis; engineering economics; mathematical models; program planning.

The Center for Building Technology of the National Bureau of Standards is conducting a project to develop an economically sound method for estimating area cost factors for military construction projects. Accurate estimates of area cost factors are of crucial importance to the military since these factors are used as deflators to control for regional cost differentials among planned projects. The focus of this report is on the theoretical and empirical considerations associated with the estimation and use of cost functions to control for variations in construction cost due to changing location and structure type. Three classes of cost functions are estimated based on an assumed Cobb-Douglas production technology. A base city is then chosen for use as a deflator. This approach permits area cost factors for each major geographical region to be calculated. Included in the report are annual estimates of the area cost factors for military construction projects in each major geographical region between the years of 1975 and 1978.

**NBS-GCR-80-198. Application of decision analysis to a regulatory problem: Fire safety standards for liquid insulated transformers.** D. Levinthal (NBS contact: Nora Jason), 98 pages (Apr. 1980). Order from NTIS as PB80-182108.

Key words: cost analysis; decision analysis; dielectric fluids; fire safety; flammable liquids; standards; transformers.

This analysis is an illustrative application of the methodology of decision analysis to the complex regulatory problem of setting fire safety standards for liquid-insulated transformers. The choice among alternative standards is difficult because of the divergence of opinion among experts, the uncertainty inherent in the evaluation of strategies for reducing accidental losses, and the difficult questions of valuing human losses.

The analysis provides a preliminary structuring of the decision problem. The losses that would ensue under selected alternative safety measures are estimated by the use of a decision tree with probability assignments derived from the expert judgment of transformer manufacturers, developers of insulating fluids, researchers at insurance companies, fire engineers, and available statistical data. Alternative safety measures are evaluated in terms of their cost, the degree of property damage, and level of human losses.

Despite the fire community's professed lack of knowledge concerning transformer fires, it was possible to develop a rigorous framework for making this difficult regulatory decision. Although there are significant technological uncertainties, the analysis shows that the critical factor affecting the choice of fire safety standards for liquid-insulated transformers is the level of risk tolerance.

**NBS-GCR-80-199. Software tool taxonomy annotated bibliography.** D. J. Reifer and H. A. Montgomery (NBS contact: Lee Rhodes), 38 pages (Dec. 1, 1979). Order from NTIS as PB80-176902.

Key words: automated aids; programming aids; software engineering; software techniques; software tools; taxonomy.

This report covers the results of a literature search conducted to identify source material useful in the development of a software tool taxonomy. The findings are organized into three parts. Part 1 summarizes twelve articles which deal with taxonomies. Each article is abstracted and evaluated in terms of its strengths and weaknesses. Part 2 provides an annotated bibliography of thirty articles which survey, compare and/or report experience with tools. Part 3 lists 197 references which were reviewed during the investigation.

**NBS-GCR-80-200. An examination and analysis of the dynamics of the human behavior in the fire incident at the Taylor House**



on April 11, 1979, J. L. Bryan, J. A. Milke, and P. J. DiNenno (NBS contact: Nora Jason), 42 pages (Apr. 1980). Order from NTIS as PB80-179054.

**Key words:** evacuation; fire departments; fire fatalities; fire investigations; flashover; group homes; halfway houses; mental disorders; smoke; upholstered furniture.

This fire incident originated on a sofa in the first floor lounge of the duplex unit at 1715 Lamont Street, N.W. Washington, DC, on April 11, 1979. The duplex dwelling at 1715-17 Lamont Street, was known as the "Taylor House" and operated as a Community Residence Facility for fifty-one psychiatric residents on an out-patient status from St. Elizabeth's Hospital. At the time of the fire incident, there were a total of 26 residents in the 1717 duplex unit which received only light smoke damage. There were a total of 21 residents in the 1715 duplex unit, with two staff members at the time of the fire incident. This fire incident was initially detected by a resident who observed flames approximately two inches high on the couch and attempted to extinguish the flames with a jar of water four times at approximately 0056 hours. The resident alerted the staff member who phoned the maintenance man, residing in the basement, and then the fire department. The flames, heat and smoke spread up the one interior open stairway creating an untenable condition for the egress of the residents. Two residents jumped from the second floor and were severely injured, one fatally. The District of Columbia Fire Department upon arrival found a post flashover fire which had extended to all three floors with residents calling for help from room windows, the front porch roof and the roof of the building. The fire department personnel evacuated and rescued 7 residents from the building. There were a total of ten resident fatalities, and five residents suffered injuries requiring hospital treatment.

**NBS-GCR-80-202. Trench pressure measurements with hydraulic shores, R. L. Tucker, L. C. Reese, and M. H. Nicholas (NBS contact: Pam Benjamin), 86 pages (May 1980). Order from NTIS as PB80-192800.**

**Key words:** construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability.

A system was developed by which strut-loads in shallow trench bracing can be measured. The system makes use of commercially available hydraulic shores. The results of a pilot study in which the system was developed and used to measure strut loads are reported. Data on strut loads in a fissured clay, taken during and after the development of failure slip surfaces, are reported.

**NBS-GCR-80-203. Electro-optical measurements of solid insulator surface fields and surface charging in vacuum, D. M. Hyslop, J. E. Thompson, and T. S. Sudarshan (NBS contact: Sandy Kelly), 113 pages (Apr. 21, 1980). Order from NTIS as PB80-192875.**

**Key words:** electrical breakdown; electro-optics; interfacial breakdown; Pockels effect; space charge; surface flashover; vacuum breakdown.

Electro-optical measurements of the electric field along insulator surfaces and in the bulk of insulator materials have been made to determine the mechanisms associated with insulator surface flashover. The Pockels effect in KDP has been used in conjunction with a polarization interferometer and a pulsed laser to measure interfacial and bulk fields for KDP/vacuum interfaces.

The results show that the solid insulator surface and bulk electric field distributions are spatially non-uniform. The electric field at the cathode is considerably enhanced while the field at the anode is reduced. The time evolution and steady state behavior of the insulator electric field distribution for DC, 60 Hz AC, and pulsed excitations will be presented.

**NBS-GCR-80-205. An examination and analysis of the dynamics of the human behavior in the fire incident at the Sacred Heart Home, March 19, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 43 pages (July 31, 1978). Order from NTIS as PB80-183212.**

**Key words:** evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; smoke.

The fire incident at the Sacred Heart Home on March 19, 1978 was detected by the nursing staff at approximately 1330 hours. The nursing staff was investigating an odor of smoke on the third floor when the fire was detected in patient room 335, with flames issuing from a waste basket to a height of approximately eighteen inches. The facility has a capacity of 102 patients and at the time of the fire incident, had a registered capacity of 101 patients. The facility has the main building of protected noncombustible construction, is approximately forty-two years old and had the north wing of fire resistive construction added approximately 14 years ago. Upon detection of the fire, the nursing staff activated the local alarm system, which automatically transmits a signal to the fire department by a central station system arrangement, and also phoned the fire department. The nursing staff extinguished the waste container fire with water from the sink in room 335, evacuated the one ambulatory patient from room 335 and closed the patient room door. The fire emergency procedures of the facility were initiated by all the staff, the fire department responded and verified the extinguishment. There was reported to be no visible smoke accumulation in patient room 335 or the third floor corridor.

**NBS-GCR-80-206. An examination and analysis of the dynamics of the human behavior in the fire incident at the Manor Care, Hyattsville Nursing Home, January 10, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 53 pages (June 30, 1978). Order from NTIS as PB80-183221.**

**Key words:** evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; room fires; sprinkler systems.

The fire incident at the Manor Care, Hyattsville Nursing Home on January 10, 1978 was detected by the nursing staff at approximately 2130 hours. The fire at detection involved multiple ignitions, some of which had self-extinguished. A preflashover fire was detected in the bathroom of the patient room of fire origin, room 65. The two-story building of fire resistive construction was approximately 12 years old. At the time of the fire incident the building had a registered occupancy of 126 patients. The fire was confined to the bathroom by staff action and extinguished by the operation of a single automatic sprinkler head.

The facility alarm was activated and the fire department notified by telephone calls. The ten nursing staff on duty evacuated a total of ten patients from the fire zone on the terrace level and eight patients from the area above the fire zone in approximately 6.5 minutes, and was completed before the arrival of the fire department. The fire department confirmed extinguishment and performed overhaul and smoke removal operations.

**NBS-GCR-80-207. An examination and analysis of the dynamics of the human behavior in the kitchen fire incident at the Manor Care, Adelphi Nursing Home on March 1, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 42 pages (July 31, 1978). Order from NTIS as PB80-185739.**

**Key words:** fire extinguishers; fire investigations; kitchen fires; nursing homes.

The fire incident in the kitchen at the Manor Care, Adelphi Nursing Home on March 1, 1978 was detected by the cook at approximately 0615. The fire at the time of detection consisted of grease burning on the side of the stove with light smoke and flames approximately eighteen inches high. The two story build-



ing of fire resistive construction was approximately ten years old. At the time of the fire incident, the building, with a capacity for 210 patients, had a registered occupancy of 185 patients.

The cook extinguished the fire with a ten pound all purpose listed dry chemical extinguisher. The local alarm system of the facility was not activated, the fire department was not notified, and since patients were not in the fire zone, no evacuation was initiated.

**NBS-GCR-80-208. An examination and analysis of the dynamics of the human behavior in the patient room incident at the Manor Care, Adelphi Nursing Home on March 1, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 41 pages (July 31, 1978). Order from NTIS as PB80-183205.**

**Key words:** evacuation; fire departments; fire investigations; nursing homes; patients.

The fire incident in the patient room 229 at the Manor Care, Adelphi Nursing Home on March 1, 1978 was detected by the nursing staff at approximately 1230. The two story building of fire resistive construction was approximately ten years old. At the time of the fire incident, the facility, with a capacity of 210 patients, had a registered occupancy of 185 patients.

The fire incident consisted of an electrical short circuit in a heating and air conditioning unit in the exterior wall of patient room 229. Eight patients in the fire zone were evacuated by the nursing staff to adjacent areas or the second floor. The facility local alarm system was actuated, the facility emergency procedures were initiated, and the fire department notified by telephone. The fire department responded and the evacuation of patients was completed upon their arrival. The electrical unit was disconnected.

**NBS-GCR-80-209. An examination and analysis of the dynamics of the human behavior in the fire incident at the Harford Memorial Hospital on March 9, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 47 pages (July 31, 1978). Order from NTIS as PB80-181654.**

**Key words:** fire extinguishers; fire investigations; hospitals; nursing staff; patients; room fires.

The fire incident at the Harford Memorial Hospital on March 9, 1978 was detected by the nursing staff in response to a patient's cries at approximately 0315 hours. The four nursing staff members upon entering patient room 373 observed the linen involved for an area of approximately 1.5 square feet and flames with a height of approximately 1 foot adjacent to the patient. The facility has a capacity of 289 patients and at the time of the fire incident 279 patients were registered. The building containing the patient areas is approximately eight years old and of fire resistive construction.

Upon observing the fire, two of the nursing staff immediately removed the patient while the other two pulled the flaming linen on the floor and extinguished the fire with a 2-1/2 gallon labelled pressurized water extinguisher. The door to room 373 was closed; the hospital security notified; the patient placed in another room; and other patients reassured. The facility local alarm system was not activated; the facility emergency procedures were not initiated; and the fire department was not notified.

**NBS-GCR-80-210. Standards for computer-based message services, R. R. Panko (NBS contact: Shirley Watkins), 91 pages (June 1980). Order from NTIS as PB80-202393.**

**Key words:** CBMS; communications; Computer-Based Message Systems; computer based office systems; office automation.

This report surveys the complex environment in which standards for Computer Based Message Systems and Services must be created—CBMS design trends, organizational communication needs, technological trends, and the probable industry structure.

The report also discusses three major standards areas: message structure, delivery and the user interface.

**NBS-GCR-80-211. An examination and analysis of the dynamics of the human behavior in the fire incident at the Magnolia Gardens Nursing Home on April 2, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 43 pages (July 31, 1978). Order from NTIS as PB80-187578.**

**Key words:** fire departments; fire incident; nursing homes; nursing staff; patients; smoke.

The fire incident at the Magnolia Gardens Nursing Home on April 2, 1978 was detected by the nursing staff at approximately 1510 hours. A member of the nursing staff noticed smoke issuing from a ceiling ventilation diffuser in the second floor lounge area. The facility has a capacity of 104 patients and 102 patients were registered at the time of the fire incident. The facility is a two story protected noncombustible construction fully sprinklered building.

Upon the detection of the smoke in the second floor lounge area, the ten patients in the area were evacuated through smoke barrier doors to an adjacent area of the second floor. The patients involved were ambulatory or in wheelchairs. The nursing staff then notified the fire department by phone and activated the facility local alarm system. The facility emergency procedures were initiated, the fire department responded and determined the cause of smoke as an electrical motor failure. No smoke detectors or automatic sprinkler heads activated.

**NBS-GCR-80-212. An examination and analysis of the dynamics of the human behavior in the fire incidents at the University of Maryland Hospital on April 26 to May 8, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 17 pages (Nov. 30, 1978). Order from NTIS as PB80-185770.**

**Key words:** fire departments; fire investigations; hospitals.

The eleven fire incidents at the University of Maryland Hospital from April 26 to May 8, 1978 involved incipient fires in trash containers in rest rooms and corridors. The fire incidents were all suspected to be of an intentional incendiary origin. The University of Maryland Hospital complex consists of four interconnected buildings of fire resistive construction varying in age from four to forty-five years of age. The hospital complex has a total patient capacity of 864 persons.

These eleven fire incidents involved limited flame involvement and smoke production. The Baltimore City Fire Department was notified and responded in five of the incidents. The remaining six fire incidents were extinguished by the University of Maryland Hospital staff or security personnel. Evacuation was not initiated in any of the fire incidents.

**NBS-GCR-80-213. An examination and analysis of the dynamics of the human behavior in the fire incident at the Anne Arundel General Hospital on May 1, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 27 pages (Oct. 31, 1978). Order from NTIS as PB80-187859.**

**Key words:** fire departments; fire investigations; hospitals; nursing staff; patients.

The fire incident at the Anne Arundel General Hospital on May 1, 1978 was detected by a Registered Nurse at approximately 0100 hours. The nurse was summoned to room 414 of A building by the patient's call button. The patient indicated his lighter had exploded injuring his hand. The eight story building of fire resistive construction was approximately nine years old. At the time of the fire incident the facility had a full patient capacity of 277 patients.

No patients were evacuated. There was no visible fire or smoke observed by the staff, although an odor of lighter fluid was present and the patient suffered minor first degree burns to one hand. The fire involving the lighter appeared to have self



extinguished. The facility fire emergency procedures were initiated, and the city of Annapolis Fire Department responded.

**NBS-GCR-80-214. An examination and analysis of the dynamics of the human behavior in the fire incident at the Lorian Nursing Home on May 7, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 35 pages (Aug. 31, 1978). Order from NTIS as PB80-187917.**

Key words: evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; smoke.

This report presents the analysis of the fire incident at approximately 1024 hours, Sunday, May 7, 1978 at the Lorian Nursing Home in Columbia, Howard County, Maryland. This fire incident involved an odor of smoke initially detected adjacent to a vacant patient room on the second floor of the three-story, fire resistive construction, fully sprinklered building.

The facility fire reporting procedure was initiated; the fire department was notified and responded. Patients were retained in their rooms with the doors closed on the second floor, while approximately thirty patients were evacuated from the third floor by the four nursing staff members assigned to this area.

The odor of smoke was determined to have been caused by the overheating of an automatic transfer switch in an enclosed metal panel box in the emergency room on the first (ground) floor of the building.

**NBS-GCR-80-215. An examination and analysis of the dynamics of the human behavior in the fire incident at the Manor Care, Largo Nursing Home on May 9, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 32 pages (Sept. 30, 1978). Order from NTIS as PB80-187909.**

Key words: fire departments; fire investigations; nursing homes; smoke.

The fire incident at the Manor Care, Largo Nursing Home on May 9, 1978 was detected by a staff member at approximately 0930 hours. The fire consisted of an odor of smoke, with some light visible smoke emitting from a washing machine in the laundry room on the first floor. The two-story building of fire resistive construction was approximately two years old. At the time of the fire incident the facility had a registered occupancy of 100 patients. The fire was confined to the washing machine by the staff action of disconnecting the electrical power to the machine. The facility local alarm system and public address system coded announcement were not activated. The fire department was notified and responded. Patients were not moved or evacuated, but retained in rooms with the doors closed.

**NBS-GCR-80-216. An examination and analysis of the dynamics of the human behavior in the fire incident at the American Nursing Home and Convalescent Center on May 11, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 45 pages (Aug. 31, 1978). Order from NTIS as PB80-192677.**

Key words: evacuation; fire departments; fire extinguishers; fire investigations; mattresses; nursing homes; nursing staff.

The fire incident at the American Nursing Home and Convalescent Center on May 11, 1978 was detected by the nursing staff at approximately 1540 hours. The fire at detection involved a polyurethane mattress on an unoccupied bed in patient room 308, the third floor west wing. The three-story and basement building of fire resistive construction was erected in 1973. At the time of the fire incident, the building had a registered occupancy of 265 patients. The fire was confined to the mattress of the bed in room 308 and essentially extinguished by nursing personnel with a 6 pound, 2A, 40BC rated extinguisher.

The fire department was notified and responded, with their services being limited to salvage, overhaul and smoke removal. Nine nursing staff, including the Director of Nursing, evacuated the approximately twenty-five patients in the fire zone to other areas on the third floor in a two phase evacuation prior to fire

department arrival. There was no patient or staff injuries in this fire incident, including the extinguishing operations.

**NBS-GCR-80-217. An examination and analysis of the dynamics of the human behavior in the fire incident at the Anne Arundel General Hospital on May 11, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 31 pages (Nov. 30, 1978). Order from NTIS as PB80-192669.**

Key words: evacuation; fire departments; fire investigations; hospitals; nursing staff; patients.

The fire incident at the Anne Arundel General Hospital on May 11, 1978 was detected by a Registered Nurse at approximately 0535 hours. The nurse was summoned to room 414 of "A" building by the patient's call button. The patient requested medication, and the nurse in moving the patient discovered a charred area in the linen one inch in diameter warm to the touch. The eight story building of fire resistive construction was approximately nine years old. At the time of the fire incident the facility had a full patient capacity of 277 patients.

Two patients were evacuated from room 414. There was no visible fire or smoke observed by the staff. The fire involving the charring of the bed linen appeared to have self extinguished. The facility fire emergency procedures were initiated, and the city of Annapolis Fire Department responded.

**NBS-GCR-80-218. An examination and analysis of the dynamics of the human behavior in the fire incident at the Allegany County Infirmary on May 16, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 47 pages (Aug. 31, 1978). Order from NTIS as PB80-194863.**

Key words: evacuation; fire alarm systems; fire departments; fire extinguishers; fire investigations; nursing homes; patients.

The fire incident at the Allegany County Infirmary on May 16, 1978, was detected by the nursing staff at approximately 0440, at which time the fire consisted of a sweater and robe, fabric materials on the floor of room 112B and fabric materials on a chair held by a patient at the corridor door to room 112B. The two story building of fire resistive construction was thirty years old. At the time of the fire incident, the facility had a registered occupancy of 71 patients. With the exception of minor burning on a chair held by a patient at the door to room 112B, the fire was confined within room 112B. The patient involved with moving the chair with the fire on it suffered first degree burns to one hand and both legs and feet. The fire department was notified automatically with the activation of the local fire alarm system within the facility at 0440 through an auxiliary system arrangement with the public fire alarm system. The four nursing staff in the facility evacuated the two nonmobile patients in their beds and extinguished the fire with a 2-1/2 gallon soda and acid extinguisher. The patients had been evacuated from the room of fire origin, other patients room doors closed and the fire extinguished upon arrival of the first due engine company. The fire department removed the smoke from the facility and performed salvage operations.

**NBS-GCR-80-219. An examination and analysis of the dynamics of the human behavior in the fire incident at the Sligo Gardens Nursing Home on June 10, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 41 pages (Aug. 31, 1978). Order from NTIS as PB80-191018.**

Key words: doors; evacuations; fire alarm systems; fire extinguishers; fire investigations; nursing homes; nursing staff; patients; room fires.

The fire incident at the Sligo Gardens Nursing Home on June 10, 1978 was detected by the Second Floor, Nursing Wing charge nurse at approximately 1330 hours. The fire at detection consisted of a flaming power cord to a television set in patient room 228. The two story building of fire resistive construction



was approximately ten years old. At the time of the fire incident the building had a registered occupancy to the full capacity of 100 patients.

One patient was evacuated by the nursing staff from the room of fire origin without injury. The fire and smoke propagation was limited to room 228 by the closing of the 3/4 hour fire resistive rated doors. The facility local alarm system was activated, the fire department notified and they responded. The fire had been extinguished prior to fire department arrival by nursing staff with a 5 pound all purpose dry chemical extinguisher.

**NBS-GCR-80-220. An examination and analysis of the dynamics of the human behavior in the fire incident at the Avalon Manor Convalescent Center on June 16, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 36 pages (Oct. 31, 1978). Order from NTIS as PB80-191000.**

**Key words:** doors; evacuations; fire departments; fire extinguishers; nursing staff; patients; room fires; smoke; upholstered furniture.

The fire incident at the Avalon Manor Convalescent Center on June 16, 1978 was detected by the nursing staff at approximately 1215 hours. At detection, the fire involved an occupied upholstered chair in the second floor T.V. lounge. The two story building of fire resistive construction is approximately five years old. At the time of the fire incident, the facility had a full capacity of 115 patients.

The facility emergency procedures were initiated and the volunteer fire department automatically notified with the activation of the local alarm system, through a remote station arrangement to their station response siren. The nursing staff initially evacuated eight patients from the area of origin, and a secondary evacuation of approximately thirty patients from the west wing, second floor to the east wing was accomplished. The fire and smoke were confined to the room of origin by the nursing staff closing of the patient room door and the construction.

The fire was extinguished by the facility staff, prior to arrival of the fire department, with a 2½ gallon pressurized water extinguisher and a five pound carbon dioxide extinguisher.

**NBS-GCR-80-221. An examination and analysis of the dynamics of the human behavior in the fire incident at the St. Annes Infant Home on June 20, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 26 pages (Sept. 30, 1978). Order from NTIS as PB80-197262.**

**Key words:** doors; fire departments; fire investigations; smoke.

The fire incident at the St. Annes Infant Home on June 20, 1978, was detected by the administrator at approximately 2015 hours. The fire at detection involved the overheating of electrical switch gear, which produced a white-colored smoke, completely filling the boiler room in the basement. The four-story and basement building of fire resistive construction was erected approximately 15 years ago. At the time of the fire incident, the facility had an occupancy of 79 children and 15 mothers. The fire was confined to the overheated electrical switch gear, with no visible flames, and smoke limited to the boiler room, the area of fire origin.

The fire department was notified and responded. No residents were moved within the facility or evacuated from the facility. The staff action of turning off the electrical power stopped the overheating, and closing of the boiler room door confined the smoke.

**NBS-GCR-80-222. An examination and analysis of the dynamics of the human behavior in the fire incident at the Maryland General Hospital on Aug. 8, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 28 pages (May 31, 1979). Order from NTIS as PB80-195704.**

**Key words:** fire departments; fire investigations; hospitals; nursing staff; smoke.

This fire incident at the Maryland General Hospital on August 8, 1978 was detected by a nurses aide at approximately 0813 hours. The nurses aide detected an odor of smoke in the west corridor of the sixth floor central nursing unit. The nurses aide immediately reported the condition to the patient care coordinator who went to the corridor and observed a light haze of smoke at the ceiling. The patient care coordinator directed the nurses aide to report the fire incident to the facility telephone operator. The security director was also notified by phone and upon arrival activated the local alarm system. Activation of the local alarm system also automatically transmitted an alarm to the Baltimore City Fire Department through an auxiliary system arrangement.

The smoke source was discovered to be a smoldering fire in an ash tray covered with a sheet. Upon staff removal of the sheet and adjacent fuel materials, the fire self-extinguished. The seven story central hospital building of fire resistive construction was approximately thirteen years old. At the time of the fire incident the sixth floor central nursing unit was at full capacity with thirty-eight patients. The Baltimore City Fire Department responded and verified extinguishment.

**NBS-GCR-80-223. An examination and analysis of the dynamics of the human behavior in the fire incident at the Manor Care, Largo Nursing Home on Aug. 14, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 36 pages (Sept. 30, 1978). Order from NTIS as PB80-195605.**

**Key words:** evacuation; fire departments; fire extinguishers; fire investigations; nursing homes; nursing staff; smoke.

The fire incident at the Manor Care, Largo Nursing Home on August 14, 1978 was detected by the maintenance engineer at approximately 1100 hours. The fire at detection consisted of flaming in the flue of the incinerator with smoke propagation to the incinerator room and the first floor corridor of the east wing. The two story building of fire resistive construction was approximately two years old. At the time of the fire incident the building had a registered occupancy of approximately 100 patients.

Forty patients were evacuated by the nursing staff from the second floor skilled care areas, above the area of fire origin, to the second floor solarium. The fire was contained within the incinerator and extinguished by the maintenance engineer with a 5 pound all-purpose dry chemical extinguisher immediately prior to fire department arrival. The smoke spread was confined to the first floor east wing area by the smoke barrier doors, with smoke migration to the second floor east wing through minor openings between the first and second floors.

**NBS-GCR-80-224. An examination and analysis of the dynamics of the human behavior in the fire incident at the North Arundel Hospital on Sept. 4, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 29 pages (Oct. 31, 1978). Order from NTIS as PB80-197254.**

**Key words:** fire investigations; hospitals; nursing staff; patients.

The fire incident at the North Arundel Hospital on September 4, 1978 was detected by a nurse at approximately 1315 hours. The fire at detection consisted of a smoldering propagation with a char area approximately two inches in diameter on the bedspread and blankets covering a sleeping sedated patient. The building in which the fire zone was located was of fire resistive construction, approximately four years old. At the time of the fire incident the building had a registered occupancy of approximately 285 patients.

No patients were evacuated or moved in this fire incident. The bedding materials involved were removed from the bed and patient, carried to a utility room and extinguished by dousing with water in a sink. The staff and fire department were not notified, no visible smoke spread occurred, and there were no staff or patient injuries.



**NBS-GCR-80-225. An examination and analysis of the human behavior in the fire incident at the Manor Care, Towson Nursing Home on Oct. 18, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 29 pages (Dec. 22, 1978). Order from NTIS as PB80-194293.**

**Key words:** doors; fire departments; fire investigations; nursing homes; nursing staff; patients.

The nursing staff at this nursing home facility were alerted to the occurrence of the fire incident at approximately 1957 hours on October 18, 1978 by an unusual "popping" noise and an odor of smoke. The odor was localized in the area of the second floor nurses station. The patients were immediately moved from the corridors into their rooms and all the patient room doors on the second floor were closed. Upon investigation the source of the smoke odor was identified as the electrical transformer box for the patient call system. The box was internally heated and warm to the touch. No smoke or flames were visible in the fire incident.

Upon identification of the source of the smoke odor, the facility emergency procedures were initiated, the local alarm system was activated, and the fire department was notified. It responded and disconnected the power to the transformer and verified extinguishment.

The two story fire resistive building was approximately two years old. The capacity of this nursing home was 115 patients, and the facility had a registered population of 109 patients at the time of the fire incident.

**NBS-GCR-80-226. An examination and analysis of the dynamics of the human behavior in the fire incident at the Lafayette Square Nursing Center on Oct. 24, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 30 pages (Feb. 28, 1979). Order from NTIS as PB80-195621.**

**Key words:** fire departments; fire extinguishers; fire investigations; nursing homes; smoke.

A staff member observed smoke issuing from the vacant patient room 313 on wing C at approximately 1130 hours on October 24, 1978. The staff member immediately activated the local alarm system and notified the security staff by phone. The security staff initiated the facility fire emergency procedures with the verbal public address system announcement and notified the fire department. The twenty-two patients on wing C had been moved to allow insect extermination operations that morning so wing 3-C was vacant. None of the 262 patients in the facility were evacuated. The fire was of electrical origin and propagated to the interior void space in the partition wall between patient rooms 311 and 313. The fire was extinguished by staff personnel utilizing six 2 1/2 gallon soda and acid extinguishers and two 10 pound carbon dioxide extinguishers. The Baltimore City Fire Department arrived, verified extinguishment and checked for extension of the fire within the wall. The five-story protected ordinary construction and fire resistive construction building was seventy-five years old. The area of fire origin was in the protected ordinary construction section fully protected with automatic sprinklers. The 264 capacity facility had a registered occupancy of 262 patients at the time of the fire incident.

**NBS-GCR-80-227. An examination and analysis of the dynamics of the human behavior in the fire incidents at the Sheppard and Enoch Pratt Hospital on Oct. 25 and 26, 1978, J. L. Bryan and P. J. DiNenno, 36 pages (Jan. 31, 1979). Order from NTIS as PB80-195944.**

**Key words:** fire departments; fire extinguishers; fire investigations; hospitals; smoke.

Two fire incidents occurred in this hospital facility on October 25 and 26, 1978. Both fires involved the suspected incendiary ignition of office papers and records on the desk top and the

top of file cabinets in Room 327 of "B" Building. Both fire incidents were detected by administrative staff personnel as an odor of smoke. The telephone operator of the facility was notified and the facility "Fire Call" announcement was initiated over the public address system with the location of smoke odor.

The facility fire brigade extinguished the fire on October 25 and the fire department was not notified. A safety officer extinguished the fire on October 26, and the fire department was notified at the request of the safety officer. It responded and verified extinguishment. Both fires were extinguished with six pound all purpose dry chemical extinguishers.

Patient areas were not involved in either fire incident; no personnel were evacuated. The four-story fire resistive building was approximately 80 years old.

**NBS-GCR-80-228. An examination and analysis of the dynamics of the human behavior in the fire incident at the Anne Arundel General Hospital on Nov. 14, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 30 pages (Dec. 22, 1978). Order from NTIS as PB80-195811.**

**Key words:** fire departments; fire investigations; mattresses; nursing staff; patients.

The fire incident at the Anne Arundel General Hospital on November 14, 1978 was detected by a nursing assistant at approximately 2015 hours. The nursing assistant entered room 412 of "A" building to prepare the patient for sleeping. The nurses assistant in approaching the patient discovered a charred area completely through the linen one inch in diameter, and a scorched area on the mattress. The eight story building of fire resistive construction was approximately nine years old. At the time of the fire incident the facility had a full patient capacity of 277 patients.

The 77 year old male patient was moved from the bed to a chair in room 412. There was no visible fire, smoke, or smoke odor observed by the staff. The fire involving the charring of the bed linen, and the scorching of the mattress appeared to have self extinguished. The facility fire emergency procedures were initiated, and the city of Annapolis Fire Department responded.

**NBS-GCR-80-229. An examination and analysis of the dynamics of the human behavior in the fire incident at the Washington Adventist Hospital on Dec. 9, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason) 29 pages (Mar. 31, 1979). Order from NTIS as PB80-196025.**

**Key words:** doors; fire departments; fire investigations; nursing staff; patients; smoke.

This fire incident at the Washington Adventist Hospital on December 9, 1978 was initially detected by a nurse's aide in nursing unit 3200 as an odor of smoke in the corridor near the elevator. The nurse's aide immediately activated the facility local alarm system at approximately 1047 hours. In accordance with the facility emergency procedures the hospital operator initiated the verbal "Doctor Red" announcement on the public address system and notified the Department of Fire and Rescue Services Communication Center on the direct private phone line. The nursing staff in the facility placed patients in their rooms and closed the patient room doors. The hospital security staff and the Takoma Park Volunteer Fire Department responded to nursing unit 3200 which is located on the third floor of the 5-story and 2 basement fire resistive building. When the source of the smoke odor was not identified on the third floor, an investigative search of the lower floors was initiated. A light haze of smoke was detected outside the ladies locker room, room LL2 on the subbasement level, and a developing fire involving three lockers within the room. The fire department personnel immediately extinguished the fire with one 1-1/2 inch hose line supplied from the building wet standpipe system. Due to the fire resistive construction of the building, the location of



the fire, and its immediate suppression, the need for patient evacuation was precluded.

**NBS-GCR-80-230. An examination and analysis of the dynamics of the human behavior in the fire incident at the Spring Grove Hospital Center on December 14, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 30 pages (Jan. 31, 1979). Order from NTIS as PB80-199235.**

**Key words:** evacuation; fire departments; fire investigations; hospitals; smoke.

A secretary on Ward A of the White Building at the Spring Grove Hospital Center on December 14, 1978 at approximately 1205 hours detected an odor of smoke. The odor was localized in the corridor in the South West portion of the building. The secretary notified the telephone operator, who sent maintenance personnel to the building to locate the source of the smoke odor. Since smoke odor persisted the secretary called the safety officer. The safety officer immediately notified the telephone operator who initiated the facility emergency procedures and notified the fire department. The White Building was evacuated of approximately 120 patients and 12 nursing staff. The safety officer located the source of the smoke odor from a fluorescent light ballast in an office. The Baltimore County Fire Department arrived, verified extinguishment and removed residues of the smoke. The one-story, fire resistive building was approximately twenty years old. This is one building at this residential regional mental hospital center consisting of twenty-two buildings with a total capacity of 1,484 patients.

**NBS-GCR-80-231. An examination and analysis of the dynamics of the human behavior in the fire incident at the Washington Adventist Hospital on December 22, 1978, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 31 pages (Jan. 31, 1979). Order from NTIS as PB80-207905.**

**Key words:** doors; evacuation; fire extinguishers; fire investigations; hospitals; nursing staff; patients; smoke.

The fire incident at the Washington Adventist Hospital on December 22, 1978 was detected by a staff employee at approximately 1028 hours. The fire at detection consisted of a plastic food tray, with plastic containers and paper combustibles on an energized hot plate in the clean utility room of nursing unit 2200 on the second floor. At detection, flames had achieved a height of approximately 24 inches and a dense black layer of smoke had accumulated 18 inches in depth at the ceiling of the room of origin. The six story building of fire resistive construction was approximately twenty-eight years old. At the time of the fire incident this hospital had a registered occupancy of 360 patients. Two patients were evacuated from the corridor adjacent to the room of origin, and one patient from a room across the corridor by the nursing staff. The fire and smoke propagation was limited to the clean utility room by the closing of the 20 minute fire resistive rated door. The hospital local alarm system was activated, the hospital fire brigade and the fire department were notified. The fire was extinguished by a physician and nursing staff personnel with a pitcher of ice water and a 2-1/2 gallon pressurized water extinguisher prior to fire department arrival. The fire department verified extinguishment and conducted overhaul and ventilation operations.

**NBS-GCR-80-232. An examination and analysis of the dynamics of the human behavior in the fire incident at the Southern Maryland Hospital Center on January 2, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 33 pages (Feb. 28, 1979). Order from NTIS as PB80-207343.**

**Key words:** fire departments; fire extinguishers; fire investigations; hospitals; nursing staff; smoke; smoke detectors.

The fire incident at the Southern Maryland Hospital Center on January 2, 1979 was detected by a patient at approximately 0001 hours. The male patient in the psychiatric care unit on the

fourth floor, west wing, reported to a nurse at the nurses station that there was an odor of smoke in the south corridor outside the closed door of vacant patient room 414. The nurse immediately initiated the facility fire emergency procedures with a phone call to the facility telephone operator. The telephone operator alerted the facility with a verbal "Code Red" announcement over the public address system and phoned the Prince George's County Fire Communications Center on the "911" emergency number. The fire in a fiber glass waste container was extinguished by a male psychiatric patient using a 10 pound, listed all purpose dry chemical extinguisher, rated 5A, 60B, C. The smoke propagation was heavy in room 414, and moderate in the south corridor of the fourth floor, west wing. The smoke was confined to the west wing area by the smoke barrier doors. The smoke detector system in the psychiatric care unit, including room 414, activated immediately following extinguishment. The seventeen patients in the psychiatric care unit were all ambulatory and were evacuated to the fourth floor, east wing, following extinguishment for the duration of the night. The five- and two-story building of fire resistive construction was approximately thirteen months old. At the time of the fire incident, there were 17 patients in the 25 bed capacity psychiatric unit.

**NBS-GCR-80-233. An examination and analysis of the dynamics of the human behavior in the fire incident at the Crownsville Hospital Center on January 26, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 28 pages (June 30, 1979). Order from NTIS as PB80-208986.**

**Key words:** evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients; smoke; sprinkler systems.

The fire incident at the Crownsville Hospital Center on January 26, 1979 was detected by a patient at approximately 0420. The fire at detection consisted of a flaming linen bag in the linen room of ward 91 in the Medical-Surgical Building with flames to a reported height of four to five feet. The fire was reported by phone to the facility operator, and the local alarm system was activated, and the fire department notified.

Approximately twenty-five patients were on ward 91 at the time of the fire incident. Fifteen patients were evacuated to ward 93. Nine patients were moved in beds, five were ambulatory and walked, and one was carried. Smoke spread through ward 91 due to the linen room door being left open, and the open plan design of the ward. The one story, fire resistive medical-surgical building was approximately twenty-two years old.

The Anne Arundel County Fire Department responded and verified the fire extinguishment by a staff member with a five pound dry chemical listed extinguisher with a 5A, 10BC rating. The wet pipe automatic sprinkler system also activated from a single ordinary rated head. The fire department also performed salvage and overhaul operations.

**NBS-GCR-80-234. An examination and analysis of the dynamics of the human behavior in the fire incident at the University of Maryland Hospital on February 6, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 29 pages (Mar. 31, 1979). Order from NTIS as PB80-204993.**

**Key words:** fire departments; fire extinguishers; hospitals; nursing staff; patients.

This fire incident at the University of Maryland Hospital on February 6, 1979 was detected by a nurse at approximately 0840 hours. The nurse was alerted to the observation of flames in a microwave oven in the emergency room doctor's lounge, room G-1142, by a loud unusual noise. The nurse immediately reported the fire at the emergency room treatment area nurses station. The hospital emergency procedures were initiated with a phone call to the University Communication Center and activation of the building local alarm system.



The fire in the microwave oven was extinguished by the nurse using a 10 pound, listed carbon dioxide extinguisher, rated 5 B, C. Following extinguishment a light haze of smoke was confined to the doctor's lounge. One patient in an adjacent emergency room treatment area was evacuated as a precautionary action.

The fifteen story North Hospital Building of fire resistive construction was approximately five years old. At the time of the fire incident the twenty-five patient emergency room treatment area had ten patients. The Baltimore City Fire Department responded and verified extinguishment.

**NBS-GCR-80-235. An examination and analysis of the dynamics of the human behavior in the fire incident at the Sheppard and Enoch Pratt Hospital on February 7, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 27 pages (Mar. 31, 1979). Order from NTIS as PB80-207897.**

Key words: fire departments; fire extinguishers; fire investigations; hospitals; kitchen fires.

This fire incident occurred at approximately 0832 hours on February 7, 1979 in the main kitchen on the first floor of the Central Building. The fire was immediately detected by two of the kitchen staff since it was initiated with the explosive rupture of an aerosol can of grill cleaner. The can became a projectile and upset two 1-1/4 gallon cans of cooking grease which upon contacting heated areas of the gas fired stove and grill, immediately ignited. The resulting flames involved an area on the grill surface of approximately six square feet, with eight-inch high flames. The smoke produced was immediately exhausted through the kitchen grill hood and duct system. The fire was extinguished by kitchen staff personnel using a 10 pound, listed carbon dioxide, rated 5 B, C extinguisher. The facility emergency procedures were initiated by the staff and both the hospital fire brigade and the Baltimore County Fire Department responded. The fire had been extinguished by the kitchen staff before the arrival of the fire brigade or the fire department. The dry chemical stove and duct extinguishing system were not activated in this fire incident. The fire had no effect on any area beyond the kitchen in this three story and basement fire resistive building, which is approximately 80 years old. None of the patients in this 301 bed capacity psychiatric care institute were involved or threatened by this isolated and controlled fire incident, and no patients were evacuated.

**NBS-GCR-80-236. An examination and analysis of the dynamics of the human behavior in the fire incident at the Pikesville Nursing and Convalescent Center on February 8, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 20 pages (Aug. 31, 1979). Order from NTIS as PB80-204985.**

Key words: fire departments; fire investigations; nursing homes.

This fire incident at the Pikesville Nursing and Convalescent Center on February 8, 1979 was initially detected by a laundress entering the laundry room. The laundress turned off the washing machine and also manually tripped the circuit breaker immediately after detection, which resulted in the extinguishment of the fire.

The laundress then called the desk receptionist to initiate the facility emergency procedures and to notify the Baltimore County Fire Department. Patient room doors were closed by staff personnel and no patients were evacuated during this fire incident.

Damage was limited to clothing inside the washing machine located in the basement of this two-story, 8-year-old facility of protected non-combustible construction. The Baltimore County Fire Department responded and verified extinguishment.

**NBS-GCR-80-237. An examination and analysis of the dynamics of the human behavior in the fire incident at the Ellicott City Middle School on February 14, 1979, J. L. Bryan and P. J.**

**DiNenno (NBS contact: Nora Jason), 28 pages (Mar. 31, 1979). Order from NTIS as PB80-207889.**

Key words: evacuation; fire departments; fire investigations; flashover; schools; smoke.

This fire incident at the Ellicott City Middle School was detected at approximately 1030 hours on February 14, 1979. The fire was apparently detected in the two-story ordinary construction building, approximately forty years old, by two teachers simultaneously. The detection involved an observation of a light haze of smoke in the second floor learning center with an odor of smoke. An odor of smoke was also detected in the first floor corridor near the cafeteria. Investigation of the source of the first floor odor resulted in the observation of a smoke accumulation in the locked and unoccupied band room. Approximately 4 teachers and 120 students, the classes from the first floor cafeteria and the second floor learning center, initiated their evacuation prior to the activation of the local alarm system. The remaining 27 teachers and 400 students evacuated the building in approximately 1-1/2 minutes. With the activation of the local alarm system, the school secretary notified the Howard County Fire and Rescue Emergency Communications Center by phone and the Ellicott City Volunteer Fire Company was dispatched. Due to the extreme cold weather, about 20 °F, the principal allowed the students and teachers to reenter the building to the gymnasium on the first floor after five minutes. The fire department command officer upon arrival requested the total evacuation of the building again. The fire department completed extinguishment of the fully developed post flashover fire in the first floor band room with 1-1/2 inch hose lines in approximately twenty minutes.

**NBS-GCR-80-238. An examination and analysis of the dynamics of the human behavior in the fire incident at the Hidden Brook Treatment Center on February 15, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 32 pages (Aug. 31, 1979). Order from NTIS as PB80-209059.**

Key words: evacuation; fire departments; fire investigations; nursing staff; patients; smoke; smoke detectors.

This fire incident was detected at approximately 2330 by the activation of a smoke detector in the first floor corridor and the concurrent activation of the local alarm system. The nursing staff of three persons and one visitor directed and assisted the thirty-five ambulatory patients from the building in approximately seven minutes.

The fire was initiated in the first floor lounge of the four-story protected ordinary constructed building. The spread of fire within the lounge was initiated by fire retardant treated wall paneling. The vertical spread of flames and heat up the west stairway was limited by the one hour fire resistant rated door at the first floor. The spread of smoke was limited to a light accumulation in the patient occupied areas, even though dense smoke was observed in the first floor lounge, due to the effective operation of the corridor smoke barrier doors.

The Harford County Communications Center was immediately notified by the staff. The Bel Air Volunteer Fire Department responded and extinguished the fire with one 1-1/2 inch hose line within 15 minutes of the activation of the detector, confining the fire to the area of origin, the first floor lounge. The fire department also performed ventilation, overhaul and salvage operations.

**NBS-GCR-80-239. An examination and analysis of the dynamics of the human behavior in the fire incident at the Montgomery General Hospital on March 28, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 28 pages (May 31, 1979). Order from NTIS as PB80-207335.**

Key words: bedding; fire departments; fire investigations; hospitals; nursing staff; patients; smoke; smoldering.



This fire incident at the Montgomery General Hospital on March 28, 1979 was initially detected by a nurses aide on the fifth floor, west wing as an odor of smoke while she was in room 517 at approximately 0100. The nurses aide immediately notified the charge nurse. Both nursing personnel then investigated to determine the source of the smoke odor.

A light haze of smoke was observed at the ceiling of room 516, and a smoldering fire approximately four to five inches in diameter, on the cotton bed spread of an occupied patient bed. The nursing staff removed the bed spread and top sheet to a bathroom across the corridor and extinguished the fire in a sink. One staff member remained with the patient, and following extinguishment, the nursing shift coordinator and the fire department were notified.

The Sandy Spring Volunteer Fire Department responded and verified extinguishment. The facility local alarm system and verbal fire announcement were not initiated and no evacuation was conducted in this 7-story fire resistive building constructed in 1971.

**NBS-GCR-80-240. An examination and analysis of the dynamics of the human behavior in the fire incident at the University of Maryland Hospital on April 4, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 29 pages (May 31, 1979). Order from NTIS as PB80-205651.**

**Key words:** evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients.

This fire incident at the University of Maryland Hospital on April 4, 1979 was detected by two nurses at approximately 2130 hours. The nurses observed light white smoke being discharged from a heating and air conditioning unit with electrical arcing in room 4-207. The two patients in the room were evacuated and the facility emergency procedures were initiated with the phone call to the University Communication Center and the activation of the building local alarm system.

The fire was attacked by a nursing staff member with a listed 3A, 30BC rated, all-purpose dry chemical extinguisher. All ten patients on wing 4B were evacuated, eight patients in their beds, and two of these patients required portable oxygen. The initial arriving fire department personnel from the Baltimore City Fire Department assisted in the evacuation of the last three patients. Fire department personnel extinguished the fire by disconnecting the electrical power supply to the unit and the fire then self-extinguished.

The fire department removed glass from two openable windows in rooms 4-207 and 4-209 to achieve ventilation in this twelve-story main hospital building of fire resistive construction.

**NBS-GCR-80-241. An examination and analysis of the dynamics of the human behavior in the fire incident at the Sheppard and Enoch Pratt Hospital on April 5, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 32 pages (July 31, 1979). Order from NTIS as PB80-207236.**

**Key words:** beds (furniture); evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients.

The fire incident at the Sheppard and Enoch Pratt Hospital on April 5, 1979 was detected by a patient at approximately 1721 hours. The fire at detection consisted of the blankets, linen and top surface over three-fourths of the area of a single bed in room 110 of wing 1-E of the Chapman Building. The fire was reported by phone to the facility operator who initiated the "fire call" announcement on the public address system and notified the Baltimore County Fire Department.

The approximately twenty ambulatory patients on the wing at the time of the fire were evacuated initially through the smoke barrier door to the stairway and eventually to the second floor of the building. The fire was extinguished by staff and the facility fire brigade, expending fifteen 5-pound dry chemical listed extinguishers with a 5A, 10BC rating. The fire department

responded, verified extinguishment and performed salvage and overhaul operations.

**NBS-GCR-80-242. An examination and analysis of the dynamics of the human behavior in the fire incident at the Kensington Gardens Nursing Home on April 14, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 26 pages (June 30, 1979). Order from NTIS as PB80-207228.**

**Key words:** evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; smoke.

This fire incident at the Kensington Gardens Nursing Home on April 14, 1979 was initially detected by a nurse on the first floor central wing as an odor of smoke in the corridor adjacent to room 123, at approximately 0115 hours. The nurse detected smoke in room 123 and observed smoke issuing from an electrical unit heater in the room. The nurse immediately disconnected the electrical power cord to the heater from the wall socket and evacuated the single female patient in her bed from the room, along the corridor beyond the smoke barrier doors to the new section.

During the evacuation of the patient other nursing staff were alerted, the local alarm system activated, the facility emergency procedures initiated and the Montgomery County Emergency Operations Center notified. The Kensington and Silver Spring Volunteer Fire Departments responded, verified extinguishment and conducted ventilation operations. The patient and one nursing staff member were transported by ambulance to the hospital for medical observation and examination as a precautionary measure.

There was no fire damage beyond the electrical unit heater in this two-story, fire resistive original section of the facility constructed approximately 32 years ago.

**NBS-GCR-80-243. An examination and analysis of the dynamics of the human behavior in the fire incident at the Maryland Masonic Home on June 21, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 31 pages (Aug. 31, 1979). Order from NTIS as PB80-203672.**

**Key words:** accumulation of smoke; dry chemical extinguishers; fire incident; ventilation procedures.

This fire incident at the Maryland Masonic Home on June 21, 1979 was detected by a housekeeper upon entering resident room 116 at approximately 0910 hours and observing a light accumulation of smoke at the ceiling. The housekeeper turned on a window fan in the unoccupied room to remove the smoke, and left the room closing the door, to report the smoke. The housekeeper reported the smoke to the administrator who immediately ordered the fire department to be notified. The housekeeper and the administrator returned to room 116 to investigate the source of the smoke. Upon opening the closet doors, flames involving the contents evolved. The administrator ordered evacuation of the first floor and the assistant administrator extinguished the fire with the application of two, five-pound, listed dry chemical extinguishers, rated 2A, 10BC.

Three residents from the adjacent section A of the first floor were assisted in their evacuation by staff. Most of the residents of this facility were already outside the building due to a scheduled field trip, and approximately eight percent of the residents are ambulatory.

The fire and smoke effects of this fire incident were primarily limited to room 116 in this 100 bed facility of fire resistive construction, erected in 1934. The Baltimore County Fire Department responded and verified extinguishment with overhaul operations, and also conducted ventilation procedures.

**NBS-GCR-80-244. An examination and analysis of the dynamics of the human behavior in the fire incident at the Sheppard and Enoch Pratt Hospital on June 24, 1979, J. L. Bryan and P. J. DiNenno (NBS contact: Nora Jason), 26 pages (Aug. 31, 1979). Order from NTIS as PB80-206204.**



**Key words:** fire departments; fire extinguishers; fire investigations; hospitals; smoke.

The fire was detected by a security officer during a normal routine patrol at approximately 2016 hours. The security officer observed smoke issuing into the corridor from room 48A, a laundry room, with a closed door. The security officer immediately activated an alarm box on the local alarm system, phoned the facility operator, and then radioed the security office. The fire incident occurred on the ground floor of the "B" building erected approximately 80 years ago of fire resistive construction.

The security officer obtained a five-pound dry chemical listed extinguisher, rated 2A, 10BC, entered the laundry room, crawled to a trash can which contained the fire and discharged the extinguisher which effectively extinguished the flames. The fire was extinguished prior to the arrival of the facility fire brigade and the Baltimore County Fire Department. The Fire Department verified extinguishment, overhaul, and ventilation of the laundry room area.

No patients were in the fire area, and no patients were evacuated.

**NBS-GCR-80-245. Draft report—Features of the transport and session protocols, J. Burruss (NBS contact: LuAnn Riorden), 78 pages (Mar 1980). Order from NTIS as PB80-205214.**

**Key words:** communication protocols; computer network protocols; feature analysis; network architecture; networking; session protocol; transport protocols.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), has initiated a program to develop computer network protocol standards as Federal Information Processing Standards (FIPS). **FEATURES OF THE TRANSPORT AND SESSION PROTOCOLS** is one of a series of draft reports being prepared under the network protocol standards program for distribution to government agencies, voluntary standards organizations, computer and communications equipment manufacturers, and other interested parties. This draft report analyses protocol features as a method of determining the kernel set of essential features of a protocol along with the clusters of value-added features which will support various application categories.

**NBS-GCR-80-246. Draft report—Service specification of transport and session protocols, G. Pearson and J. Burruss (NBS contact: LuAnn Riorden), 73 pages (Mar. 1980). Order from NTIS as PB80-226947.**

**Key words:** communication protocols; computer network protocols; design specification; formal specification; network architecture; networking; session protocols; transport protocols.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), has initiated a program to develop computer network protocol standards as Federal Information Processing Standards (FIPS). **SERVICE SPECIFICATION OF TRANSPORT AND SESSION PROTOCOLS** is one of a series of draft reports being prepared under the network protocol standards program for distribution to government agencies, voluntary standards organizations, computer and communications equipment manufacturers, and other interested parties. This draft report specifies the actual operation of the proposed transport and session protocols.

**NBS-GCR-80-247. Draft report—Formal description techniques for network protocols, System Development Corp., 7929 Westpark Drive, McLean, Virginia 22102 and Bolt Beranek and Newman Inc., 10 Moulton Street, Cambridge, Massachusetts 02128 (NBS contact: LuAnn Riorden), 89 pages (Aug. 1980). Order from NTIS as PB80-215700.**

**Key words:** action table; computer program; finite automata; formal description technique; graphs; natural language; Petri net; state diagram.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), has initiated a program to develop computer network protocol standards as Federal Information Processing Standards (FIPS). **FORMAL DESCRIPTION TECHNIQUES FOR NETWORK PROTOCOLS** is one of a series of draft reports being prepared under the network protocol standards program for distribution to government agencies, voluntary standards organizations, computer and communications equipment manufacturers, and other interested parties. This draft report contains two formal description techniques, a general survey, and a set of criteria for evaluation of these techniques.

**NBS-GCR-80-251. An investigation of fire impingement on a horizontal ceiling, H. Z. You and G. M. Faeth (NBS contact: Nora Jason), 49 pages (July 1980). Order from NTIS as PB80-220437.**

**Key words:** ceilings; convection; field; flame impingement; heat transfer; radiation; temperature; velocity.

This report covers the second year of a three-year study. The first year of the investigation was devoted to convective ceiling heat flux measurements. The present effort concentrated on radiative heat flux measurements and a portion of the flow structure measurements.

A new experimental apparatus was constructed which allows the long term testing needed for structure measurements. This arrangement has a water-cooled ceiling, 1 m in diameter. The fire source is simulated by a 55 mm ID burner fueled with natural gas operating at heat release rates up to 8.5 kW. Convective and radiative heat fluxes are measured with heat flux gages, mean gas temperatures were obtained with fine wire thermocouples, mean velocities and velocity fluctuations are measured with a laser Doppler anemometer, an impact probe is also used for mean velocities, and mean concentrations are measured by isokinetic gas sampling with gas chromatograph.

Measurements completed to date include: flame shape, convective and radiative heat fluxes to the ceiling, radiative heat fluxes to the ambience, mean temperatures, and mean velocities and velocity fluctuations in the plume portion of the flow.

**NBS-GCR-80-253. An examination and analysis of the dynamics of the human behavior in the fire incident at the Roosevelt Hotel on April 24, 1979, J. L. Bryan, J. A. Milke, and P. J. DiNenno (NBS contact: Nora Jason), 36 pages (Oct. 1979). Order from NTIS as PB80-220429.**

**Key words:** breathing apparatus; evacuation; fire departments; fire fatalities; flashover; hotels; room fires; senior citizens; smoke.

This fire incident occurred on the eighth floor of the Roosevelt Hotel, 2101 Sixteenth Street, N.W., Washington, DC, on April 24, 1979. The fire incident was initially detected by a resident on the eighth floor who detected an odor of smoke and phoned the Hotel receptionist. The Hotel receptionist phoned the building engineer in the basement and the fire department. The District of Columbia Fire Department arrived after flashover had occurred in the room of fire origin, room 818, with extensive smoke throughout the eighth floor corridors. The fire was extinguished with one preconnected 1-1/2 inch hose line by the first due engine company, located 1-1/2 blocks away. The fire department evacuated the eighth floor with personnel providing assistance to some residents from their breathing apparatus. The fire damage was limited to the room of origin, and smoke propagation to the eighth floor of this fire resistive constructed building. A total second alarm fire department response was required to assure the evacuation of the residents. One resident, the sole occupant of room 818, was fatally injured, and



four other residents received medical treatment at hospitals. Two of the injured residents from the eighth floor were treated for smoke inhalation and two residents from other floors were treated for chest pains.

**NBS-GCR-80-256. Draft report—Common command language feature analysis, J. Moulton (NBS contact: LuAnn Riorden), 141 pages (June 1980). Order from NTIS as PB80-211261.**

**Key words:** common command language; communication protocols; computer network protocols; feature analysis; file access function; file manipulation function; network architecture.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), has initiated a program to develop computer network protocol standards as Federal Information Processing Standards (FIPS). **COMMON COMMAND LANGUAGE FEATURE ANALYSIS** is one of a series of draft reports being prepared under the network protocol standards program for distribution to government agencies, voluntary standards organization, computer and communications equipment manufacturers, and other interested parties. This draft report analyzes common command language protocol features.

**NBS-GCR-80-257. Performance requirements for standards processing software, S. J. Fenves (NBS contact: Pam Benjamin), 58 pages (Apr. 1979). Order from NTIS as PB80-221112.**

**Key words:** codes; computer program; decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering.

A methodology for the analysis and synthesis of standards exists which can provide significant assistance to standard writers and developers. Several of the methods have been implemented as computer programs. With the experience gained in the use of the first generation of programs, this report presents a set of performance requirements for a new generation of standards processing software. It is intended that these requirements serve as a basis for defining functional specifications for the subsequent development of the new software. The performance requirements are organized into six categories (general, database, interaction, user interaction, analysis, and processing environment), and they provide an ability to work with all the major elements of the methodology: decision tables for the meaning of individual provisions, information networks for the precedence between provisions, and classification systems for the production of indexes and outlines. The report also presents a concise overview of the methodology for analysis and synthesis of standards with an annotated, chronological bibliography and brief descriptions of previously developed computer programs.

**NBS-GCR-80-258. Functional specifications for standards processing software, S. J. Fenves (NBS contact: Pam Benjamin), 171 pages (June 1979). Order from NTIS as PB80-221120.**

**Key words:** codes; computer program; decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering.

This is the second in a series of reports leading to the development of a standards processing software capability. The first report was *Performance Requirements for Standards Processing Software*. The reader of this report will need to have read and be familiar with the concepts and terms used in the first report. This report provides the complete functional specifications which establish the technical basis for the development of the software. The salient features are: 1) the integration of all user functions into a single system, 2) maintenance of all information in a data base, 3) facilities for convenient user interaction, 4) facilities for processing and combining large standards subdivided into several units, such as chapters, and 5) facilities for

interfacing with additional capabilities to be developed in the future, both external and internal to the system.

**NBS-GCR-80-259. Use of technical analysis in editing, L. Tavis and J. W. Melin (NBS contact: Pam Benjamin), 150 pages (Jan. 1980). Order from NTIS as PB80-149073.**

**Key words:** codes; decision theory; editing; networks; specifications standards; systems analysis/engineering.

This manual puts forth a technology that enables analysts to assist authors of laws, regulations, codes, standards, and specifications in reducing the risk of imprecision. The techniques move from the basic premise that much imprecision in such documents occurs in the verbal expression of interconnection, and at significant levels of detail. The technology makes use of decision tables and trees to express interconnected logic, of an information network to express interconnected precedence, and of equivalency lists to express equivalence of terms used in the verbal expression. Three iterative cycles are used: the translation of the verbal expression of a text to a technical expression (i.e., the decision tables, information network, and equivalency lists); the preparation of an analytic commentary on the technical expression; and the editing of both the technical and the verbal expressions to reduce imprecision. Previously developed computer programs assist in the development and analysis of the technical expression.

**NBS-GCR-80-260. An examination and analysis of the dynamics of the human behavior in the fire incident at the Franklin Square Hospital on June 13, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 29 pages (Aug. 1980). Order from NTIS as PB80-218076.**

**Key words:** doors; fire alarm systems; fire departments; fire investigations; hospitals; mattresses; nursing staff; room fires.

This fire incident at the Franklin Square Hospital on June 13, 1979 was initially detected at approximately 1026 by a nurses aide who observed smoke issuing from under the door of the vacant patient room 13. The nurses aide immediately activated the local alarm system, and the hospital operator initiated the verbal announcement on the public address system to activate the hospital emergency procedures. The operator also immediately notified the Baltimore County Fire Department via the direct private phone. Patient room doors were closed by the nursing staff throughout the three-central fire zone. Two members of the hospital fire brigade entered the room of fire origin, room 3113, and extinguished the fire in a cotton, boric acid treated mattress. The fire brigade members then removed the mattress through the window of room 3113. Damage was limited to the mattress, with smoke spread from room 3113 in both corridors of the three-central area. No patients were evacuated and there was no fire damage beyond the room of origin to this three-story, fire resistive building constructed in 1977. The Baltimore County Fire Department responded, verified extinguishment of the mattress, and assisted the staff in ventilation of the third floor of the facility.

**NBS-GCR-80-261. An examination and analysis of the dynamics of the human behavior in the fire incident at the Union Hospital of Cecil County on July 29, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 25 pages (Aug. 1980). Order from NTIS as PB80-218084.**

**Key words:** fire departments; fire investigations; hospitals; smoke; smoke detectors.

This fire incident at the Union Hospital of Cecil County on July 29, 1979 was initially detected by a pharmacy technician who perceived a smoke odor in the pharmacy on the first floor at approximately 1212 hours. The pharmacy technician immediately phoned the facility operator who initiated the facility fire emergency procedures with the public address system an-



nouncement and notified the fire department. The pharmacy technician and the laundry supervisor located the source of the smoke emitting from an exhaust duct in the linen finishing room on the first floor. Damage was limited to the duct in the finishing room and light smoke damage first floor area in the six-story, fire-resistive, nine-year-old building. Patients were protected in their rooms behind closed doors. The fire self-extinguished following the smoke detector activation of dampers in the duct. Ventilation of the first floor area with fans and overhaul procedures was performed by the Elkton and North East, Maryland Fire Departments with the Christinia and Newark, Delaware Volunteer Fire Departments.

**NBS-GCR-80-262. An examination and analysis of the dynamics of the human behavior in the fire incident at the Mt. Wilson Center on June 10, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 32 pages (Aug. 1980). Order from NTIS as PB80-218092.**

Key words: evacuation; fire department; fire investigations; mattresses; smoke.

This fire incident at the Mount Wilson Hospital Center on June 10, 1979 was initially detected by a Health Assistant who perceived smoke odor on the second floor of the Richie Building at approximately 1837 hours. The Health Assistant immediately directed the residents to evacuate and called to other staff for assistance. The arriving staff observed the smoke conditions in the corridors and activated the local alarm system and phoned the first floor staff to initiate the Hospital fire emergency procedures which include notification of the Baltimore County Fire Department. The Hospital Center security staff responded to the area of fire origin, room 205 and a security guard suppressed the mattress flames with a five-pound dry chemical extinguisher, rated 2A, 10BC. Damage was limited to the room of origin with smoke limited to two of the four smoke zones on the second floor of the protected ordinary construction building erected approximately fifty years ago. All fifty-one of the residents of the Richie Building were evacuated without staff assistance and without injury. The Baltimore County Fire Department responded and completely ventilated the second floor fire zone with fans placed in opened windows.

**NBS-GCR-80-263. An examination and analysis of the dynamics of the human behavior in the fire incident at the Bethesda Center on June 12, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 27 pages (Aug. 1980). Order from NTIS as PB80-218423.**

Key words: fire alarm systems; fire departments; fire investigations; smoke; sprinkler systems.

This fire incident at the Bethesda Health Center on June 12, 1979 was automatically detected with the activation of a sprinkler head on the wet pipe system. Water from the sprinkler head on the water flow switch, thereby activating the local alarm system and extinguish the fire in the laundry cart. The nursing supervisor proceeded through the facility attempting to locate the source of the waterflow alarm. The water flow activation of the sprinkler system is not indicated on the annunciator panel and she continued to search and noted smoke and water in the vicinity of the first floor laundry room. She reported the occurrence of the fire incident by dialing the 911 emergency number of the Montgomery County Emergency Operations Center and then continued to monitor the status of all areas of facility. Two patients were evacuated from their room in an adjacent area to a neighboring room in wheelchairs for precautionary purposes because of a small amount of smoke and water in the vicinity of their room. The fire was limited to a laundry cart, and the smoke was limited to the proximity of the laundry storage room. The Bethesda Fire Department verified extinguishment, performed ventilation, salvage, overhaul operations, including resetting of the alarm and sprinkler system.

**NBS-GCR-80-264. An examination and analysis of the dynamics of the human behavior in the fire incident at the Reeder's Memorial Nursing Home, July 29, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 29 pages (Aug. 1980). Order from NTIS as PB80-218100.**

Key words: doors; evacuation; fire investigations.

This fire incident at the Reeder's Memorial Nursing Home on July 29, 1979 was initially detected by the nursing supervisor who perceived a smoke odor in the area adjacent to the dining area on the second floor at approximately 2206. The supervisor investigated and observed smoke in the dining room, which appeared to be centered in the nourishment center. The supervisor immediately closed the smoke barrier doors to isolate the smoke in the dining room area with another staff member. The supervisor then phoned other staff personnel and the Boonsboro Volunteer Fire Department. The staff responded to the fire area and evacuated nine patients, from rooms 112, 115, and 117 adjacent to the dining room and nourishment center. The fire department arrived and determined the source of the smoke to be from an overheated electrical cord to an ice machine. Fire department personnel de-energized the ice machine and ventilated the nourishment center with portable fans. There were no injuries in this fire incident and no damage to the two-story, three year old fire resistive building.

**NBS-GCR-80-265. An examination and analysis of the dynamics of the human behavior in the fire incident at the Crownsville Hospital Center on August 19, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 32 pages (Aug. 1980). Order from NTIS as PB80-218118.**

Key words: fire alarm systems; fire departments; fire investigations; patients; smoke.

This fire incident at the Crownsville Hospital Center on August 19, 1979 was initially detected by two patients in ward 02, adjacent to room 8D at approximately 1530. The patients observed smoke issuing from around the closed door to room 8D. The patients immediately phoned the staff at the nurses station on adjacent ward 01, and then evacuated the ward 02 area without assistance. The nursing staff on ward 01 activated a manual station on the local alarm system, and the system failed to operate as it was undergoing repair. The staff also phoned the facility operator who initiated the facility fire emergency plan and phoned the Anne Arundel County Fire Communication Center. The nursing supervisor entered the ward 02 area to confirm the complete evacuation of all patients and was forced to leave the area due to the heavy black smoke. Two facility maintenance personnel attempted to enter the building and the ward through the north exterior door and were prevented by heavy black smoke. The Anne Arundel County Fire Department units included the Herald Harbor Volunteer Fire Department responded and personnel with self-contained breathing apparatus extinguished the fire consisting of a polyurethane mattress in room 8D with one 1-1/2 inch hose line. Fire department personnel performed overhaul, salvage and ventilation operations. The heavy black smoke was removed from this 25 year old, partially sprinklered, fire resistive construction building with fans through both doors and windows.

**NBS-GCR-80-266. An examination and analysis of the dynamics of the human behavior in the fire incident at the Mount Wilson Center on September 4, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 30 pages (Aug. 1980). Order from NTIS as PB80-218357.**

Key words: evacuation; fire departments; fire investigations; mattresses; patients; smoke.

This fire incident at the Mount Wilson Hospital Center on September 4, 1979 was initially detected by a Health Assistant who observed smoke issuing from room 512 east wing of the



main hospital building at approximately 0925 hours. The health assistant immediately called to other staff for assistance. The arriving staff observed the smoke flaming mattress in room 512, with smoke in the corridors and activated the local alarm system which initiated the hospital fire emergency procedures which include notification of the Baltimore County Fire Department. Additional hospital staff responded to the area of fire origin, room 512, and suppressed the mattress flames with two five pound dry chemical extinguishers, rated 2A, 10BC, following the initial suppression action of water from a trash can. Damage was limited to one of the five smoke zones on the fifth floor, east wing of the fire resistive construction building erected approximately twenty-seven years ago. All thirty-two of the patients of the fifth floor, east wing of the main hospital building were evacuated with staff assistance and without injury. The Baltimore County Fire Department responded and verified extinguishment of the mattress fire, and ventilated the fifth floor fire zone with fans placed in the opened windows.

**NBS-GCR-80-267. An examination and analysis of the dynamics of the human behavior in the fire incident at the Thomas B. Finan Center on September 9, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 35 pages (Aug. 1980). Order from NTIS as PB80-218845.**

Key words: intermediate care facilities; mattresses; sprinkler systems.

This fire incident at the Thomas B. Finan Center on September 9, 1979 was detected by two housekeepers and a direct care aide who were investigating the ambiguous perceptual cue of an abnormal odor. At approximately 1255 hours they observed the mattress, with the resident on the mattress flaming in the seclusion room of cottage 4. The direct care aide went to initiate the alarm and the facility fire emergency procedures. One housekeeper took a blanket, entered the seclusion room and smothered the flames on the mattress and the resident. The other housekeeper gathered the remaining nineteen residents of cottage 4 and evacuated them to the exterior of the building. With the next extinguishment of the flames, the housekeeper and the direct care aide together moved the smoldering mattress into the pod area, adjacent to the seclusion room, and administered first aid to the resident. The City of Cumberland Fire Department responded, confirmed extinguishment and performed salvage operations. The fire department administered medical aid to the resident who had burns over 34 percent of the body and transported to the resident hospital. The resident was the only person injured in this fire incident and the smoke damage, to the one year old, unprotected, noncombustible constructed fully sprinklered building was limited to the seclusion room in the cottage 4 area. There was not enough heat generated to activate the sprinkler head in the seclusion room.

**NBS-GCR-80-268. An examination and analysis of the dynamics of the human behavior in the fire incident at the Crownsville Hospital Center on October 5 and 12, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 41 pages (Aug. 1980). Order from NTIS as PB80-218415.**

Key words: evacuations; fire alarm systems; fire departments; fire investigations; mattresses; nursing staff; smoke.

Both of the fire incidents at the Crownsville Hospital Center on October 5 and 12, 1979 were initially detected by patients in ward 01. The fire incident was detected at approximately 1353, and the second fire incident was detected at approximately 1455. The patients observed smoke issuing from room 3 due to a mattress fire. The patients immediately called to the staff at the nurses station on ward 01. The staff evacuated the ward 01 area without assistance, due to the mobile nature of the twenty-five patients. The nursing staff on ward 01 activated a manual station on the local alarm system, and also phoned the facility operator who initiated the facility fire emergency plan and phoned the

Anne Arundel County Fire Communications Center in both fire incidents. Both of these mattress fires were extinguished by nursing staff with a 2-1/2 gallon, pressurized water, rated 2A, extinguisher. Staff personnel then removed the smoldering mattress to the exterior of the building. The Anne Arundel County Fire Department responded and personnel confirmed the extinguishment of the mattress. Fire department personnel performed overhaul, salvage and ventilation operations. The smoke was removed from this 25 year old, partially sprinklered, fire resistive construction building with fans through both doors and windows. There were no patient injuries in either of these fire incidents and the damage was limited to the mattress in both incidents.

**NBS-GCR-80-269. An examination and analysis of the dynamics of the human behavior in the fire incident at the Crownsville Hospital Center on October 12, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 30 pages (Aug. 1980). Order from NTIS as PB80-219009.**

Key words: fire investigations; odors; smoke.

This fire incident in the Meyers Building at the Crownsville Center on October 12, 1979 was initially detected by a resident as an ambiguous abnormal odor. The incident was detected at approximately 1612. The resident perceived the odor in the corridor of the central area of the building, adjacent to the dining area. The resident reported the suspected smoke odor to the staff at the nurses ward on 04. The health assistant and the resident investigated the suspected smoke odor in the dining area and detected flames on top of a desk. The health assistant immediately activated the local alarm system, and extinguished the flames with a 2-1/2 gallon, pressurized water, rated 2A extinguisher. The staff then ventilated the area through the exterior doors of the dining area. The Anne Arundel County Fire Department responded and personnel confirmed the extinguishment of the top desk. Fire department personnel performed overhaul, salvage and ventilation operations. The smoke was removed from this 25 year old, partially sprinklered, fire resistive construction building with fans through both doors and windows. There were no resident or staff injuries in this fire incident and the damage was limited to the top of the desk, with smoke damage confined to the dining area during the five minutes of this fire incident on October 12, 1979. This was the second fire incident in the Meyer's Building on this date with the first fire incident consisting of a mattress fire on ward 01 as previously reported.

**NBS-GCR-80-270. An examination and analysis of the dynamics of the human behavior in the fire incident at the Peninsula General Hospital on September 22, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 38 pages (Aug. 1980). Order from NTIS as PB80-218381.**

Key words: fabric flammability; fire departments; fire investigations; smoke.

This fire incident was apparently initiated with the ignition of the robe and bed clothes of a male patient in the bathroom of room 2102, on the second floor, East wing in the Cardiac Care Unit. The fire was detected by the observation of smoke emitting from under the bathroom door by three visitors in room 2102 at approximately 1650 on September 22, 1979. The visitors opened the door to the bathroom and observed the patient standing with the bathrobe in flames. Two of the visitors ran into the corridor calling "Fire," while the third visitor attempted to smother the flames with a blanket. Staff personnel responded to the calls of "Fire," and initiated the facility emergency procedures by dialing "11" on the facility phone. The facility operator initiated the verbal public address system announcement of "Condition One," and notified the City of Salisbury Fire Department. The Facility Fire Brigade personnel responded with the "Fire Cart." Staff personnel in the area



removed the patient from room 2102 by carrying and dragging while six patients in room 2102, 2103, and 2104 were evacuated in wheel chairs. The fire involving the patient and his clothing in the bathroom was extinguished with a listed 4A, 60BC, rated dry chemical extinguisher, and by smothering with bed linens. The patient was taken to the emergency room for medical treatment. The fire damage was confined to the clothing and the male cardiac patient who died on September 24, 1979.

**NBS-GCR-80-271. An examination and analysis of the dynamics of the human behavior in the fire incident at the Gunston School on November 30, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 35 pages (Aug. 1980). Order from NTIS as PB80-218407.**

**Key words:** evacuation; fire investigations; smoke.

This fire incident at the Gunston School on November 30, 1979 was initially detected by a student in room 35 at approximately 2250. The student observed flames emanating from an electric blanket on the floor in the South West corner of the room. The student left the room, crossed the corridor, and notified the student hall monitor. The student hall monitor returned to the room and verified the fire incident. The student resident of room 35 awakened her roommate. Prior to evacuation, the roommate attempted to smother the flames with bedding and being unsuccessful, she also suffered 3d degree burns on both hands. The student hall monitor notified other students on her way to the second floor to notify the on-duty faculty member. She decided to activate the local alarm system from the manual activation station on the third floor at the North East Stairway. The faculty member returned with the student hall monitor to room 35 and upon observing the flames, she immediately ordered the complete evacuation of the building. She returned to her second floor apartment and phoned the Queen Annes County Fire Board. The 30 students evacuated the building in accordance with the pre-practiced evacuation routes. The Centerville Fire Department responded and extinguished the fire in room 35 with two 1-1/2 inch hose lines. The one student suffered minor burns to both hands. Damage was limited to room 35 and the third floor corridor of this 7-year-old fire resistive constructed building.

**NBS-GCR-80-272. An examination and analysis of the dynamics of the human behavior in the fire incident at the Sheppard and Enoch Pratt Hospital on December 10, 1979, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 32 pages (Aug. 1980). Order from NTIS as PB80-224090.**

**Key words:** evacuation; fire alarm systems; fire departments; fire investigations; smoke.

This fire incident was detected simultaneously by staff personnel on the basement level and first floor of A-3 wing, the "A" building, at approximately 2108 on the evening of December 10, 1979. The staff member in the basement detected a smoke odor, but also visibly observed light smoke in the corridor adjacent to room 123. One staff member immediately phoned the operator, while the other staff member activated the local alarm system. The twenty-two ambulatory patients in the A-3 wing were evacuated to the A-1 wing immediately, and the smoke was not a factor in inhibiting the evacuation. The Baltimore County Fire Department was notified by the auxiliary system arrangement and responded. The electrical power to the "A" building was discontinued at approximately 2110, while staff and fire department personnel investigated to find the smoke source. The source of the smoke was located in an overheated fan coil unit located above the ceiling of the first floor corridor of A-3 wing, and above the ceiling of room 123. There was no appreciable damage and no injuries in this fire incident in the 80-year-old fire resistive building.

**NBS-GCR-80-273. An examination and analysis of the dynamics of the human behavior in the fire incident at the Fallston**

**General Hospital, January 27, 1980, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 40 pages (Aug. 1980). Order from NTIS as PB80-218399.**

**Key words:** evacuation; fire departments; fire extinguishers; fire investigations; patients; smoke.

This fire incident in the Fallston General Hospital on January 27, 1980 was detected by several patients who observed smoke emitting from under the door of patient room 2036, at approximately 1749. The patients in the psychiatric care ward in the south section, second floor of the service building alerted the staff by their verbal cries. A nursing assistant immediately responded to room 2036, and upon observing the smoke and feeling heat through the closed room door, he immediately returned to the office and phoned the facility operator. The operator initiated the facility emergency procedures and notified the Hartford County Emergency Operations Center. The ten patients in the psychiatric care ward were evacuated into the adjacent north section geriatric ward on the second floor to the dining and day room. A maintenance man and orderly attacked the fire involving two mattresses on beds in room 2036 with two 2-1/2 gallon pressurized water extinguishers. Unsuccessful, they closed the door to the room and left. The maintenance man immediately returned and attempted to extend the 1-1/2 inch standpipe hose, but was forced to leave due to the smoke. The twenty-two geriatric patients were moved to the dining and day room on the geriatric ward. Upon the arrival of the fire department, all thirty-two of the patients were evacuated from the second floor to the first floor cafeteria. The fire department personnel extinguished the fire in patient room 2036 with the 1-1/2 inch standpipe hose and ventilated the psychiatric care ward.

**NBS-GCR-80-274. An examination and analysis of the dynamics of the human behavior in the fire incident at the Washington Adventist Hospital on March 5, 1980, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 25 pages (Sept. 1980). Order from NTIS as PB80-224918.**

**Key words:** fire alarm systems; fire departments; fire extinguishers; smoke; sprinkler systems.

This fire incident at the Washington Adventist Hospital on March 5, 1980 was initially automatically detected by the activation of a 165 °F sprinkler head on the wet pipe sprinkler system at approximately 0933 hours, which activated the local alarm system. In accordance with the facility emergency procedures the hospital operator initiated the verbal "Doctor Red" announcement on the public address system and notified the Montgomery County Emergency Operations Center on the direct private phone line. Due to the initiation of a disaster simulation exercise at 0930 hours, the local alarm system activation for the fire was perceived to be related to the exercise. However, the hospital security staff and the Takoma Park Volunteer Fire Department responded to the x-ray area. The x-ray area is located on the first basement floor of the four-story and two-basement fire resistive building which is approximately seven years old. The fire department was at the hospital due to the disaster simulation exercise, and upon verification of a sprinkler activation radioed for a complete alarm assignment. Staff personnel in the x-ray area detected the fire in the Records Storage Room closet by the water on the floor with the smoke in the area, and utilized one 4A, 10BC rated and listed dry chemical extinguisher. Due to the fire resistive construction of the building, the location of the room of fire origin on the first basement level, and the automatic sprinkler system extinguishment, the need for patient evacuation was precluded.

**NBS-GCR-80-275. An examination and analysis of the dynamics of the human behavior in the fire incident at Chesapeake Hall on February 3, 1980, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 43 pages (Aug. 1980). Order from NTIS as PB80-218373.**



**Key words:** fire alarm systems; fire departments; fire investigations; smoke.

This fire incident occurred on the second floor, north wing of Chesapeake Hall, University of Maryland at Baltimore County in Catonsville, Maryland. The fire incident was simultaneously detected by the resident assistant on the second floor by smoke in her room, the activation of a smoke detector in resident room 257, and activation of a trouble alarm in the resident director's apartment on the first floor at approximately 0359. The resident assistant opened her room door and observed heavy smoke and flames in the corridor on the north wing adjacent to room door 257. She returned to her room 266, and dialed the public safety dispatcher on 3133 to have him notify the Baltimore County Fire Department in accordance with the facility emergency procedures. The resident director on the first floor, investigating the trouble alarm, heard screams from the second floor and investigated and upon seeing smoke, activated the local alarm system at the station on the first floor. The Baltimore County Fire Department received the alarm at 0403 and upon arrival the building had been evacuated by the approximately 200 residents. The fire was extinguished by the fire department personnel. It was confined to an area of approximately 80 square feet in the corridor with the smoke propagation confined to the second floor, north wing. The resident assistant was treated at the scene for smoke inhalation suffered in alerting the residents and a female resident was treated at St. Agnes Hospital for injuries received from jumping from the second floor.

**NBS-GCR-80-276. An examination and analysis of the dynamics of the human behavior in the fire incident at the Diagnostic Center of the Patuxent Institute on March 5, 1980, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 40 pages (Aug. 1980). Order from NTIS as PB80-218365.**

**Key words:** evacuation; fire extinguishers; fire investigations; smoke.

This fire incident in the Diagnostic Center Building at the Patuxent Institute on March 5, 1980 was initially detected by a correctional officer in the guard station of the visitor's room in the basement at approximately 1020. The officer directed a visitor to leave and notify the building control center. Three correctional officers responded with two converted pressurized water 2-1/2 gallon extinguishers. The extinguishers were not able to produce an effective stream of water. The control center was notified to initiate the facility emergency procedures and three additional correctional officers responded with two dry chemical 2A, 10BC extinguishers and one 15 pound CO<sub>2</sub>, extinguisher. These extinguishers were discharged on the flames with marginal effects. The correctional captain notified the control center to phone the Howard County Fire Department. The correctional officers evacuated from the visitors room and initiated the evacuation of approximately fifty staff personnel from the first floor. These personnel were moved through smoke during the evacuation. The fire department extinguished the fire in the basement visitors room with 1-1/2 inch hose line and one 2 inch hose line after a delayed interior attack due to the building security features. A second alarm response was initiated as a precautionary measure.

**NBS-GCR-80-277. An examination and analysis of the dynamics of the human behavior in the fire incident at the Wilson Health Care Center on June 25, 1980, J. L. Bryan and J. A. Milke (NBS contact: Nora Jason), 50 pages (Sept. 1980). Order from NTIS as PB80-224934.**

**Key words:** fire departments; fire extinguishers; fire investigations; mattresses; nursing homes; nursing staff; room fires; sprinkler systems.

A series of three fires occurred in the Wilson Health Care Center, 301 Russell Avenue, Gaithersburg, Maryland, in the early morning hours of June 25, 1980. The fires were all of

undetermined, suspicious origin and all occurred in patient room 239, located on the second floor of the southwest wing. The Wilson Health Care Center is a portion of the Asbury Methodist Home Complex. The building of fire resistive construction was initially constructed in 1973 and the southwest wing involved in these fire incidents was constructed in 1980. The southwest wing is protected with combination smoke detectors and door closers on the patient room doors, wet pipe sprinkler system, class III standpipe system, smoke barrier doors in the corridors, and extinguishers distributed according to standard practice. The initial fire incident was detected after the flames had self-extinguished in a metal waste container in room 239 at about 0015 hours. The second fire incident was detected at about 0118 hours by the operation of the combination smoke detector and door closer on the door to patient room 239. This fire involved the cotton mattress, bedding and the vinyl covering of the foot board of a patient bed. Extinguishment was begun by staff use of a dry chemical extinguisher, and completed by the fire department. A third incident was discovered at 0448 hours by a nursing assistant who noticed water flowing from under the door of room 239. The sprinkler system had operated, extinguishing the fire in a combustible wardrobe.

**NBS-GCR-80-278. Assessment of computer mass storage technology, Measurement Concept Corporation, Rome, New York 13440 (NBS contact: Linda Ross), 125 pages (Jan. 1980). Order from NTIS as PB80-224926.**

**Key words:** computer architecture; computer hardware; computer computer mass storage systems; computers; computer storage.

The objective of this study is to assess the state-of-the-art of computer mass storage devices and technology, giving particular emphasis to computer system architecture implications.

Provided in this report is an overview of the technologies that presently are and, in the near future and intermediate future, can be applied in the construction of mass storage systems. Discussed are implementation considerations of mass storage systems ranging from the most primitive interface techniques to sophisticated back-end data base processor approaches. The concept of data base machines is introduced in particularly the way they impact on architectural requirements of mass storage systems. Finally, the consequences of the eventual use of mass storage systems in distributed and network processing systems are discussed.

The major finding in our report is an expected departure from the traditional tape libraries to physically smaller and denser mass storage systems such as optical disks as part of a hierarchical memory structure. Reasons for this finding can be found in technological arguments and considerations related to interface implementations, data base machinery architecture and distributed networks.

**NBS-GCR-80-281. Draft report—Formal methods for communication protocol specification and verification, C. A. Sunshine (NBS contact: LuAnn Riordan), 106 pages (June 1980). Order from NTIS as AD-A083263.**

**Key words:** alternating bit protocol; communication protocol; file transfer protocol; protocol specification; readability analysis; service specification transport protocol; verification.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), has initiated a program to develop computer network protocol standards as Federal Information Processing Standards (FIPS). FORMAL METHODS FOR COMMUNICATION PROTOCOL SPECIFICATION AND VERIFICATION is one of a series of draft reports being prepared under the network protocol standards program for distribution to government agencies, voluntary standards organizations, computer and communications equipment manufactur-



ers, and other interested parties. This draft report is a study of methods for specifying and verifying communication protocols. It surveys the state of the art, identifies promising directions for future work, and makes some initial progress in some of these directions.

**NBS-GCR-80-282. Alternatives to precision measuring and test equipment (PMTE) out-of-service calibrations**, Raytheon Service Company (NBS contact: Ken Edinger), 98 pages (Aug. 12, 1980). Order from NTIS as PB81-110181.

Key words: calibration labs; calibration, out-of-service; central calibration; in situ calibration; measurement; metrology; on-site calibration; PMTE.

This report describes various alternatives to out-of-service calibration within the Federal Government and private industry. Current calibration practices and recommendations for improvement are presented. Findings and recommendations are based on data gathered from visits to 23 government and industry calibration laboratories and survey questionnaires received from 51 representative calibration labs in the Federal Government.

**NBS-GCR-80-283. Optimizing calibration recall intervals and alternatives**, Raytheon Service Company (NBS contact: Ken Edinger), 112 pages (Oct. 1980). Order from NTIS as PB81-109597.

Key words: calibration interval; calibration interval algorithms; calibration requirements; decision table; interval adjustment; measurement; metrology; PMTE; recall intervals.

This report describes methods currently used for establishing and/or adjusting calibration intervals within the Federal Government and private industry. Each interval method is analyzed in some detail and recommendations of feasibility for use are presented. Data for the report were gathered from visits to 23 government and industry calibration laboratories and survey questionnaires received from 51 representative calibration labs in the Federal Government.

**NBS-GCR-80-284. Waking effectiveness of household smoke and fire detection devices**, E. H. Nober, H. Pierce, A. Well, C. C. Johnson, and C. Clifton (NBS contact: Nora Jason), 85 pages (Oct. 1980). Order from NTIS as PB81-127565.

Key words: adults; alarm responses; auditory perception; decibal levels; fire departments; frequency distribution; noise (sound); sleep; smoke detectors; wakefulness.

Normal-hearing, young adults were subjected to home smoke detector alarm signals of 85, 70, and 55 dBA while asleep in their own bedrooms under quiet background conditions. In addition, other adults received 70 and 55 dBA alarm signals masked by window air conditioner background noise. Each person, upon awakening from the alarm signal, was instructed to shut off the alarm and telephone the local fire department. The 85, 70, and 55 dBA alarm levels were all sufficient to awaken the subjects at varying hours of the night and days of the week, under quiet background conditions. While there were statistically significant differences in waking times between 55 dBA and the other two alarm levels, the total times never exceeded 115 seconds for the combined alarm shutoff and the fire department telephone call at any alarm level. With background noise, waking times for the 70 and 55 dBA alarm levels increased (85 dBA not tested). At 70 dBA, the total time for the alarm shutoff and the fire department telephone call ranged from 36 to 119 seconds. At 55 dBA, two persons failed to awaken and one person awakened after the four-minute test termination criteria. For the remaining seven persons, the total time for the combined alarm shutoff and the fire department telephone call ranged from 45 to 137 seconds.

**NBS-GCR-80-286. Literature Review: The building regulatory system in the United States**, E. S. Smyrl, Ed., (NBS contact:

Steve Webber), 324 pages (Oct. 1980). Order from NTIS as PB81-128845.

Key words: building codes; building laws and regulations; code development; court decisions; legal basis; liability; regulation; regulatory impacts; technology.

This review, annotated bibliography and index covers literature and legal citations on the U.S. building regulatory system. The scope of the review generally includes the period from 1950 through 1978.

The review is divided into two parts. The first part deals with court decisions and legal citations which serve to define code authority and establish the legal basis of building regulations in the United States. The second part deals with articles and other information on the development and philosophy of building codes, their economic impacts, regulatory obstacles, and the application of building codes to existing buildings and new technologies.

**NBS-GCR-80-287. Performance vs. design standards**, D. Hemenway (NBS contact: Maureen Breitenberg), 44 pages (Oct. 1980). Order from NTIS as PB81-120362.

Key words: automobile standards; design standards; economics of standards; health care standards; innovation; performance standards; standards.

This report compares and contrasts performance and design standards from an economic perspective. The research consisted of a careful examination of the literature and interviews with interested NBS personnel. The paper describes the characteristics of performance standards, explains why they are not used more often, and discusses particular areas where they may be appropriate. The report examines the design versus performance issue in automobile regulation and health care. There are suggestions for further NBS action to promote performance standards, and a listing of areas for further research. Nine brief cases at the end of the paper illustrate points made in the main text.

**NBS-GCR-80-288. Microcomputer interfacing standards survey and analysis**, Network Analysis Corporation, Washington Operations, 301 Tower Building, Vienna, VA 22108 (NBS contact: Dana Grubb), 205 pages (Aug. 1980). Order from NTIS as PB81-105868.

Key words: backplane bus; component level bus; local area networks; microcomputer bus; microcomputer interfacing; microcomputer standards.

This study is a survey of the field of microcomputer interfacing standards for the 1984-1994 time frame. The study identifies the characteristics of the typical microcomputer of the 1984 time frame; identifies and defines interfacing categories for potential standards development; identifies existing and potential candidate standards in each of the interfacing categories; and recommends those candidate standards in each interfacing category that the authors consider appropriate for further consideration.

**NBS-GCR-80-289. Draft report—Formal specification of the transport and session protocols**, R. Tenney, J. Burruss, and G. Pearson (NBS contact: LuAnn Riorden), 281 pages (June 1980). Order from NTIS as PB81-105322.

Key words: communication protocols; computer network protocols; network architecture; networking; protocol design specification; session protocols; transport protocols.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST), has initiated a program to develop computer network protocol standards as Federal Information Processing Standards (FIPS). FORMAL SPECIFICATION OF THE TRANSPORT AND SESSION PROTOCOLS is one of a series of draft reports being prepared under



the network protocol standards program for distribution to government agencies, voluntary standards organization, computer and communications equipment manufacturers, and other interested parties. This report specifies the actual operation of the transport and session control protocols.

**NBS-GCR-ETIP 79-72. Regulatory lag: Administrative causes and solutions**, Temple, Barker & Sloane, Inc. (NBS contact: Darlene Carver), 33 pages (Nov. 1979). Order from NTIS as PB80-146996.

**Key words:** caseload management; case scheduling; common data formatting; Experimental Technology Incentives Program; hearing procedures; regulatory lag; utility commissions.

The report contains findings on methods for reducing the administrative causes of regulatory lag, that is the reduction of the time between the filing of an electric utility rate request and the final disposition of that request. The findings resulted from research and experiments performed for the Experimental Technology Incentives Program (ETIP) in several states during which an independent investigator analyzed all activities and information flows of several state utility commissions. Chief among the identified solutions to lag are caseload management, case scheduling, common data formatting, and delegated hearing procedures. The other tools, described in published reports, deal with performance evaluation, productivity, automatic and discretionary adjustment, rate structure, future test year, and long range planning.

**NBS-GCR-ETIP 79-73. Regulatory analysis financial model RAM descriptive documentation. Volume I and usage and evaluation**, Temple, Barker & Sloane, Inc. (NBS contact: Darlene Carver), 191 pages (Nov. 1979). Order from NTIS as PB80-150675.

**Key words:** computer program; electric utilities; ETIP; financial projections; regulatory commissions; regulatory process; technological innovation.

The Regulatory Analysis Model, known as RAM, is a computer based model for making financial projections for an electric utility, given a set of assumptions or projections concerning demand, capital expenditures, operating costs, and financial and regulatory policies. RAM can be used for industry or regional analysis as well as for individual electric utility projections. The model was developed as part of an Experimental Technology Incentives Program (ETIP) project involving other analytic and management tools designed to improve and accelerate rate case decisions as an incentive to technological innovation. The model, as in the case of the other ETIP work, was tested and modified in experimental settings involving actual rate cases. The use in Ohio is evaluated as part of this volume. Volume II and III of RAM are not published as part of this series but are available from Temple, Barker, & Sloane (TBS) or ETIP. Volume II focuses on input data requirements and program operating procedures. Volume III contains the computer system design. Operating procedures, system design and computer tapes can be obtained from Temple, Barker, & Sloane. The other tools, described in published reports, deal with automatic and discretionary adjustment, performance evaluation, productivity, rate structure, future test year, long range planning and regulatory lag in general.

**NBS-GCR-ETIP 79-74. Performance evaluation model: Suggestions for use and description of the model**, Temple, Barker & Sloane, Inc. (NBS contact: Darlene Carver), 160 pages (Nov. 1979). Order from NTIS as PB80-144744.

**Key words:** computer model; electric utilities; Experimental Technology Incentives Program; financial projections; productivity; regulatory commissions; regulatory process; technological innovation.

The Performance Evaluation Model, known as PEM, is a set of computer programs for manipulating, displaying and analyzing time-series, cross-section, or pooled data and was designed to facilitate the application of ratio-analysis and multiple regression techniques to the financial and operating data of electric and gas utilities. It can be used by utility commissions and managers to identify potential areas for improving utility efficiency. PEM can also assist utilities and regulatory commissions in surveillance and in making financial and operating projections. The model was developed as part of an Experimental Technology Incentives Program (ETIP) project involving other analytic and management tools designed to improve and accelerate rate case decisions as an incentive to technological innovation. The other tools, described in published reports, deal with automatic and discretionary adjustment, productivity, rate structure, future test year, long range planning and regulatory lag in general.

**NBS-GCR-ETIP 79-76. Use of a future test year for electric utility ratemaking appendices A-D**, R. E. Miller, J. W. Wilson & Associates, Inc. (NBS contact: Darlene Carver), 161 pages (Nov. 1979). Order from NTIS as PB80-142102.

**Key words:** electric utility; future test year; regulatory commission; regulatory process; technological innovation.

This report is one of a series involving work by the Experimental Technology Incentives Program (ETIP) designed to accelerate or otherwise improve decisions in electric utility rate cases in state regulatory commissions. The objective is to provide incentives for technological innovation. The future test year method has been found to reduce greatly the amount of time and personnel resources involved in a rate case and to extend the scope and quality of analyses performed. The method projects an electric utility's costs forward into the first full year when proposed new rates will be in effect so that rates can be matched to costs. The report explains how all the elements of a test year cost of services may be projected into the future. The other tools, described in published reports, deal with performance evaluation, productivity, automatic and discretionary adjustment, long range planning, and regulatory lag in general.

**NBS-GCR-ETIP 79-77. Automatic and discretionary adjustment procedures for electric utility rates. Volume I**, R. E. Miller, J. W. Wilson & Associates, Inc. (NBS contact: Darlene Carver), 129 pages (Nov. 1979). Order from NTIS as PB80-137920.

**Key words:** computer programs; electric utilities; Experimental Technology Incentives Program; interim adjustment procedures; regulatory commissions; regulatory process.

This report contains three volumes. Volume I is an analytic report exploring the policy considerations relating to the use of interim adjustment procedures, with an emphasis on fuel adjustment. Volume II is a user's guide to the computer software developed for the project. Volume III, which can be obtained from J. W. Wilson & Associates, Inc. (JWWA) is not published in this series. The work on interim adjustment procedures is part of an Experimental Technology Incentives Program (ETIP) project involving the development of analytic and management tools designed to accelerate and otherwise improve rate case decisions in state regulatory commissions. The other tools, described in published reports, deal with performance evaluation, productivity, rate structure, future test year, long range planning and regulatory lag in general.

**NBS-GCR-ETIP 79-79. Innovative approaches to electric utility rate structure: Marginal costs and time-varying rates. Volume I and usage and evaluation**, R. E. Miller, J. W. Wilson & Associates, Inc. (NBS contact: Darlene Carver), 143 pages (Nov. 1979). Order from NTIS as PB80-148604.

**Key words:** computer models; electric utilities; Experimental Technology Incentives Program; marginal costing; rate



structure; regulatory commissions; regulatory process; technological innovation; time varying rates.

The report is an analysis of the possibilities for using rate structure innovations to help the economic efficiency and equity of the performance of the electric utility industry. It focuses on two innovations: marginal cost concepts and time-varying rates. Volume I of this report is analytic; Volume II is a user's guide to the innovative rate structure approaches developed in the project; and Volume III (obtainable from Experimental Technology Incentives Program or J. W. Wilson & Associates) is a programmer's guide to computer software available to assist in applying these innovative techniques. The work in these volumes is part of a larger ETIP project which developed analytic and management tools to accelerate or otherwise improve rate case decisions. This tool, like the others, was tested and modified, in actual rate case settings in cooperation with state regulatory commissions. This usage is evaluated as part of Volume I. The other tools, described in published reports, deal with automatic and discretionary adjustment, performance evaluation, productivity, future test year, long range planning and regulatory lag in general.

**NBS-GCR-ETIP 79-81. The measurement of electric utility productivity. Volume I and usage and evaluation, L. A. Merewitz, R. E. Miller, J. W. Wilson & Associates, Inc. (NBS contact: Darlene Carver), 190 pages (Jan. 1980). Order from NTIS as PB80-147333.**

**Key words:** electric utilities; Experimental Technology Incentives Program; productivity; regulatory commissions; regulatory process; technological innovation.

This report is one of a series in an Experimental Technology Incentives Program (ETIP) project that developed analytic and management tools designed to accelerate or to otherwise improve electric utility rate case decisions in state regulatory commissions. The objective was to provide incentives for technological innovation. This report describes the performance evaluation work performed by J. W. Wilson & Associates, Inc. (JWWA) in actual rate case settings where the methods were tested and modified in experimental approaches. The work focuses on factor productivity methods which combine rate analysis and econometric approaches. Volume I is an analytical report and Volume II is a user's guide to the computer software developed in the experiments. Usage of the work is described and evaluated as part of Volume I. The other tools, described in published reports, deal with performance evaluation, regulatory lag, automatic and discretionary adjustment, rate structure, future test year and long range planning.

**NBS-GCR-ETIP 79-82. The measurement of electric utility productivity, Vol. II, R. A. Shepherd, R. E. Miller, J. W. Wilson & Associates, Inc. (NBS contact: Darlene Carver), 248 pages (Jan. 1980). Order from NTIS as PB80-151202.**

**Key words:** electric utilities; Experimental Technology Incentives Program; productivity; regulatory commissions; regulatory process; technological innovation.

This report is one of a series in an Experimental Technology Incentives Program (ETIP) project that developed analytic and management tools designed to accelerate or to otherwise improve electric utility rate case decisions in state regulatory commissions. The objective was to provide incentives for technological innovation. This report describes the performance evaluation work performed by J. W. Wilson & Associates, Inc. (JWWA) in actual rate case settings where the methods were tested and modified in experimental approaches. The work focuses on factor productivity methods which combine rate analysis and econometric approaches. Volume I is an analytical report and Volume II is a user's guide to the computer software developed in the experiments. Usage of the work is described and evaluated as part of Volume I. The other tools, described in

published reports, deal with performance evaluation, regulatory lag, automatic and discretionary adjustment, rate structure, future test year and long range planning.

**NBS-GCR-ETIP 80-85. Interim report on potential ICC/ETIP administrative experiments, M. Mulkey, W. Frederick, D. Fulmer (NBS contact: Darlene Carver), 166 pages (Mar. 1980). Order from NTIS as PB80-202575.**

**Key words:** administrative experimentation; economic de-regulation; evaluability assessment; evaluation; Experimental Technology Incentives Program; intermodal freight transportation; Interstate Commerce Commission; rail freight transportation; regulatory experimentation; regulatory policy; technological innovation.

This document is a report of work performed toward evaluating the commercial effects and implications for innovation of the recent decision of the Interstate Commerce Commission (ICC) to exempt railroad transportation of fresh fruits and vegetables from regulation. It is one product of the Regulatory Processes and Effects Project of the Center for Field Methods (ETIP). The work built upon a previous ETIP project, undertaken jointly with the Federal Railroad Administration, which studied the distribution system for fresh produce in the United States.

The first chapter provides an introduction and summary. Chapter II describes the historical background of ETIP's work in the area of regulation and freight transportation innovation, and the genesis of ICC's regulatory exemption for rail transportation of fresh produce. Chapter III discusses expectations, concerns and issues related to this exemption, and the environment for change in fresh produce rail transportation operations. Chapter IV addresses possible effects of the exemption on the ICC and in the commercial sector. Chapter V discusses other areas of transportation regulatory change which may be appropriate for study by ETIP.

**NBS-GCR-ETIP 80-86. Emission offset policy at work: A summary analysis of eight cases, W. H. Foskett (NBS contact: Darlene Carver), 50 pages (Apr. 1980). Order from NTIS as PB80-187610.**

**Key words:** air pollution; economic incentives; Emission Offset Interpretative Ruling; Environmental Protection Agency; market mechanisms; regulation.

The Emission Offset Interpretative Ruling of 1976 is analyzed into its administrative components. Eight permit applications involving emission offsets provide data describing the administrative functioning of the offset policy in terms of these components. In the eight cases presented here, offsets were easy to find, but the process for determining Lowest Achievable Emission Reduction (LAER) was typically quite complex. Offsets were not bought and sold in any of these cases. Third parties promoting local economic development were an important factor in locating offsets.

In these eight cases, technological innovation involved development of new control techniques and diffusion of known technology to hitherto uncontrolled sources of emissions. "Technology-forcing" standards, such as LAER, and offset requirements contributed to the development of innovative control techniques.

**NBS-GCR-ETIP 80-87. Market mechanisms for emission regulation and enforcement of emission limits: Deterrence and demand, W. H. Foskett (NBS contact: Darlene Carver), 32 pages (May 1980). Order from NTIS as PB80-186083.**

**Key words:** air pollution; Clean Air Act; economic incentives; emission offsets; emission reduction trading; enforcement; Environmental Protection Agency; market mechanisms.



This report focuses on the necessity of strong enforcement of air pollution emission limits for the creation of a marketplace demand for market mechanisms, such as offsets. Both trading and direct pricing types of market mechanisms for stationary source emission reduction will require strong, even enforcement of individual source emission limits. Enforcement will likewise influence the degree to which the private sector will organize and invest in the research and development work underlying technological innovation in air pollution control. Present enforcement inconsistencies, such as those among regional offices, and remedial actions are noted. If an EPA effort to strengthen detection of violations can be successfully implemented, its effect on a regulatee's perceived probability of getting caught could contribute to market participation. If the probability of detection and penalty is high, purchase of emission reductions on the market may be a more appealing alternative to regulatees than evasion or litigation.

**NBS-GCR-ETIP 80-88. Opportunities for innovation: Administration of sections 111(j) and 113(d)(4) of the Clean Air Act and industry's development of innovative control technology.** J. Evans (NBS contact: Janet Hockman), 107 pages (Apr. 1980). Order from NTIS as PB80-205024.

**Key words:** air pollution; Clean Air Act; emission control technology; Environmental Protection Agency; innovative technology; innovative waivers; regulation.

This paper describes the administration of two provisions of the Clean Air Act Amendments of 1977, Sections 111(j) and 113(d)(4), which allow short-term emissions violations by companies installing innovative technology for air pollution reduction. The waivers are intended to induce industry to risk development of better air pollution control technology without the fear of prosecution or penalties for emissions violations expected during the debugging of innovative technology. This report has four parts: review of legislation and statutory requirements; review of the administration of these sections as reported by EPA and regulated companies; summary and observations resulting from these reviews; and, presented as an annex, a detailed case study of one Section 111(j) waiver application. The major finding presented is that the current administration of these sections has only modestly encouraged the industrial sector to develop innovative air pollution control technology (no Section 111(j) waivers had been approved; only one 113(d)(4) had been approved). However, the report notes future possibilities for significantly greater utilization of these sections through more effective administrative procedures.

**NBS-GCR-ETIP 80-89. Analysis of the rationale and public comment regarding EPA's proposed regulation on regional consistency.** J. Evans and W. H. Foskett (NBS contact: Janet Hockman), 62 pages (May 1980). Order from NTIS as PB80-203730.

**Key words:** air pollution; Clean Air Act; Environmental Protection Agency; public comment; regulation; rulemaking.

This report focuses on the proposed regulation for regional consistency in administration of regulations under the Clean Air Act of 1977. The origin of this proposed regulation is described. The proposed regulation is analyzed into logical components which structure a descriptive analysis of its specific administrative provision. Public comments on the "advance notice" and subsequent "notice of proposed rulemaking" are also reviewed and analyzed with reference to the administrative components on proposed regulation. Copies of the public comments and other pertinent documents are appended.

**NBS-GCR-ETIP 80-90. An annotated bibliography of literature on market mechanisms and economic incentives for environmental regulation.** S. Watson (NBS contact: Janet Hockman), 32 pages (Apr. 1980). Order from NTIS as PB80-205610.

**Key words:** air pollution; economic incentives; emission offsets; emission reduction trading; market mechanisms; regulation.

This bibliography cites and annotates literature regarding market mechanisms and economic incentives for environmental regulation. References emphasize air pollution and stationary source regulation. Primary attention is given to regulatory tactics that could entail internal or external trading in emission reductions, such as emission offset policy. References involving emission fees are included but not emphasized. Scholarly literature as well as government reports and articles from other sources are included in the bibliography.

**NBS-GCR-ETIP 80-91. Innovation, competition, and government policy in the semiconductor industry.** Charles River Associates Incorporated (NBS contact: Janet Hockman), 403 pages (Sept. 1980). Order from NTIS as PB81-105009.

**Key words:** competition; Experimental Technology Incentives Program; government policy; innovation; semiconductor industry; technological change.

Federal policy with respect to technological change is currently a major issue due to the relationship of technological change to international competition, inflation, and economic growth. This volume presents a case study of the semiconductor industry that applies a framework for examining the impact of federal policy on innovation, competition, and performance in technology-based industries.

Analyzing the actual and potential effects of government policy requires an understanding of the fundamental forces that shape industry behavior. To provide this understanding, the study presents detailed analyses of the environment and technology of the semiconductor industry, of innovative behavior by semiconductor firms, of strategies and competitive behavior, and of the performance of industrial firms and the industry as a whole. These analyses are the subject of Chapters 2, 3, 4, and 5, respectively. Chapter 1 presents an overview of the effects of government policies and Chapter 6 analyzes the impact of procurement, R&D funding, antitrust, trade, tax, and manpower policies on the semiconductor industry.

**NBS-GCR-ETIP 80-92. Innovation, competition, and government policy: A framework for analysis.** Charles River Associates Incorporated (NBS contact: Janet Hockman), 168 pages (Sept. 1980). Order from NTIS as PB80-226327.

**Key words:** Experimental Technology Incentives Program; framework; methodology; policy experiments; policy problems; technology-based industries.

This study has the following objectives: 1) to develop a methodology that policy makers can use to gain an increased understanding of the relationships between federal policies and the behavior and performance of firms in technology-based industries; 2) to test and refine this methodology; 3) to identify important policy problems; and 4) to design policy experiments.

Chapter 2 delineates a schemata that isolates the key relationships that determine the performance of firms in technology-based industries. It identifies and explains the central elements of the analysis and traces important interrelationships among them. Chapter 3 discusses how important characteristics of the firm and the way it allocates its resources may affect its innovative output. Chapter 4 examines how the firm's innovative output feeds into its overall competitive behavior. Chapter 5 builds on Chapter 4 and develops an empirical methodology for determining the effects of the environment and the competitive interaction among strategic groups on the growth, profitability, and innovative performance of individual firms and of an industry as a whole. Chapter 6 seeks to develop a comprehensive framework which policy makers can use to trace and analyze the effects of their programs and actions on the performance of firms in technology-based industries.



U.S. Patent 4,184,127. **Frequency stabilized laser**, R. B. Green, R. A. Keller, G. G. Luther, P. K. Schenck, and J. C. Travis, 6 pages (Jan. 15, 1980).

Key words: analytical flame; discharge tube; laser; opto-galvanic effect; transition frequency.

An apparatus and method for utilizing the opto-galvanic effect to perform spectroscopic or analytic investigations of atomic or molecular species. A sample of the substance to be analyzed is vaporized in an analytical flame, gas discharge tube, high temperature furnace or the like, and the vapor is irradiated with chopped or pulsed variable wavelength monochromatic light. The electrical resistance of the vapor is monitored as the frequency of the radiation is tuned through one or more electronic transition frequencies of the substance. The resistance spectrum resembles the optical absorption spectrum of the species in the vapor. The optogalvanic effect may also be used to frequency lock a laser to a transition frequency of a substance in a gas discharge cell.

U.S. Patent 4,193,115. **Method and apparatus for implementation of the CMAC mapping algorithm**, J. S. Albus, 12 pages (Mar. 11, 1980).

Key words: adaptive control system; intermediate mapping variables.

An adaptive control system is disclosed in which control functions involving many input variables are computed by referring to data stored in a memory. Each value of the control functions is distributed over a number of physical memory locations, such that the linear sum of the contents of these physical locations defines the value. An addressing algorithm is used in which the input variables are mapped into a set of intermediate mapping variables. Apparatus for accomplishing the intermediate mapping comprises first and second counters which are used to address a memory in which the intermediate variables are stored in a predetermined arrangement.

U.S. Patent 4,217,264. **Microporous glassy fillers for dental resin composites**, C. P. Mabie and D. L. Menis, 23 pages (Aug. 12, 1980).

Key words: dental composite resin restorations; finishability; gelled inorganic "polymers"; microporous filler; system nontoxicity; x-ray opacification.

A microporous filler for dental composite resin restorations has been developed which gives greatly improved finishability, system nontoxicity and x-ray opacification. These fillers are prepared from frits obtained by the low temperature calcination of gelled inorganic "polymers" followed by a pulsed high-heat treatment.

U.S. Patent 4,224,279. **Reactive gas generator**, W. Tsang, J. Walker, and D. Cornell, 6 pages (Sept. 23, 1980).

Key words: diffusion cell; organic parent compound; pyrolyzing tube; reactive gas.

A dilute mixture of a large organic parent compound in an inert diluent is formed using a specially designed diffusion cell to control the amount of parent compound that is taken up by the diluent gas. The dilute mixture flows through a hot pyrolyzing tube where the parent compound is decomposed solely and totally by a gas phase unimolecular reaction into equimolar amounts of reactive gas and a stable reaction product. The method produces an internal standard for determining the concentration of the reactive gas since the stoichiometry of the reaction requires that the concentration of the reactive gas be equal to the concentration of the other reaction product, which can be easily calibrated by standard methods.

U.S. Patent 4,227,096. **Microwave integrated circuit for Josephson voltage standards**, L. B. Holdeman, J. Toots, and C. C. Chang, 6 pages (Oct. 7, 1980).

Key words: Josephson junctions; microstrip; microwave integrated circuit; stripline transmission line.

A microwave integrated circuit, comprised of one or more Josephson junctions and short sections of microstrip or stripline transmission line, is fabricated from thin layers of superconducting metal on a dielectric substrate. The short sections of transmission line are combined to form the elements of the circuit, and particularly, two microwave resonators. The Josephson junctions are located between the resonators, and the impedance of the Josephson junctions forms part of the circuitry that couples the two resonators. The microwave integrated circuit has an application in Josephson voltage standards. In this application, the device is asymmetrically driven at a selected frequency (approximately equal to the resonance frequency of the resonators), and a D.C. bias is applied to the junction. By observing the current-voltage characteristic of the junction, a precise voltage, proportional to the frequency of the microwave drive signal, is obtained.

U.S. Patent 4,233,107. **Ultra-black coating due to surface morphology**, C. E. Johnson, Sr., 6 pages (Nov. 11, 1980).

Key words: etchant bath; light absorption; microscopic pores; nickel-phosphorus alloy; solar collector; surface morphology; ultra-black surface 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 method involves preparing the substrate for plating with a nickel-phosphorus alloy, as by cleaning and/or activating it, immersing the thus-prepared substrate in an electroless plating bath containing nickel and hypophosphite ions in solution until an electroless nickel-phosphorus alloy coating has been deposited on the substrate, and then removing the substrate, coated with the electroless nickel-phosphorus alloy, from the plating bath and washing and drying it.

The dried substrate, coated with the electroless nickel-phosphorus alloy, is then immersed in an etchant bath consisting of an aqueous solution of nitric acid, wherein the nitric acid concentration ranges from a 1:5 ratio with distilled or de-ionized water to concentrated, until the coated surface of the substrate develops ultra-blackness, the blackness being associated with the surface morphology as described above.

The resulting substrate, covered with the ultra-black coating is thereafter washed and dried.

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

Reprints from the journals listed in this section may often be obtained from the authors. See page 3 for additional information.

- 19049.** Bloss, R. L., *Thoughts on the stability of strain gages and strain gage based transducers under load*, *Proc. Tech. Comm. on Strain Gages in Field Test Environments*, Silver Spring, MD, May 10, 1976, P. H. Adams, Ed., pp. 16-18 (Society for Experimental Stress Analysis, Westport, CT, 1976).

Key words: adhesive; backing; connection; environment; gage element; leads; load; protective coating; resistance; sensitivity change; stability; strain gages; structure; transducers; zero shift.

Although information exists on the change of strain gage and transducer response with time during storage and when occasional load cycles are imposed, there is almost no published information on the changes that occur when loads are sustained for long periods of time (week to years). This paper speculates on factors that could cause various changes and suggests that an effort should be made to evaluate some of these factors.

- 19050.** McMichael, J. M., Deutsch, S., *Magnetohydrodynamic pipe flow in nonuniform, axisymmetric fields*, *Phys. Fluids* 22, No. 11, 2087-2092 (Nov. 1979).

Key words: fringing fields; magnetohydrodynamics, MHD; nonuniform fields; pipe flow.

The perturbation of Poiseuille pipe flow by nonuniform, axisymmetric magnetic fields with weak axial gradients is treated theoretically for small magnetic Reynolds numbers and finite Hartmann and Reynolds numbers. Numerical examples for pipe flow through a finite length magnet solenoid are given. The results indicate that separated flow may develop in the fringing magnetic fields accompanied by appreciable local static pressure gradients and high local current densities.

- 19051.** Wilson, C. B., *Standardizing computer performance measures*, *Proc. CMG X Int. Conf. on Controlled Resource Management Through Computer Performance Evaluation*, Dallas, TX, Dec. 4-7, 1979, pp. 67-72 (Computer Measurement Group, Inc., Bethesda, MD, Dec. 1979).

Key words: ADP installation management; ADP installation models; computer performance evaluation; computer performance management; computer performance measurement; standard performance measures.

Almost since the inception of performance measurement, the need for standard performance measures has been indicated. The underlying cause of many of the current inadequacies in the computer performance area can be attributed to a lack of standard performance measures and reporting formats. The Institute for Computer Sciences and Technology of the National Bureau of Standards has recently embarked on a project to determine the feasibility of developing a set of standard performance measures, as well as an accompanying standard reporting format. This paper discusses the reasons behind the project and the methodology which is being employed in this task.

- 19052.** Paffenbarger, G. C., Rupp, N. W., *Dental materials*, Paper in *Kirk-Othmer: Encyclopedia of Chemical Technology*, 7, Third Edition, 461-521 (John Wiley & Sons, Inc., New York, NY, 1979).

Key words: alloy, base, dental; alloy, gold, dental; amalgam, dental; cements, dental; dental materials; gypsums,

dental; impression materials, dental; polymers, dental; refractories, dental; specifications, dental; waxes, dental.

Dental materials encompass organic, metallic and ceramic components and combinations of these. Many of these have unique therapeutic or prosthetic applications since much of dental therapy involves the replacement of hard and soft tissues lost through disease.

The operative restorations and prostheses employ amalgam, chromium-based alloys, precious and noble metal alloys, special cements, synthetic polymers, and porcelain, all of which must serve in the mouth with mechanical efficiency, freedom from toxicity, and the ability to withstand the corrosive oral environment. Many accessory materials are needed in fabrication of dental appliances. These include synthetic polymers, gums, waxes, hydrocolloids, elastomers, gypsums and refractories.

The employment, values for the pertinent physical and chemical properties, the compositions and specifications characterizing the foregoing materials are presented and documented along with adequate sources for additional information.

The total value of dental supplies of all kinds manufactured in the USA was estimated at \$520 million in 1976. These materials and devices will be used by about 106,000 practicing dentists and over 8,500 dental laboratories employing almost 38,000 technicians.

- 19053.** Jones, F. E., *Application of an improved volume calibration system to the calibration of accountability tanks*, (Proc. IAEA Int. Symp. on Nuclear Materials Safeguards, Vienna, Austria, Oct. 2-6, 1978), Paper in *Nuclear Safeguards Technology 1978*, II, 653-659 (International Atomic Energy Agency, Vienna, Austria, 1979).

Key words: accountability tanks; differential pressure gage; nuclear materials processing; nuclear safeguards; volume calibration; volumetric test measures.

This paper describes a very significantly improved system for the volume calibration of nuclear materials accountability tanks. The system involves the transfer of the current technology of liquid volume measurement and differential pressure measurement to the field, enabling an improvement of tank volume calibration by one to two orders of magnitude, and a consequent improvement in process solution volume measurement, leading to significantly improved accountability of nuclear materials for nuclear safeguards purposes. The system has been used in a very successful calibration of an input accountability tank at the Savannah River Plant operated for the US Department of Energy.

- 19054.** Sullivan, D. B., Vorreiter, J. W., *Space applications of superconductivity*, *Cryogenics*, pp. 627-631 (Nov. 1979).

Key words: aerospace; digital; electronics; gravitational experiments; high-Q cavities; interference; Josephson effect; magnets; superconductivity.

This is the first of a seven part series on the potential applications of superconductivity in space. The series considers six classes of superconducting instrumentation for space applications; high field magnets, low frequency sensors, digital electronics, microwave and infrared detectors, instruments for gravitational studies, and high-Q cavities. This introductory article provides background information for the study and briefly summarizes the contents of the articles which follow. This series is derived from a study supported by NASA and, as such, contains some speculation about ultimate instrument performance levels and future space missions.

19055. Wineland, D. J., Itano, W. M., **Laser cooling of atoms**, *Phys. Rev. A* 20, No. 4, 1521-1540 (Oct. 1979).

Key words: anti-Stokes Raman scattering; atomic physics; laser scattering; laser spectroscopy; Mössbauer effect; optical pumping; radiation pressure; radiative cooling; Raman scattering; spectroscopy.

Various aspects of the laser cooling of atoms are investigated theoretically. More generally, the authors investigate a process through which the kinetic energy of a collection of resonant absorbers can be reduced by irradiating these absorbers with near-resonant electromagnetic radiation. The process is described here as anti-Stokes spontaneous Raman scattering. Cooling mechanisms, rates, and limits are discussed for both free and bound atoms.

19056. Hamilton, C. A., Lloyd, F. L., Peterson, R. L., Andrews, J. R., **A superconducting sampler for Josephson logic circuits**, *Appl. Phys. Lett.* 35, No. 9, 718-719 (Nov. 1, 1979).

Key words: amplitude comparator; Josephson junction; risetime; sampler; transition duration.

A method is described for automating a technique which is used to sample transition duration (rise time) in superconducting logic circuits. The method is based on measuring the time at which a biased Josephson junction switches under the influence of an applied signal. The system transition duration is limited primarily by time jitter which is estimated to be 7 ps. Transition durations of as little as 9 ps have been observed.

19057. Harris, R. E., Hamilton, C. A., Lloyd, F. L., **Multiple-quantum interference superconducting analog-to-digital**, *Appl. Phys. Lett.* 35, No. 9, 720-721 (Nov. 1, 1979).

Key words: a/d converter; cryogenic electronics; digital instrument; high speed instruments; Josephson effect; superconducting electronics.

Multiple-quantum interference in a superconducting interferometer is used for analog-to-digital conversion. The simple fully parallel four-bit converter which is described is the first known use of this effect in a digital circuit. Sampling rates of  $2 \times 10^3$  per second were achieved, and much higher rates appear possible.

19058. Mangum, B. W., Thornton, D. D., **Determination of the triple-point temperature of gallium**, *Metrologia* 15, No. 4, 201-215 (1979).

Key words: defining temperature fixed point; gallium; gallium melting-point temperature; gallium triple-point temperature; secondary temperature fixed point; thermometry.

We have determined the triple-point temperature of high-purity gallium to be  $29.77406^\circ\text{C}$  using three standard platinum resistance thermometers (SPRTs) calibrated on the IPTS-68 and using samples of gallium from three commercial sources. All data obtained on the highest purity sample have a standard deviation of  $\pm 0.00011^\circ\text{C}$ . The overall systematic uncertainty is estimated to be  $\pm 0.00011^\circ\text{C}$ . The day-to-day irreproducibility of a single melt of each gallium cell was found to be  $< \pm 15^\circ\text{C}$ , while over a period of 7 months the irreproducibility among melts of each gallium cell was  $< \pm 0.00011^\circ\text{C}$ . These limits on the reproducibility appear to be largely instrumental since every time an SPRT was left in a gallium cell for several days there was no change in the indicated temperature of the triple-point to within the instrumental resolution of  $\pm 1.5^\circ\text{C}$ . The pressure dependence was measured and determined to be  $dT/dP = -2.011 \pm 0.001 \text{ m}^\circ\text{C/atm}$ .

19059. Mamrak, S. A., Abrams, M. D., **A taxonomy for valid test workload generation**, *Comput. Mag.* 12, No. 12, 60-65 (Dec. 1979).

Key words: benchmark; evaluation environments; statistical pattern recognition; test environments; test workload generation.

The valid generation and use of a benchmark that adequately represents a real system workload as required for various computer performance evaluation studies is affected by the particular evaluation environment in which the benchmark is to be used. A taxonomy of test environments is presented in this paper, along with a specification of which test workload generation methods are valid in each evaluation context. The primary impact of the taxonomy is the clear identification of the relatively small number of evaluation environments in which valid workload generation methodologies have been developed. The transfer of a valid methodology to a new environment is shown to often invalidate that methodology. A methodology based on statistical pattern recognition techniques is proposed as the best candidate for a general solution to the workload characterization problem in most evaluation environments.

19060. Lyon, G., **A criterion for packing hash tables**, *Proc. 1979 Conf. on Information Sciences and Systems, Baltimore, MD, Mar. 28-30, 1979*, pp. 262-265 (The Johns Hopkins University, Baltimore, MD, May 1979).

Key words: buckets; hashing; open addressing; worst case retrievals.

One can minimize worst case searches for "open addressing" hashing while perturbing average retrieval only slightly. Applying this observation to tables with buckets provides excellent search performances. Once bucket size equals four or more records, even worst cases—occurring perhaps for a fifth of the items—should not require more than two table probes.

19061. Chwirut, D. J., **A simple technique for visualizing transmitted or reflected sound fields**, *Mater. Eval.* 37, No. 13, 29-32 (Dec. 1979).

Key words: analog recording; C-scan; instrumentation; sound field; ultrasonics.

A simple apparatus for recording transmitted or reflected ultrasonic fields, in longitudinal or transverse section, is described. The equipment required, in addition to the flaw detector and immersion lab scanner, consists only of two position sensors with power supplies and an analog dc X-Y plotter. This system has been used at the National Bureau of Standards (NBS) for ultrasonic transducer characterization, material evaluation, and defect detection. Examples of usage and output are presented.

19062. Antonucci, J. M., Grams, C. L., Termini, D. J., **New initiator systems for dental resins based on ascorbic acid**, *J. Dent. Res.* 58, No. 9, 1887-1899 (Sept. 1979).

Key words: accelerators; ambient polymerization; ascorbic acid; dental monomers; initiator systems; organic peroxides; redox reactions; stability; transition metals.

Several promising initiator systems for the ambient polymerization of dental monomers were developed utilizing the oxidation-reduction reactions of certain organic peroxides and certain transition metal compounds with L(+) ascorbic acid and its derivatives.

19063. Müller, A. P., Cezairliyan, A., **Radiance temperature (at 653 nm) of palladium at its melting point**, *High Temp. Sci.* 11, 41-47 (1979).

Key words: dynamic measurements; high temperature; melting; normal spectral emittance; palladium; radiance temperature.

The radiance temperature (at 653 nm) of palladium 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 12 specimens is 1688 K on IPTS-68, with a standard deviation of 0.5 K and a maximum absolute deviation of 0.9 K. The total error in the radiance temperature is estimated to be not more than  $\pm 5$  K.

**19064.** Vorburger, T. V., Teague, E. C., Scire, F. E., Rosberry, F. W., **Measurements of stylus radii**, (Proc. Int. Conf. on Metrology and Properties of Engineering Surfaces, Leicester, England, Apr. 18-20, 1979), *Wear* **57**, 39-49 (1979).

Key words: metrology; profilometer; razor blade; SEM; stylus; surface; surface roughness; surface texture.

In stylus measurements of surface texture the measured results for roughness depend on the stylus radius. Therefore it is important to determine the stylus radius. Since stylus tips are not perfectly spherical, the local radius of curvature varies significantly over the surface which makes the determination of an effective radius difficult. Both the techniques used to generate stylus profiles and the subsequent algorithms used to derive an effective radius are discussed. Comparisons are made between three techniques: sharp-edge traces, optical microscopy and scanning electron microscopy. Several algorithms, including that prescribed by the American National Standard ANSI B46-1, are discussed. It is concluded that the radius scale method is accurate, unambiguous and easy to use for routing measurements in the laboratory.

**19065.** Schoenwetter, H. K., **NBS provides voltage calibration service in 0.1—10-Hz range using ac voltmeter/calibrator**, *IEEE Trans. Instrum. Meas.* **28**, No. 4, 327-331 (Dec. 1979).

Key words: ac-dc difference; ac-dc transfer; ac voltage calibration; ac voltage calibrator; ac voltage measurements; rms voltmeter; thermal voltage converter.

Prompted by the need to support vibration and pressure measurements at frequencies down to 0.5 Hz (with expected future needs to 0.1 Hz), NBS now offers a calibration service for voltage standards and rms voltmeters in the range of 0.1—10 Hz. The means for the service is an "ac Voltmeter/Calibrator," an NBS-developed instrument containing an rms digital voltmeter and ac and dc voltage calibrators. The methods used to calibrate the ac voltage calibrator are discussed; also, application of the ac Voltmeter/Calibrator to the calibration of customers' voltage and voltmeter standards is described. Finally, a multifrequency voltage reference source with frequency-independent amplitude is proposed as a more suitable transfer standard than thermal voltage converters (TVC's) for the 0.1—10-Hz range.

**19066.** So, E., Shields, J. Q., **Losses in electrode surface films in gas dielectric capacitors**, *IEEE Trans. Instrum. Meas.* **28**, No. 4, 279-284 (Dec. 1979).

Key words: capacitor; dielectric film; dissipation factor; electrode surface; loss angle; phase angle; power factor; surface loss.

The surface characteristic of a number of electrode materials including stainless steel, brass, brass with various plated surfaces, aluminum, and anodized aluminum has been examined over a wide range of humidity. The measurements of surface characteristic, expressed in microradian millimeters, have an estimated uncertainty of 0.01  $\mu$ rad-mm.

**19067.** Ruegg, R., **Calculating the solar dollar gains: Ins and outs of life cycle costing**, *Sol. Eng. Mag.*, pp. 11-14 (July 1979).

Key words: energy conservation; federal buildings; life-cycle costing; solar energy.

This article provides an overview of life-cycle costing and describes briefly how the federal government is applying the technique to different kinds of investment decisions in its programs to conserve non-renewable energy and to demonstrate the use of solar energy in federal buildings.

**19068.** Munro, R. G., Block, S., Piermarini, G. J., **Correlation of the glass transition and the pressure dependence of viscosity in liquids**, *J. Appl. Phys.* **50**, No. 11, 6779-6783 (Nov. 1979).

Key words: correlation model; glass transition; pressure; ruby  $R_1$  linewidth; viscosity.

The determination of the glass-transition pressure by the ruby  $R_1$  line-broadening method is quantitatively confirmed to within 10% by an independent method. The procedure utilizes a model which describes the pressure dependence of the viscosity and contains the glass-transition pressure as a parameter. The two methods are compared for three liquids, *n*-butyl chloride, 4:1 methanol-ethanol, and isopropyl alcohol. Data from earlier works are used for 4:1 methanol-ethanol and isopropyl alcohol. The viscosity of *n*-butyl chloride at room temperature is measured as a function of pressure to 36 kbars in a diamond-anvil falling-sphere viscometer, and the glass-transition pressure is determined by a separate measurement using the ruby  $R_1$  line-broadening method.

**19069.** Roberts, J. R., Knystautas, E. J., Sugar, J., **One-electron spectrum of Xe VIII**, *J. Opt. Soc. Am. Lett.* **69**, No. 11, 1620-1622 (Nov. 1979).

Key words: Ag I; energy levels; isoelectric sequence; VUV spectra; wavelengths; xenon.

The spectrum of Xe VIII has been observed in a theta-pinch discharge. New line identifications were made that determine the energies of the 6s, 7s, 6p, and 5f terms relative to the 5s  $^2S$  ground state and confirm the previously known 5p and 5d terms. An independent system of levels derived from the observed 4f-ng ( $n = 5, 6$ ) transitions was found. Its position relative to the ground state is obtained from a predicted value for the 5g effective quantum number  $n^*$ . From the *ns* series ( $n = 5-7$ ) a value for the ionization energy of  $105.91 \pm 0.05$  eV was derived.

**19070.** Guildner, L. A., Burns, G. W., **Accurate thermocouple thermometry**, (Proc. 6th European Thermophysical Properties Conf., Dubrovnik, Yugoslavia, June 26-30, 1978), *High Temp.—High Pressures* **11**, 173-192 (1979).

Key words: high temperature thermocouples; recommended thermocouples; temperature measurement; thermocouple insulators; thermocouple lead tempering; thermocouple materials; thermocouples; thermocouple thermometry.

<sup>4</sup> To obtain high accuracy by thermocouple thermometry, a combination of factors must be satisfied: a choice of thermocouple consistent with the chemical and physical conditions of the experiment; its annealing, verification of homogeneity and subsequent calibration; the selection of insulators and sheaths; and an installation to achieve adequate tempering and sensing of the desired temperature. Thermocouples that have been standardized are reviewed along with research and development work on W-3%Re/W-25%Re, Nicrosil/Nisil and Pt-Rh combinations that have given improved high-temperature measurements. Thermocouples for high accuracy and stability are recommended for a given temperature range and conditions of experiment, with their sensitivities, stability, and compatible choices of insulators and sheaths.

**19071.** Moldover, M. R., Waxman, M., Greenspan, M., **Spherical acoustic resonators for temperature and thermophysical property measurements**, (Proc. 6th European Thermophysical Properties Conf., Dubrovnik, Yugoslavia, June 26-30, 1978), *High Temp.—High Pressures* **11**, 75-86 (1979).



**Key words:** acoustic radial resonances; acoustic velocity of sound; dilute gases; low-frequencies; spherical cavity; thermophysical properties.

A theoretical and experimental study is reported of the advantages and limitations of using the acoustic radial resonances in a spherical cavity to obtain thermophysical property data in dilute gases. The velocity of sound in dilute gases (0.1-0.5 MPa) is now measured with an accuracy of 0.02% and a precision of 0.001%, and a significant increase in accuracy is anticipated. The measurements are at sufficiently low frequencies (3-15 kHz) to be of value in determining thermophysical properties in many polyatomic gases.

**19072.** Brauer, G. M., Dulik, D. M., Antonucci, J. M., Termini, D. J., Argentar, H., **New amine accelerators for composite restorative resins**, *J. Dent. Res.* **58**, No. 10, 1994-2000 (Oct. 1979).

**Key words:** amine accelerators; composite restorative resins; dimethylaminogluthethimide; dimethylaminophenylacetic acid and esters; properties of composites; tertiary aromatic amines.

A number of newly synthesized tertiary aromatic amines were compared with commonly used accelerators in the benzoyl peroxide initiated room temperature polymerization of composite restorative resins. The order of reactivity of the more desirable amines based on the cure times of the composite is *p*-dimethylaminophenylacetic acid (DMPAA) > *N,N*-dimethyl-*sym*-xylidine (DMSX) > *N,N*-dimethyl-*p*-toluidine (DMPT), *N,N*-dimethylaminogluthethimide (DMAG) > methyl ester of *p*-dimethylaminophenylacetic acid (MDMPAA) > *N,N*-dihydroxyethyl-*p*-toluidine (DHEPT). The overall characteristics of the composites (hardening time, strength and color stability) containing DMPAA, MDMPAA and DMAG compared favorably to resins cured with commonly used tertiary amines or the other accelerators evaluated. Maximum compressive and tensile strength for the composites are obtained only over a narrow concentration range of accelerator used.

**19073.** Ruegg, R., **The grand scheme/An economist's view of energy conservation**, *Proc. Conf. Conservation: Energy Management by Design*, El Paso, TX, Mar. 1979, pp. 1-19 (Department of Energy, Washington, DC, 1979).

**Key words:** building economics; economic analysis; energy conservation; windows.

This paper gives an overview of the role of economics in planning and implementing energy conservation. It explains how the economist seeks to find the economically efficient balance among the alternatives to nonrenewable energy use. It discusses the use of economic analysis to solve problems of importance to designers, engineers, builders, manufacturers, public utilities, government policy makers, and consumers. A brief case study of the life-cycle cost performance of alternative window systems is presented to show how economic analysis can guide decisions of mutual concern to different members of the building community.

**19074.** Polturak, E., Rosenbaum, R., Soulen, R. J., Jr., **Anomalous cooling power of dilution refrigerators and the heat of transport of He<sup>3</sup>-He<sup>4</sup> solutions**, *Cryogenics* **19**, No. 12, 715-724 (Dec. 1979).

**Key words:** cooling power; dilution refrigerator; liquid He<sup>3</sup>; refrigeration; thermometry.

The experimental cooling power of a dilution refrigerator employing two mixing chambers was found to exceed the theoretical cooling power by as much as 50%: with a single mixing chamber the experimental cooling power exceeded the theoretical value by 15%. This excess cooling power is explained by assuming that the He<sup>3</sup> flow is partially diffusive. Information

concerning the thermal diffusion ratio  $k_T$  and the He<sup>3</sup> relaxation time in a He<sup>3</sup>-He<sup>4</sup> solution is extracted from the data.

**19075.** Souders, T. M., Flach, D. R., **An automated test set for high resolution analog-to-digital and digital-to-analog converters**, *IEEE Trans. Instrum. Meas.* **28**, No. 4, 239-244 (Dec. 1979).

**Key words:** analog-to-digital converter testing; automatic; digital-to-analog converter testing; gain; high resolution; linearity; noise; offset; static test set.

An automated test set is described for characterizing the static performance of high resolution ADC's and DAC's. Measured parameters include gain, offset, linearity, and equivalent ADC input noise with uncertainties of 2-4 ppm. Measurements to full accuracy can be made at a rate up to 40/s. A 20-bit DAC serves as a comparison standard.

**19076.** Sockut, G. H., Goldberg, R. P., **Database reorganization—Principles and practice**, *ACM Comput. Surv.* **11**, No. 4, 371-395 (Dec. 1979).

**Key words:** data base; database management; file maintenance; reformatting; reorganization; restructuring.

Database reorganization can be defined as changing some aspect of the way in which a database is arranged logically and/or physically. An example is changing from a one-to-one to a one-to-many relationship. Reorganization is a necessary function in a database system. This paper introduces the basic concepts of reorganization, including why it is performed. Many types of reorganization are described and classified into logical/physical levels. Then pragmatic issues such as reorganization strategies, a survey of several commercial reorganization facilities, case studies, and database administration considerations are covered. Finally, several research efforts are surveyed.

**19077.** Clifton, J. R., Mathey, R. G., Anderson, E. D., **Creep of coated reinforcing bars in concrete**, *ASCE J. Struct. Div.* **105**, No. ST10, 1935-1947 (Oct. 1979).

**Key words:** concrete (reinforced); creep tests; evaluation; organic coating; pullout tests; reinforcing steels; structural engineering.

The creep properties of organic coated and uncoated No. 6 deformed steel reinforcing bars, embedded in concrete prisms, were determined for corresponding tensile stresses in the bars at the loaded ends of 15,000 psi (103 MN/m<sup>2</sup>) and 30,000 psi (206 MN/m<sup>2</sup>). Slip of the bars in the concrete under static loading was measured at both the free and loaded ends of the specimens at periodic intervals for two years. Twenty-four reinforcing bars were included in the tests, they consisted of 18 bars coated (in duplicates) with 9 different epoxy materials; 2 bars coated with a poly(vinyl chloride) material; and 4 uncoated reinforcing bars.

Reinforcing bars coated with six of the epoxy materials developed slip-time relationships (creep) after two years of testing that were nearly the same as those for the uncoated bars. The remaining epoxy coated bars exhibited higher rates of slip in the concrete and were judged to have poor creep properties. The excessive rates of slip of the poly(vinyl chloride) coated bars in the concrete should preclude their substitution for uncoated reinforcing bars in concrete.

The relative performance of some coated reinforcing bars in the creep study were different than those obtained in earlier pullout tests. Therefore, from the data obtained in this study, it appears that the long-term structural performance of organic coated reinforcing bars in concrete cannot be estimated solely on the basis of their bond strength determined from pullout tests.

**19078.** Pierce, D. T., Wang, G. C., Celotta, R. J., **Face dependence of the spin polarization of photoelectrons from NEA GaAs**



(100) and (110), *Appl. Phys. Lett.* **35**, No. 3, 220-222 (Aug. 1, 1979).

Key words: depolarization; polarized electron source; polarized photoemission GaAs; spin-exchange scattering; spin polarization.

We present measurements of the spin polarization  $P$  of photoelectrons from negative electron affinity (NEA) GaAs(100) and find  $P = 43\%$  at a photon energy of 1.57 eV. This contrasts with a maximum  $P = 21\%$  measured by Erbudak and Reihl for NEA GaAs(110), which led them to conclude that NEA and high  $P$  exclude each other. This difference in  $P$  is important for sources of polarized electrons employing photoemission from GaAs. We suggest that the origin of this difference may be connected with differences in the photoelectron emission process at the two faces, as calculated by Burt and Inkson.

**19079.** Pommersheim, J. M., Clifton, J. R., **Mathematical modeling of tricalcium silicate hydration**, *Cem. Concr. Res.* **9**, 765-770 (1979).

Key words: cement; hydration; mathematical modeling; tricalcium silicate.

Based on conceptual models for the stages in the hydration of tricalcium silicate, a mathematical model was developed. The separate resistances in the mathematical model correspond to the phenomenological stages of the conceptual model. Comparison of model output with available hydration data gave a reasonable fit between the model and the data.

**19080.** Furukawa, G. T., **Realization of triple point of argon in a transportable sample cell**, *12th Session Comité Consultatif de Thermométrie Meeting, Sèvres, France, May 9-10, 1978, Annexe T 13*, pp. T100-T102 (Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92310, Sèvres, France, 1979).

Key words: argon triple point; fixed point; transportable fixed point.

An argon sample of stated purity of 99.9999 percent was sealed in a miniature pressure cell and the triple point was investigated by meltingpoint measurements. The triple point of argon was found to be 83.8003<sub>8</sub> K. The results of the measurements show that the exchange of miniature pressure cells of argon should permit the definition of the argon triple-point temperature to within 0.1 mK or smaller.

**19081.** Furukawa, G. T., Riddle, J. L., **Comparison of freezing temperatures of the National Bureau of Standards SRM-740 zinc standards**, *12th Session Comité Consultatif de Thermométrie Meeting, Sèvres, France, May 9-10, 1978, Annexe T 23*, pp. T133-T135 (Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92310, Sèvres, France, 1979).

Key words: fixed point; freezing point; zinc point.

Freezing-point cells prepared with National Bureau of Standards SRM-740 zinc standards of 99.9999 percent nominal purity were intercompared. The results show that the freezing points agree within about 0.1 mK.

**19082.** Larzillière, M., Jacox, M. E., **Infrared and ultraviolet absorption spectra of PO and HPO isolated in an argon matrix**, *J. Mol. Spectrosc.* **79**, 132-150 (1980).

Key words: discharge sampling; HPO; infrared spectrum; matrix isolation; PO; PO<sub>2</sub>; (PO)<sub>2</sub>; ultraviolet spectrum; vacuum ultraviolet photolysis.

Upon vacuum ultraviolet photolysis of Ar:PH<sub>3</sub>:N<sub>2</sub>O deposits at 14 K, PO is formed in sufficient concentration for observation of its vibrational fundamental absorption and of bands associated with three of its electronic transitions, and HPO is formed in sufficient concentration for the identification of both of its ground-state stretching fundamental absorptions. The in-

frared identifications are supported by studies of the products of the codeposition at 14 K of an Ar:PH<sub>3</sub> sample with an Ar:O<sub>2</sub> sample that had been passed through a microwave discharge. The matrix observations support the assignment of the  $B^2\Sigma^- - X^2\Pi$  band system of PO as a valence transition. Detailed isotopic substitution studies have confirmed the assignment of the PH stretching fundamental of ground-state HPO near 2100 cm<sup>-1</sup>, implying a relatively weak and long PH bond. A four-constant valence force potential has been derived for HPO. Tentative infrared identifications of PO stretching absorptions of PO<sub>2</sub> and (PO)<sub>2</sub> are suggested.

**19083.** Kuehner, E. C., Pella, P. A., **Energy-dispersive x-ray spectrometric analysis of NBS Standard Reference Material 1571 Orchard Leaves after oxidation and borate fusion**, *Appl. Spectrosc.* **33**, No. 6, 632-634 (1979).

Key words: automated borate fusion; botanical samples; energy-dispersive x-ray spectrometry; NBS-SRM 1571 Orchard Leaves.

An automated borate fusion procedure was investigated as a sample preparation method, after removal of organic matter, for the analysis of seven elements in NBS Standard Reference Material 1571 Orchard Leaves by energy-dispersive x-ray spectrometry. A 2.0 g sample was penetrated by oxidation with H<sub>2</sub>SO<sub>4</sub>-HNO<sub>3</sub> acid mixture and the residue was fused with 6.5 g of lithium tetraborate in the conventional manner. Relative errors on the order of 2 to 10% were obtained for K, Ca, Fe, Mn, Zn, and Pb.

**19084.** Konowalow, D. D., Stevens, W. J., Rosenkrantz, M. E., **Long-range interactions in low-lying states of Li<sub>2</sub><sup>+</sup>**, *Chem. Phys. Lett.* **66**, No. 1, 24-28 (Sept. 15, 1979).

Key words: ab initio computation; exchange forces; ion-induced dipole interactions; ion-quadrupole interactions; lithium molecule-ion; long-range interactions.

The long-range portions of the potential energy curves for the states of Li<sub>2</sub><sup>+</sup> which correspond to the interaction of Li<sup>+</sup>(1s<sup>2</sup>S) with either Li(1s<sup>2</sup>s<sup>2</sup>S) or Li(1s<sup>2</sup>p<sup>2</sup>P) are analyzed to deduce their exchange and ion-multipole interaction components.

**19085.** Fong, J. T., **Direct observations—The essential ingredients for discovering fundamental mechanisms of fatigue**, (Proc. ASTM-NBS-NSF Fatigue Mechanisms Symp., Kansas City, MO, May 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* **675**, pp. 287-291 (1979).

Key words: failure data; fatigue; fracture; inservice data; mechanical engineering; nuclear reactors; piping; pressure vessel; pump; reliability; risk analysis; valves.

Through two stories from the history of medical science, both related to the theory of bloodletting as a treatment for inflammatory diseases, the importance of direct observations and the use of a numerical scheme in all scientific work, including fatigue mechanism research, are illustrated. Brief remarks on two specific questions arising from two earlier sessions on direct observations are inserted. The two questions are: (1) What is the connection between direct observations and quantitative microscopy? (2) What could fatigue design and testing engineers learn from the direct observations of fatigue damage at microscopic levels? A cautionary note on the temptation to extrapolate from insufficient direct evidence of fatigue damage is also included.

**19086.** Fong, J. T., **Statistical aspects of fatigue at microscopic, specimen, and component levels**, (Proc. ASTM-NBS-NSF Fatigue Mechanisms Symp., Kansas City, MO, May 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* **675**, pp. 729-758 (1979).

Key words: fatigue; fracture; mathematical modeling; micromechanics; microstructure; nuclear fuel element; paper; quantitative microscopy; size effect; solid mechanics; statistical methods; steel.



The study of fatigue mechanisms at the microscopic level is examined. The complexity of the microstructure and the availability of quantitative microscopy concepts created a need to introduce statistical tools to the fundamental aspects of fatigue research. Examples of the corrosion fatigue of high-strength steel, the bending fatigue of currency paper, and the swelling of nuclear fuel elements are used to illustrate this new viewpoint. The statistical concept of stress in a medium with distributed voids or other geometric imperfections is introduced to permit the use of models different from the conventional continuum viewpoint. The concept of a nested model and the incorporation of a size effect in the study of fatigue at three microscopic levels and three macroscopic (specimen, component, structure) levels are discussed.

**19087.** Fong, J. T., **Fatigue mechanism—Key to the solution of the engineer's second fundamental problem**, (Proc. ASTM-NBS-NSF Fatigue Mechanisms Symp., Kansas City, MO, May 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 675, pp. 3-8 (1979).

Key words: composite materials; corrosion fatigue; dislocations; fatigue mechanism; fracture mechanics; mathematical modeling; micromechanics; polymers; quantitative microscopy; slip bands; statistical aspects of fatigue; striations.

The rationale for studying fatigue and fatigue mechanism is examined by considering two fundamental problems in engineering, namely, the problem of feasibility, by asking whether a product works, and the problem of fatigue, by asking whether a product lasts. It is shown that the first problem (feasibility) is easier than the second (fatigue) because the solution to the second requires experimental information of a time scale incompatible with that available to the engineer or the material scientist. To resolve this dilemma, it is proposed that advances in computer-aided quantitative microscopy, fracture mechanics, and many other allied disciplines, be incorporated in measuring microstructural changes due to fatigue at a time scale workable in a laboratory. It is concluded that such study in discovering fundamental mechanisms of fatigue holds the key to the solution of the second fundamental problem in engineering.

**19088.** Fiori, C. E., Myklebust, R. L., Newbury, D. E., **A catalogue of artifacts observed in energy-dispersive x-ray spectrometry and their influence on analysis**, (Proc. Workshop on Biological X-ray Microanalysis by Electron Beam Excitation, Boston, MA, Aug. 25-26, 1977), Paper in *Microbeam Analysis in Biology*, pp. 225-263 (Academic Press, Inc., New York, NY, 1979).

Key words: electron probe microanalysis; energy dispersive x-ray spectrometry; microanalysis; qualitative analysis; quantitative analysis; scanning electron microscopy; spectral artifacts; transmission electron microscopy.

Spectra recorded with the lithium-drifted silicon detector, a type of energy dispersive x-ray spectrometer frequently used in electron beam instruments, are subject to artifacts introduced during the processes of x-ray detection and signal amplification. The artifacts observed include x-ray absorption effects in the components of the spectrometer and accompanying fluorescence of the silicon of the detector, peak broadening, peak distortion, formation of parasitic peaks caused by escape of silicon x-rays from the detector, sum peaks due to pulse coincidence, and effects due to system deadtime. Other artifacts arise from interactions of the spectrometer with its environment, including microphonic effects and sensitivity to stray sources of radiation in the sample chamber. The artifacts influence the strategy for qualitative and quantitative analysis. Qualitative analysis proceeds through the identification of all members of the family of x-ray lines for each element. Artifacts in spectra are recognized by their particular characteristics and eliminated from consideration as possible elemental constituents of the sample. In quantitative

analysis, peak overlaps resulting from broadening can be calculated with algorithms based on the Gaussian function which describes each peak. Peak distortions and silicon escape peaks can also be calculated with appropriate algorithms.

**19089.** Kuyatt, C. E., Galejs, A., **Tests of fourth-order difference equations for Laplace's equation in cylindrical coordinates**, *Proc. Eighth Int. Conf. on Electron and Ion Beam Science and Technology*, Seattle, WA, May 21-26, 1978, pp. 655-657 (The Electrochemical Society, Inc., Princeton, NJ, 1978).

Key words: cylindrical coordinates; difference equations; electron optics; fourth-order; Laplace's equation.

While most digital computer solutions of Laplace's Equation have employed the second-order five-point difference equations, a few recent calculations used nine-point difference equations. In principle, nine-point equations should be capable of giving the potential to an accuracy which is fourth-order in the mesh size. However, only Durand's equations are derived in such a way that fourth-order accuracy is clearly obtained. To demonstrate the accuracy of Durand's equations, and to assess the accuracy of other equations, we have tested several difference equations for cylindrical coordinates on the analytic potential distribution between two spheres.

**19090.** Rumble, J. R., Jr., Beaty, E. C., Pitchford, L. C., **Unreliable data—Its impact in modelling MHD power-generating devices**, *Proc. Sixth Int. Conf. on CODATA*, Santa Aavia, Italy, May 1978, B. Dreyfus, Ed., pp. 243-246 (Pergamon Press, New York, NY, 1979).

Key words: electron scattering cross section; error analysis; MHD; plasma conductivity.

A promising method of advanced utilization of coal as an energy source is power generation by coal-fired magnetohydrodynamics (MHD). This involves burning pulverized coal, adding an easily ionized metal salt, expanding the ionized gas through a nozzle and passing it through a high magnetic field. Electric current is extracted as the free electrons to migrate to the walls. Resistance in the circuit results from electron collisions with the gas atoms and molecules. The conductivity is the relevant physical characterization of the gas, and the electron scattering cross section is the measure of resistance. We have calculated the conductivity of typical MHD gases, using our best estimates of the cross-sections for all species present. We then recalculated the conductivity using the high and low estimates reflecting the experimental uncertainties for the cross sections. The results show that the conductivity and hence, the electric current extractable, varied by as much as a factor of two. The implications of this variance are obvious in 1) the design of large scale MHD plants and 2) the basic physics research that must provide better cross-section data. It is clear that ignoring this possible large error can have potentially major effects in the success of MHD power generation.

**19091.** Gross, J. G., Spence, J. C., Crist, R. A., **Solving problems in the structural design field**, *Consult. Eng.*, pp. 86-90 (Jan. 1980).

Key words: building regulations; building standards development; consensus standards; development of standards; structural design standards.

This paper provides background information on the development and use by the United States building community of structural design standards. The use of such standards for regulatory purposes is discussed. Standard generation methods, with particular emphasis on the "consensus process," are compared. Potential new structural design standards resulting from technical advancements and changing societal needs are identified. Federal Government, building community, legal and consumer interest concerns for changing developmental processes are reviewed. Five possible major changes in approach are foreseen.



**19092.** Kurylo, M. J., Anderson, P. C., Klais, O., A flash photolysis resonance fluorescence investigation of the reaction  $\text{OH} + \text{CH}_3\text{CCl}_3 \rightarrow \text{H}_2\text{O} + \text{CH}_2\text{CCl}_3$ , *Geophys. Res. Lett.* 6, No. 10, 760-762 (Oct. 1979).

Key words: atmospheric chemistry; methyl chloroform; OH radicals; rate constant; resonance fluorescence; stratospheric ozone.

The absolute rate constant for the reaction  $\text{OH} + \text{CH}_3\text{CCl}_3 \rightarrow \text{H}_2\text{O} + \text{CH}_2\text{CCl}_3$  has been determined by the flash photolysis resonance fluorescence technique from 253 to 363 K. The results are used to recommend the Arrhenius expression:

$$k_1 = (5.4 \pm 1.8) \times 10^{-12} \exp[-(1810 \pm 100)/T]$$

in units of  $\text{cm}^3 \text{ molec}^{-1} \text{ s}^{-1}$ . Use of this equation with atmospheric observational data on methyl chloroform nearly doubles the predicted tropospheric OH reaction sink strength for the removal of important atmospheric gases whose lifetimes are controlled by OH. Comparison of the results reported here with previously reported literature values indicates a strong interference of olefinic impurities on the past investigations.

**19093.** VanderBrug, G. J., Nagel, R. N., Vision systems for manufacturing, *Proc. 1979 Joint Automatic Control Conf., Denver, CO, June 17-21, 1979*, pp. 760-770 (American Institute of Chemical Engineers, New York, NY, 1979).

Key words: automation; image processing; inspection; manufacturing; pattern recognition; robotics; vision systems.

Most manufacturing processes require a visual inspection of some aspect of the process. In the most straight forward applications, a vision system is used to inspect for part completeness, or to check for flaws in the manufactured product. In a more sophisticated use of vision systems the inspection task may be secondary to tasks such as part location, identification, or determining part orientation. In general these tasks are important when the vision system is used in conjunction with a robot manipulator. In robot systems, vision is needed to allow the robot to acquire, manipulate, and inspect parts without the need for elaborate fixturing, or complex part delivery systems. The labor cost of manual inspection, and the high cost of special purpose part delivery systems for robots have led many manufacturers to investigate vision systems, for use in manufacturing. Digital image processing and pattern recognition are providing the basis for a growing number of attempts to achieve an automated vision system.

This paper begins with a brief historical perspective on image processing and pattern recognition. Next a series of state of the art examples of visual inspection systems, and then robot vision systems is presented. The paper contains a list of other areas in manufacturing for the application of vision systems, and concludes with an assessment of the future of vision systems in manufacturing.

**19094.** Wiese, W. L., Atomic transition probabilities, *Transactions of the International Astronomical Union*, Vol. XVIIA—Part 1, Reports on Astronomy, E. A. Müller, Ed., Commission 14, Working Group 2, pp. 38-43 (D. Reidel Publ. Co., Dordrecht, Holland, 1979).

Key words: atomic transition probabilities; literature survey; oscillator strengths.

A survey of the new atomic transition probability literature, covering the period late 1975 to late 1978, is given.

**19095.** Haisch, B. M., Linsky, J. L., van der Hucht, K. A., Lyman alpha initiated winds in late-type stars, *Proc. Symp. The First Year of IUE*, London, England, Apr. 4-6, 1979, pp. 383-393 (A. J. Willis, Ed., U. College, London, 1979).

Key words: cool stars; radiation pressure; stellar winds; ultraviolet spectra.

One of the first major results of the IUE survey of late-type stars was the discovery of a sharp division in the HR diagram between stars with solar type spectra (chromosphere and transition region lines) and those with non-solar type spectra (only chromosphere lines). This result is especially interesting in view of observational evidence for mass loss from G and K giants and supergiants discussed recently by both Reimers and Stencel. We have calculated models of both hot coronae and cool wind flows using stellar model chromospheres as starting points for stellar wind calculations in order to investigate the possibility of having a "supersonic transition locus" in the HR diagram dividing hot coronae from cool winds. We conclude from these models that the L flux may play an important role in determining the location of a stellar wind critical point. We investigate in detail the interaction of L radiation pressure with Alfvén waves in producing strong, low temperature stellar winds in the star Arcturus.

**19096.** VanderBrug, G. J., Albus, J. S., Barkmeyer, E., A vision system for real time control of robots, *Proc. 9th Int. Symp. on Industrial Robots*, Washington, DC, Mar. 13-15, 1979, pp. 213-231 (Society of Manufacturing Engineers, Dearborn, MI, 1979).

Key words: line following; part acquisition; plane of light; real time; robot; sensory feedback; vision system.

This paper describes a robot vision system which consists of a solid state camera, a strobographic light source, and an 8-bit microprocessor. The camera is mounted obliquely at the wrist of the robot, so that its field of view covers a region extending from inside the finger tips out to a distance of one meter. The light source flashes a plane of light parallel to the wrist of the robot into this region. The plane of light strikes any object in this region and produces an image of line segments. The system computes a run length encoding representation of line segments. Interpretation algorithms are based on the fact that triangulation gives range data, the slope of the lines indicate the orientation of the object, and the end points of the lines give information on the edges to be grasped.

**19097.** Hertz, H. S., Hilpert, L. R., May, W. E., Wise, S. A., Brown, J. M., Chesler, S. N., Guenther, F. R., Interlaboratory comparison of environmental analyses associated with increased energy production, (Proc. American Society for Testing and Materials Symp. on Measurements of Organic Pollutants in Water and Wastewater, Denver, CO, June 18-22, 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 686, pp. 291-301 (1979).

Key words: alternate fuels; gas chromatography; high performance liquid chromatography; N-heterocyclic compounds; phenols; polynuclear aromatic hydrocarbons; priority pollutants.

In order to begin evaluating the state of the art of the determination of pollutants associated with the production of alternate fuels (for example, liquefied coal and shale oil,) five collaborative studies have been conducted by the National Bureau of Standards. The aim of these initial studies was to ascertain how well participating laboratories could perform the chromatographic quantitation that is often the final step in a trace organic analytical scheme for priority pollutants. The materials examined in the collaborative studies were polynuclear aromatic hydrocarbons in hexane, phenols in water, phenols in hexane, and N-heterocyclic compounds in hexane. Each of these materials contained between five and eight pure compounds, each compound present at the 1 to 100  $\mu\text{g}/\text{ml}$  (ppm) level.

**19098.** Soulen, R. J., Jr., A superconductive device to provide reference temperatures for use below 0.5 K, *12th Session Comité Consultatif de Thermométrie Meeting*, Sèvres, France,



May 9-10, 1978, *Annexe T7*, pp. T83-T85 (Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92310, Sèvres, France, 1979).

Key words: fixed points; standard reference material; superconductivity; temperature.

We report on the development of a device containing five superconductive materials, W, Be, Ir, AuAl<sub>2</sub>, and AuIn<sub>2</sub> which provides reference temperatures at 0.015 K, 0.024 K, 0.0975 K, 0.159 K and 0.204 K respectively. The reproducibility of three of these prototype units each containing these five superconductors was found to vary from 0.1 to 0.4 mK except for Be where it was 1 mK.

19099. Mangum, B. W., Thornton, D. D., **Proposed role for the triple-point temperature of gallium in the definition of the international practical temperature scale, 12th Session Comité Consultatif de Thermométrie Meeting, Sèvres, France, May 9-10, 1978, Annexe T22**, pp. T130-T132 (Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92310, Sèvres, France, 1979).

Key words: International Practical Temperature Scale; SPRTs; temperature fixed point; the kelvin; thermometric fixed point; triple point of gallium; triple point of water.

We have found that as a temperature fixed point the triple point of gallium at 29.77406 °C is superior in many regards to the triple point of water which presently plays a key role in the IPTS. In this submission, we propose that the national standards laboratories undertake appropriate testing of the gallium triple point as a thermometric fixed point and if it is found to be suitable, that the triple point of gallium displace the triple point of water from its role in the IPTS.

19100. Iman, M. A., Fraker, A. C., Gilmore, C. M., **Corrosion fatigue of 316L stainless steel, Co-Cr-Mo alloy, and ELI Ti-6Al-4V**, (Proc. American Society for Testing and Materials Symp. on Corrosion and Degradation of Implant Materials, Kansas City, MO, May 22-23, 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ. 684*, pp. 129-143 (1979).

Key words: cobalt-chromium alloy; corrosion-fatigue; fatigue; stainless steel; surgical implant metals; titanium alloy.

The purpose of this paper is to compare corrosion-fatigue properties of selected implant alloys and to discuss the corrosion fatigue-life in terms of the corrosion behavior and the metal microstructure. The tests were conducted in fully reversed torsion in flowing Hank's solution at a temperature of 37 °C and a pH of 7.4. Specimens were subjected to fatigue at shear strains ranging from 0.006 to 0.018 and at a frequency of 1 Hz. Surfaces of the 0.5-cm-diameter specimens were prepared by mechanically polishing through a 0.05 alumina powder and following this with steam sterilization.

During the tests, the specimen electrode potentials versus time were monitored on a strip chart recorder. The potential-time curves for the metals studied show the establishment of a steady rest potential which does not change until fatigue motion has been applied. The potential then goes in the negative direction. The rate of this decline in potential appears to be related to the metal microstructure as well as to the alloy composition. This electronegativity of the potential-time curves indicated the formation of cracks in the oxide film. These curves were more electronegative with increased shear strain, and the curves were different for the different metals tested.

Fatigue results of these tests show that the ELI Ti-6Al-4V has the longest fatigue life under these conditions. The fatigue strength of the Ti-Al-4V can be increased many times by changing the microstructure through heat treating and quenching. The Type 316L stainless steel had the next longest fatigue life. The cast Co-Cr-Mo alloy had the shortest fatigue life and also showed more scatter in the results. Other workers have shown

that further heat treating and processing improves the fatigue resistance of this material too.

19101. Schooley, J. F., **Superconductive fixed points for temperatures above 0.5 K, 12th Session Comité Consultatif de Thermométrie Meeting, Sèvres, France, May 9-10, 1978, Annexe T8**, pp. T86-T88 (Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92310, Sèvres, France, 1979).

Key words: cryogenics; fixed points; pure materials; superconductivity; temperature scale; thermometry.

This paper is a progress report to the International Advisory Committee on Thermometry (CCT) on the National Bureau of Standards study of superconductive temperature reference points above 0.5 K. In it, we note firstly that Nb samples ( $T_c = 9.3$  K) prepared by ac resistance heating in vacuum show sample-to-sample reproducibility at the one millikelvin level. Secondly, we note that some progress has been made in preparing Nb<sub>3</sub>Sn and V<sub>3</sub>Ga samples, but that the superconductive transition widths ( $W$ ) are 17 mK and 40 mK, respectively. Thirdly, we report that specially-prepared samples of the NBS SRM 767 device show  $W$  values of 0.5 mK or less, offering the possibility of  $T_c$  uncertainties of less than the current value of  $\pm 1$  mK. Finally, we suggest that superconductive fixed point samples prepared from different sources of materials be compared in order to provide uniformity of  $T_c$  values.

19102. Ruegg, R. T., **Life-cycle costing translating cost-saving potential into real dollars in the area of building energy management, Build. Oper. Manage.** 26, No. 3, 52-56 (Mar. 1979).

Key words: buildings; cost-effective; energy conservation; investment problems; life-cycle costing.

This article provides an overview of life-cycle costing as an aide to making energy conservation investment decisions in buildings. It reports briefly on the current status of the life-cycle costing approach in government and business as applied to energy conservation, reviews essential features of the method, and explains how it can be used to solve five common investment problems. It is aimed at operators, owners, and managers of commercial, industrial, institutional, and educational buildings.

19103. Fahey, D. W., Schearer, L. D., Parks, W. F., **Alignment of ions in Penning collisions, Phys. Rev. A** 20, No. 4, 1372-1375 (Oct. 1979).

Key words: Penning collisions; polarized emission; strontium ions.

The authors have observed the alignment of the  $5p^2P_{3/2}$  state of strontium ions produced in Penning collisions between an unpolarized beam of helium metastable atoms and a strontium vapor target. The alignment is shown by a linear polarization of the optical emission from the excited ion. For a 66-meV beam of helium metastable atoms a 3.5% linear polarization of the emission relative to the beam axis was measured. It is shown how the alignment may be used to determine the probabilities for populating the various final quasimolecular states of the ion-atom pair. The alignment of the Penning ions is an important new parameter in the description of these reactions.

19104. Celotta, R. J., Pierce, D. T., Wang, G. C., Bader, S. D., Felcher, G. P., **Surface magnetization of ferromagnetic Ni(110): A polarized low-energy electron diffraction experiment, Phys. Rev. Lett.** 43, No. 10, 728-731 (Sept. 3, 1979).

Key words: ferromagnetism; LEED; magnetism; nickel; PLEED; polarized LEED; surface magnetism.

The magnetic field dependence (hysteresis curve) and the temperature dependence of the magnetization at a Ni(110) surface was measured by polarized low-energy electron diffraction. The diffracted intensities are spin dependent by a few percent.



The temperature dependence of the surface magnetization measured in the range  $0.5 < T/T_c < 0.8$ , is significantly different from that of the bulk.

**19105.** Ehrstein, J. R., **Two-probe (spreading resistance) measurements for evaluation of semiconductor materials and devices**, (Proc. Conf. NATO Advanced Study Institute on Nondestructive Evaluation of Semiconductor Materials and Devices, Villa Tuscolano, Italy, Sept. 19-29, 1978), Chapter 1 in *Nondestructive Evaluation of Semiconductor Materials and Devices*, J. N. Zemel, Ed., pp. 1-66 (Plenum Press, New York, NY, 1979).

Key words: dopant profiles; resistivity; resistivity profiles; semiconductor; silicon; spreading resistance; two probe measurements.

This paper, based on a survey of the literature, presents an overview of the spreading resistance technique for measuring resistivity variations in silicon. It begins with the simple model of ohmic constriction resistance and deviations from this model which are typically experienced. It then extensively covers the state of empirical knowledge regarding specimen and instrument conditions which affect the reliability of the measurement. A description of the formal physical models of the spreading resistance contact ensues.

It is noted that when depth profiles of resistivity are required, it is usually necessary to deconvolute data to account for the sampling volume of the spreading resistance probe being larger than the desired data resolution scale. The development of several mathematical schemes to effect this deconvolution is outlined. Finally, borrowing heavily from the literature, numerous examples of applied spreading resistance measurements are given, with emphasis on comparison of resistivity or doping profiles by spreading resistance with those by other profiling techniques common to the semiconductor industry.

**19106.** Arens, E. A., **Designing for an acceptable wind environment**, *Proc. ASCE Convention and Exposition, Atlanta, GA, Oct. 23-25, 1979, ASCE Preprint 3756*, pp. 1-19 (American Society of Civil Engineers, New York, NY, 1979).

Key words: cool environments; microclimatic prediction; pedestrian comfort; wind; wind environment.

The comfort of pedestrians has been neglected by designers because first, there are few suitable outdoor comfort criteria, and second, it is difficult to predict the climatic characteristics around proposed buildings.

This paper summarizes available information on comfort in cool and cold environments. The mechanical effects of wind on comfort are now better understood than the thermal effects of climate and provide a practical basis for assessing pedestrian comfort in outdoor spaces. The limits of acceptable windspeed become the criteria to determine whether a space is comfortable or uncomfortable at a given time.

The report concludes with microclimatic-prediction techniques and procedures for determining the probability of a proposed pedestrian area being uncomfortable over time. Such a probability figure may indicate project acceptability, and suggest the level of mitigation measures worth taking.

**19107.** Rupp, N. W., Paffenbarger, G. C., Patel, P. R., **Effect of residual mercury content on creep in dental amalgams**, *J. Am. Dent. Assoc.* 100, 52-55 (Jan. 1980).

Key words: creep; dental amalgam; high-copper alloy; mercury content.

Research on amalgam that is compacted three minutes after trituration is analogous to use in clinical practice. It is suggested that many small mixes, rather than a single large one, be used for large amalgam restorations.

**19108.** Harman, G. G., **Non-destructive tests used to insure the integrity of semiconductor devices with emphasis on passive acoustic techniques**, (Proc. NATO Advanced Study Institute on Nondestructive Evaluation of Semiconductor Materials and Devices, Villa Tuscolano, Italy, Sept. 19-29, 1978), Chapter 13 in *Nondestructive Evaluation of Semiconductor Materials and Devices*, J. N. Zemel, Ed., pp. 677-738 (Plenum Press, New York, NY, 1979).

Key words: acoustic emission; beam lead devices; electronic devices; hermeticity; hybrids; nondestructive tests; semiconductor; tape bonded devices.

The discussion is divided into two major sections. The first consists of an introduction to device assembly techniques and problems followed by a review of six important nondestructive tests used during and after device packaging to insure the mechanical integrity of completed electronic devices. Most of these tests are called out in the military testing standard, MIL-STD-883 and are generally classified as screens. The first section concludes with a brief introduction to the economic and other factors that result in the choice of one screen over another and to production line statistical sampling (LTPD) appropriate to special high reliability device lots such as those used for space flight.

The second section begins with an introduction to acoustic emission, the status of theory as it can be applied to microelectronics. Then the published papers that have applied AE as a nondestructive test in electronics applications will be reviewed. Finally passive AE techniques are applied to establishing the mechanical bond integrity of beam lead, flip chip, and tape bonded integrated circuits as well as components in hybrid microcircuits.

**19109.** Bullis, W. M., **Metrology for submicrometer devices and structures**, *Proc. Microcircuit Engineering '79 Microstructure Fabrication Conf., Aachen, West Germany, Sept. 25-27, 1979*, pp. 271-282 (1979).

Key words: dimensional metrology; electronics; integrated circuits; materials characterization; microelectronics; semiconductors.

The metrological requirements of semiconductor microelectronics, always challenging, are made even more stringent by the trend toward submicrometer devices and structures. This comes about not only because of the obvious demands associated with the smaller feature sizes of circuit elements but also because of the attendant requirements for more efficient design verification aids, computer simulations, and process validation and control techniques and because of the concurrent trend toward larger die and package sizes. This paper examines the types of metrological requirements associated with submicrometer devices and structures, summarizes the present state of the art in selected critical areas of metrology, and reviews current research and development efforts on advanced measurement technology, especially those at the National Bureau of Standards.

**19110.** Unassigned.

**19111.** Kohler, B. E., **Site selection spectroscopy**, Paper in *Chemical and Biochemical Applications of Lasers*, C. B. Moore, Ed., 4, 31-53 (Academic Press, Inc., New York, NY, 1979).

Key words: condensed phase; emission; laser absorption; molecules; site selection.

Laser based techniques for reducing inhomogeneous broadening in condensed phase optical absorption and emission spectra are reviewed. The various laser site selection techniques are interpreted in terms of a model which adapts the basic theory of mixed crystal spectra to systems with inhomogeneous broadening.



**19112.** Kostkowski, H. J., **Precision and replication: Critique I**, (Proc. Controlled Environments Working Conf., Madison, WI, Mar. 12-14, 1979), Paper in *Controlled Environment Guidelines for Plant Research*, T. W. Tibbitts and T. T. Kozlowski, Eds., pp. 331-341 (Academic Press, Inc., New York, NY, 1979).

Key words: agricultural engineering; growth chambers; horticulture; measurement of controlled environments.

This paper consists of (1) a summary of the standards and calibrations that are pertinent to measurements of controlled environments that are available from the National Bureau of Standards, (2) estimates of the state-of-the-art accuracy available with commercial instruments, (3) a discussion of why an accurate calibration does not insure an accurate measurement, and (4) some brief remarks about the uncertainty of error estimates.

**19113.** Rhyne, J. J., **Amorphous magnetic rare earth alloys**, Chapter 16 in *Handbook on the Physics and Chemistry of Rare Earths*, K. A. Gschneidner, Jr., and L. Eyring, Eds., pp. 259-294 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1979).

Key words: amorphous alloys; magnetism; metallic glasses; neutron scattering; rare earths; structural properties.

This article reviews experimental and theoretical aspects of amorphous rare earth alloys. Special emphasis is placed on atomic structure determination and models, magnetic behavior, and the magnetic phase transition in these alloys.

**19114.** Hibbard, B. B., Krasny, J. F., **Exploratory flammability experiments with fabrics contaminated with gasoline**, *Proc. Twelfth Annual Information Council on Fabric Flammability Conf.*, New York, NY, Dec. 6-7, 1978, pp. 132-142 (Information Council on Fabric Flammability, Galveston, TX, 1979).

Key words: burn injury; evaporation rate; fabric; flammability; garments; gasoline; heat output; ignition.

The rate of evaporation of gasoline from 18 fabrics varying widely in fiber composition and construction was measured and found to be inversely related to fabric weight, and directly related to the area wetted by the gasoline. For a given fabric weight, knitted fabrics tended to have a lower rate of evaporation than more compact, woven fabrics. The fiber composition seemed to have relatively little effect on rate of evaporation. Fabrics which did not ignite from exposure to a Tesla coil leak spot detector did ignite when there was as little as 0.1 cm<sup>3</sup> of gasoline present. Additional experiments would be required to determine the relative safety of fabrics in various scenarios in which gasoline, garments, and fire are involved.

**19115.** Waxman, M., Davis, H. A., **State-of-the-art determination of the second virial coefficient of ethylene for temperatures from 0° to 175 °C**, (Proc. Symp. 176th Meeting of the American Chemical Society, Miami Beach, FL, Sept. 11-14, 1978), *ACS Symp. Series 182, Equations of State in Engineering and Research*, K. C. Chao and R. L. Robinson, Jr., Eds., Paper 16, 285-304 (American Chemical Society, Washington, DC, 1979).

Key words: Burnett PVT measurements; coefficient; ethylene; second virial; state-of-the-art; temperature.

Values of the second virial coefficient of ethylene for temperatures between 0° and 175 °C have been determined to an estimated accuracy of 0.2 cm<sup>3</sup>/mol or less from low-pressure Burnett PVT measurements. Our values, from -167 to -52 cm<sup>3</sup>/mol, agree within an average of 0.2 cm<sup>3</sup>/mol with those recently obtained by Douslin and Harrison from a distinctly different experiment. This close agreement reflects the current state of the art for the determination of second virial coefficient values. The data and error analysis of the Burnett method are discussed.

**19116.** Mansbach, P. A., Corley, D. M., **Errors due to temporal sampling**, (Proc. American Society for Testing and Materials Symp. on Community Noise, Kansas City, MO, May 24-26, 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 692, pp. 172-182 (Nov. 1979).

Key words: community noise; measurement errors; noise; noise exposure; sampling (temporal); statistics; time-varying signals.

Statistical techniques allow the prediction of the error (expressed as a standard deviation about the measured energy equivalent sound level ( $L_{eq}$ ) or time exceedance level ( $L_x$ )) due to temporal sampling of a time-varying signal. To first approximation,  $\sigma(L_{eq}) = 4.3 \sigma(p^2)/\sqrt{N} < p^2 >$ , where  $\sigma(p^2)$  is the standard deviation of pressure squared about its mean  $< p^2 >$ , and  $N$  is the number of independent data points in the sample. These predicted standard deviations are compared with experimentally determined values, obtained by computer sampling of large sets of actual field data recorded at a highway, an airport, a suburban road, and a rural residence. The predicted standard deviations, for the example given, of sampling at 30 s intervals for 1 h, range from 0.3 to 8 dB. These values agree closely with the experimentally determined values, and the small remaining discrepancies are explained. For "continuous" (or very frequent) sampling, an "effective number" of independent samples is used, computed from the autocorrelation in the time-varying signal.

**19117.** Knystautas, E. J., Sugar, J., Roberts, J. R., **New line classifications and energy levels in the triplet system of Xe VII**, *J. Opt. Soc. Am.* 69, No. 12, 1726-1727 (Dec. 1979).

Key words: energy levels; theta-pinch; wavelengths; Xenon.

A number of VUV lines, produced in a theta-pinch plasma, have been identified in the triplet system of Cd-like Xe VII. They serve to establish the positions of all the 5s5p <sup>3</sup>P<sup>o</sup>, 5p<sup>2</sup>3P, 5s6s <sup>3</sup>S, and 5s5d <sup>3</sup>D levels. An ionization energy of 743 000 ± 6000 cm<sup>-1</sup> (92.1 ± 0.8 eV) is derived from these observations.

**19118.** Reader, J., Acquista, N., **Spectrum and energy levels of eleven-times ionized zirconium (Zr XII)**, *J. Opt. Soc. Am.* 69, No. 12, 1659-1662 (Dec. 1979).

Key words: energy levels; ion; ionization energy; spectrum; wavelengths; zirconium.

The spectrum of Zr XII was observed with a low-inductance spark and a laser-produced plasma in the region from 70 to 630 Å on the 10.7-m grazing incidence spectrograph at NBS. From the identification of 36 lines, a system of 28 energy levels was determined. The level system (Cu I isoelectronic sequence, 3d <sup>19</sup>n/ includes the series np(n = 4-6), nd(n = 4-6), nf(n = 4-8), and ng(n = 5-7). The 4f<sup>2</sup>F term has an anomalously small fine-structure interval (1 ± 3 cm<sup>-1</sup>). The ionization energy is determined from the ng series (n = 5-7) to be 1 905 500 ± 200 cm<sup>-1</sup> (236.25 ± 0.03 eV).

**19119.** Linsky, J. L., Hunten, D. M., Sowell, R., Glackin, D. L., Kelch, W. L., **Stellar model chromospheres. XI. A survey of Ca II λ8542 line profiles in late-type stars of differing chromospheric activity**, *Astrophys. J. Suppl. Ser.* 41, No. 3, 481-500 (Nov. 1979).

Key words: Ca II emission, stars; chromospheres, stars; circumstellar shells; late type, stars.

We have obtained profiles of the Ca II infrared triplet λ8542 in 49 stars of spectral type F9-K3. These data were obtained with a silicon diode vidicon detector system on the KPNO McMath telescope and have a spectral resolution of 0.14 Å. We find no evidence for distinct emission features in the λ8542 lines, even for the most active chromosphere stars, but instead find



that the line cores are filled in for active chromosphere stars compared to quiet chromosphere stars of the same spectral type. We derive chromospheric radiative loss rates in the  $\lambda 8542$  line and find good correlations with chromospheric radiative loss rates in the Ca II H and K lines and Mg II  $h$  and  $k$  lines and with the Wilson-Bappu K-line index. Thus the  $\lambda 8542$  line is a good diagnostic of chromospheric activity. Computed  $\lambda 8542$  line profiles for the seven stars for which model chromospheres are available are not in as good agreement with the data as we would like, and for the three modeled giants the addition of macroturbulence cannot account for discrepancies in the line cores. We account for variability in the  $\alpha$  Aur line profile as due to orbital motions of  $\alpha$  Aur B, and we point out circumstellar features, indicating both outflowing and inflowing material, in six supergiants.

- 19120.** Perkins, R. M., Krasny, J. F., Braun, E., Peacock, R. D., **An evaluation of fabrics for thermal protective clothing**, *Proc. Twelfth Annual Information Council on Fabric Flammability Conf., New York, NY, Dec. 6-7, 1978*, pp. 212-230 (Information Council on Fabric Flammability, Galveston, TX, 1979).

Key words: aramids; burns (injuries); char strength; convective energy; cotton fabrics; fabrics; heat flux; insulative properties; modacrylics; polyesters; protective clothing; radiant energy; wool fabrics.

The thermal insulative properties of various fabrics under flaming and non-flaming exposure were studied. Fabrics tested had been made from natural fibers, man-made fibers, or from blend combinations. For studies of the insulative properties of fabrics under radiant heat flux, a modification of a method developed by the National Bureau of Standards was used. At two flux levels, the total heat transferred through the fabric after 2 minutes was recorded and the time to reach a second-degree burn injury (based on the Derksen curve) was estimated. At the higher flux level, retention of the integrity of the fabrics was noted. The influence of fabric weight, air permeability, thickness, chemical finish, and position of the sensor with relation to the fabric specimen was evaluated. Studies of the insulative properties of fabrics under convective heat flux were based on the proposed test method ASTM Designation: D 13-77-4. The time to second-degree burn injury (Derksen curve) and the cumulative total heat transferred through the fabric after a 20- or 30-second exposure were recorded; retention of integrity of the exposed specimens was observed. An attempt was made to quantify the protection afforded by charred fabrics.

- 19121.** Simiu, E., **Revised procedure for estimating along-wind response**, *J. Struct. Div. Am. Soc. Civ. Eng.* **106**, No. ST1, 1-10 (Jan. 1980).

Key words: acceleration; buffeting; buildings; buildings (codes); deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures.

A revised version is presented of a procedure for calculating along-wind response previously developed by the author. This version differs from the previous procedure in three respects. First, it incorporates recent improvements in the modeling of mean wind profiles and of the turbulence intensity. Second, it includes a correction in the Monte Carlo integration algorithm employed to obtain the rms values of the fluctuating response and thus results in more accurate values of the calculated along-wind response; and third, it is simpler to use. A numerical example is given illustrating the use of the procedure.

- 19122.** Armstrong, L., Jr., **Bistability effects in cooperative multiphoton ionisation**, *J. Phys. B Lett. to Ed.* **12**, No. 23, L719-L723 (1979).

Key words: bistability; lasers; multiphoton ionization.

Using the Bonifacio-Lugiato model of bistability, we show that bistability in a collective atomic system will greatly affect the multiphoton ionisation rate of that system. Results are shown corresponding to two possible experimental measurements.

- 19123.** MacDonald, R. A., Mountain, R. D., Shukla, R. C., **High-temperature specific heat of crystals**, *Phys. Rev. B* **20**, No. 10, 4012-4017 (Nov. 15, 1979).

Key words: anharmonicity; anomalous specific heat; atomic migration; high temperature; lattice dynamics; Monte Carlo calculations; perfect crystal; perturbation theory; rubidium; vacancies.

The Monte Carlo method is used to estimate the specific heat of a model of rubidium. Both the specific heat at constant volume,  $C_v$ , and the specific heat at constant pressure,  $C_p$ , are obtained for a range of temperatures up to the instability point of this lattice. These results for the fully anharmonic perfect crystal are compared with those obtained by perturbation theory to lowest order in the anharmonicity, (i.e., only cubic and quartic anharmonic contributions to the Helmholtz free energy are considered). It is shown that the fully anharmonic Monte Carlo calculation yields a more rapidly increasing specific heat than the linear temperature dependence given by lowest-order perturbation theory in the high-temperature limit. The Monte Carlo calculations also indicate that, at temperatures much higher than the Debye temperature, large-scale atomic displacements can occur without disrupting the lattice. When this happens, there is a further increase in the specific heat.

- 19124.** Rosenthal, R., Meisner, N., Eds., **Update: Local area networks**, (Proc. Local Area Communications Network Symp., Boston, MA, May 1979), *Book*: 347 pages (Available from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: computer communications; computer networks; computer protocols; data communications; local area networks.

This volume contains the proceedings of the Local Area Communications Network Symposium held May 7, 8 and 9, 1979 in Boston, Massachusetts.

- 19125.** Cotton, I. W., **Technologies for local area computer networks**, (Proc. Local Area Communications Network Symp., Boston, MA, May 1979), Paper in *Update: Local Area Networks*, R. Rosenthal and N. Meisner, Eds., pp. 25-44 (Available from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: communications; computer communications; computer networks; data communications; data networks; local area networks; networks.

Local area computer networks are distinguished from long distance networks by the need to serve users in a limited geographic area. The service requirements for local area computer networks are reviewed and several candidate technologies are examined. These technologies are briefly compared in the concluding section.

- 19126.** Carpenter, R. J., Sokol, J., Jr., **Serving users with a local area network**, (Proc. Local Area Communications Network Symp., Boston, MA, May 1979), Paper in *Update: Local Area Networks*, R. Rosenthal and N. Meisner, Eds., pp. 75-85 (Available from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: area; computer; data; digital; Ethernet; local; network; terminal.

The NBS local data network, NBSNET, emphasizes serial, asynchronous service at speeds up to 9600 bauds to terminal



users and small computers. Network-wide conventions have been adopted so servers need not be aware of the detailed characteristics of user terminals or computers. These conventions have been implemented in software which resides in the individual network nodes. This software does all of the necessary translation to generate the correct control and escape sequences required by the attached equipment. Nodes attached to terminals handle the following characteristics: speed, echoing, parity, flow control, within-line editing, cursor positioning, delay after format characters, and line-at-a-time or character-at-a-time transmission mode. Each network node has the correct variants of these characteristics for a single specified terminal type, but most of them may be varied under local and/or remote control. Another variant of the node software supports connections to computers acting as either servers or users of the network. Cooperating software in the attached computer can implement both TELNET (simulated terminal) connections, and a file transfer protocol. Full end-to-end flow control is provided in three stages; user-to-node, node-to-node, and node-to-user. This prevents needless lost data packets when output has been suspended by a user, and is required for speed conversion to be done correctly. By segmenting the flow control, a device need not know all the various ways that other devices do flow control. An interrupt feature allows data buffers to be flushed and supporting processes to be notified. A software rotary has been incorporated in all nodes to provide automatic sequencing of connection attempts to a computer acting as a server which has multiple nodes attached to it.

**19127.** Ritter, G. L., Currie, L. A., **Resolution of spectral peaks: Use of empirical peak shape**, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Paper in *Computers in Activation Analysis and Gamma-Ray Spectroscopy*, B. S. Carpenter, M. D. D'Agostino, and H. P. Yule, Eds., DOE Symp. Series 49, pp. 39-56 (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: empirical peak shape; gamma-ray spectrum fitting; intercomparison of computational methods; International Atomic Energy Agency; longrange interpolation; non-linear least squares; peak resolution; PICO.

A semiempirical method of gamma-spectrum peak resolution (PICO), which uses experimentally determined singlet peak shapes, has been devised to minimize sensitivity to systematic deviations from assumed analytic shape functions. The resolving power and accuracy of the method have been demonstrated through the use of International Atomic Energy Agency test spectra having Poisson measurement precision of about 0.5% and peak separations ranging from approximately 0.3 to 1.3 full width at half maximum.

**19128.** Carpenter, B. S., D'Agostino, M. D., Yule, H. P., Eds., **Computers in activation analysis and gamma-ray spectroscopy**, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Book: *DOE Symp. Series 49*, 905 pages (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: activation analysis; computers; data processing; gamma-ray spectroscopy; x-ray spectroscopy.

The increased utilization of nuclear analytical techniques in industrial, biomedical, security, and research fields has resulted in a heavy reliance on computers for providing the speed, accuracy, and automation required by current-day demands. Fortunately, the advent of minicomputers and microcomputers has greatly facilitated the implementation of control and data-reduction functions relating to activation analysis and gamma-ray and x-ray spectroscopy. However, the ever increasing availability and widespread use of these computers also have resulted in a "computer in every lab," and with it the inevitable overlap in

the development of software, the occasional "reinvention of the wheel," and the raising of questions on how to best make use of newly acquired capability.

Of the few symposiums held on this subject, the last one, *Applications of Computers to Nuclear and Radiochemistry*, was held in 1962. Included in the proceedings of that conference (published in 1963) were papers on decay-curve analysis, unfolding of pulse-height spectra, least-squares analysis of beta-ray and gamma-ray spectra, and programs to obtain quantitative results from activation-analysis spectra. Although the many advances made in these areas over the past 15 years have been reported in the proceedings of other symposia, such as the Modern Trends in Neutron Activation Analysis conferences, or in the scattered open literature, there has not been available a single reference source on this subject matter.

**19129.** Trombka, J. I., Schmadebeck, R. L., Bielefeld, M. J., Evans, L. G., Metzger, A. E., Haines, E. L., Dyer, C. S., Seltzer, S. M., Reedy, R. C., Arnold, J. R., **Analytical methods in determining elemental composition from the Apollo x-ray and gamma-ray spectrometer data**, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Paper in *Computers in Activation Analysis and Gamma-Ray Spectroscopy*, B. S. Carpenter, M. D. D'Agostino, and H. P. Yule, Eds., DOE Symp. Series 49, pp. 26-38 (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: Apollo-15 and -16; gamma-ray spectrometers; lunar chemical analysis; x-ray proportional-counter.

Analytical methods are described which were used in the analysis of data obtained with the x-ray proportional-counter and gamma-ray NaI spectrometers flown on the Apollo-15 and -16 missions for the purpose of mapping the elemental composition of the lunar surface. One method includes (1) procedures for subtracting various background radiation components from the data, (2) a least-squares unfolding of the signal, based on knowledge of the detector response, and (3) the determination of elemental abundances from the photon emission characteristics of excited nuclei. Two simpler, more-approximate methods for the analysis of the gamma-ray data are also described, which are useful in limited energy regions.

**19130.** Fiori, C. E., Myklebust, R. L., **A simplex method for fitting Gaussian profiles to x-ray spectra obtained with an energy-dispersive detector**, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Paper in *Computers in Activation Analysis and Gamma-Ray Spectroscopy*, B. S. Carpenter, M. D. D'Agostino, and H. P. Yule, Eds., DOE Symp. Series 49, pp. 139-149 (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: computer program; fitting Gaussian profiles; incomplete charge collection; lithium-drifted silicon detector; sequential simplex procedure; x-ray spectra.

A method is described for the fitting of Gaussian profiles to the pulse-height distributions of overlapping x-ray peaks measured with an energy-dispersive detector. The desired result is to know the areas under individual x-ray peaks in a spectrum in which the peaks are not resolved. A sequential simplex procedure for selection of the parameters in a mathematical expression that describes a spectral peak is used. Starting and stopping criteria for the procedure are discussed, and a computer program is outlined. Examples of the method applied to peaks obtained from a lithium-drifted silicon [Si(Li)] detector are provided.

**19131.** Schima, F. J., **A computer system used for pulse-height analysis**, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Paper in *Computers in Activation Analysis and Gamma-Ray Spectroscopy*, B. S.



Carpenter, M. D. D'Agostino, and H. P. Yule, Eds., DOE Symp. Series 49, pp. 416-425 (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: analog-to-digital conversion; computer systems; data processing concurrent with data acquisition; pulse-height analysis, on line.

A computer-based pulse-height-analysis system is described. The main components consist of: (1) a 4.5- $\mu$ sec digitizing-time analog-to-digital converter, (2) a computer with an external direct-access-to-memory channel, and (3) an interface which uses that channel to store the digital data by the increment-by-one mode. Data-processing programs can be run concurrently with the data acquisition with a minimum time loss to interrupt service.

**19132.** Schima, F. J., Hoppes, D. D., Hirshfeld, A. T., **An accurate on-line method for the evaluation of peak areas in pulse-height-analyzer data**, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Paper in *Computers in Activation Analysis and Gamma-Ray Spectroscopy*, B. S. Carpenter, M. D. D'Agostino, and H. P. Yule, Eds., DOE Symp. Series 49, pp. 177-184 (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: least squares fitting; normalized Gaussian function; photo-peak area determination; photo-peaks data, data analysis; summation method.

A simple and accurate method for obtaining areas of peaks in pulse-height-analyzer data resulting from the measurement of gamma-ray emission-rate standards with Ge or Ge(Li) spectrometer systems is described. Peaks can be located with a search procedure based on the method of second differences. For the peaks of interest, a linear background correction is made, after which a normalized Gaussian function is fitted to the counts in the near-Gaussian portion of the peak. The fitted values of the peak location and width are used to define a consistent summing interval for an accurate peak-area evaluation.

**19133.** DeVoe, J. R., Barkley, J. F., Minis, midis, and desk-top calculators, (Proc. American Nuclear Society Topical Conf., Mayaguez, Puerto Rico, Apr. 30-May 4, 1978), Paper in *Computers in Activation Analysis and Gamma-Ray Spectroscopy*, B. S. Carpenter, M. D. D'Agostino, and H. P. Yule, Eds., DOE Symp. Series 49, pp. 563-581 (Available as CONF-780421 from the National Technical Information Service, Springfield, VA 22161, 1979).

Key words: computer; instrumentation; laboratory automation; scientific computation.

A brief survey of the spectrum of computing equipment appropriate for use in the modern laboratory is presented. The rapid decline in the cost of small computers (25% per year) is making automation available to every laboratory. Current equipment in three major categories, microprocessors, calculators, and minicomputers, is described along with a historical perspective of the development of devices in each class. Finally, the impact of recent developments in electronic and communications technology on the laboratory user is discussed.

**19134.** Motz, J. W., Danos, M., **Information storage requirements in radiology**, (Proc. SPIE Conf. on Recent and Future Developments in Medical Imaging II, San Diego, CA, Aug. 27-29, 1979), *SPIE J.* **206**, 56-59 (1979).

Key words: digital image requirement; image information; information content; medical x-ray image; x-ray image storage.

The number of bits required for storing the information contained in an x-ray image depends primarily on the x-ray exposure at the image plane and on the desired spatial resolution. This dependence has been determined from calculations of the maximum attainable signal-to-noise ratios for exposures and resolutions respectively in the regions from  $10^{-2}$  to  $10^2$  milliroentgens and  $10^{-4}$  to  $1 \text{ cm}^2$ . The results show that for the different image sizes and exposures used in diagnostic radiology, the number of bits required for the storage of these images extends from approximately  $10^5$  to  $10^8$ .

**19135.** Kim, M. W., Goldburg, W. I., Esfandiari, P., Sengers, J. M. H. L., **Test of mean-field behavior by light scattering in three phases of a fluid mixture near its tricritical point**, *J. Chem. Phys.* **71**, No. 12, 4888-4898 (Dec. 15, 1979).

Key words: correlation length; mean field; sum rule; susceptibility; three coexistence phases; tricritical point.

Measurements are reported of the angular dependence of intensity and spectral width of light scattered quasielastically from three coexistent liquid phase  $\alpha$ ,  $\beta$ ,  $\gamma$  near a tricritical point. From the data, the susceptibilities  $\chi$  and correlation lengths  $\xi$  in each of the phases were calculated. Two predictions from mean-field theory were tested, namely "Griffiths' first sum rule":  $\chi_a^{1/2} + \chi_\gamma^{1/2} = \chi_\beta^{1/2}$  or  $\xi_a + \xi_\gamma = \xi_\beta$ , and "Griffiths' second sum rule":  $\chi_a^{-1/2} + \chi_\gamma^{-1/2} - \chi_\beta^{-1/2} \propto (T - T_i)$ , or  $\xi_a^{-1} + \xi_\gamma^{-1} - \xi_\beta^{-1} \propto (T - T_i)$ . The second sum rule is found to hold within the accuracy of our data. The first sum rule is violated for the correlation lengths. It is found to hold for the susceptibilities, but only after the scattered intensities are properly corrected for differences, between phases, in the derivative of the dielectric constant with respect to order parameter. This derivative was obtained from model calculations of Kaufman and Griffiths. The viscosities of the coexisting phases were measured; combined with the spectral width and correlation length data, they confirmed, with no adjustable parameters, Kawasaki's equation for the Rayleigh linewidth of a critical fluid.

**19136.** Antonucci, J. M., Brauer, G. M., Termini, D. J., **Isocyanato urethane methacrylates derived from hydroxyethyl methacrylate**, *J. Dent. Res.* **59**, No. 1, 35-43 (Jan. 1980).

Key words: adhesion; dentin; diisocyanates; hydroxyethyl; isocyanato urethane methacrylates; methacrylate; polymerization; synthesis.

Isocyanato urethane methacrylates were synthesized from five diisocyanates and hydroxyethylmethacrylate. They may be homopolymerized or copolymerized with other methacrylates by the usual free radical methods of initiation and have potential as adhesion-promoting agents for dentin.

**19137.** Eden, G. T., Franklin, O. M., Powell, J. M., Ohta, Y., Dickson, G., **Fit of porcelain fused-to-metal crown and bridge castings**, *J. Dent. Res.* **58**, No. 12, 2360-2368 (Dec. 1979).

Key words: casting accuracy; casting ring liners; crown and bridge castings; dental casting techniques; dental die; porcelain fused to metal alloys.

The dimensional accuracy of porcelain fused to metal crown and bridge castings was determined on truncated cone-shaped steel dies. Ni-Cr castings produced in manufacturers' laboratories were consistently undersize, while precious metal castings were consistently oversize. Ni-Cr castings, produced in NBS laboratories using a modified investing technique, were routinely oversize.

**19138.** Wheeler, J. C., **Blue stragglers as long-lived stars**, *Astrophys. J.* **234**, No. 2, 569-578 (Dec. 1, 1979).

Key words: clusters; evolution-stars; open-stars; stellar statistics.



With the assumption that blue stragglers in open clusters evolve as standard main-sequence stars, the mass function and other statistical properties are derived. The mass function is very similar to the present mass function of field stars and is roughly consistent with hypotheses of ongoing star formation, stellar coalescence, and perhaps extended main-sequence lifetimes to explain the nature of blue stragglers. The steep mass function argues against the hypothesis of binary mass transfer. Other features of blue stragglers are inconsistent with noncoeval star formation and stellar coalescence. The notion that some stars undergo a longer-lived quasi-homogeneous evolution is considered and shown to be consistent with many properties of blue stragglers.

- 19139.** Mendlowitz, H., Glass, S. J., **Radiation from charged particles passing through crystals**, *Phys. Lett.* **73A**, No. 4, 363-365 (Oct. 1, 1979).

Key words: channeling; charged particles; crystals; radiation.

Expressions are presented for the radiation from charged particles passing through a crystal. Two cases are considered: (1) where there is no crystal recoil; (2) where the particle is initially moving parallel to the planes perpendicular to the crystal recoil.

- 19140.** Grot, R. A., **Field performance of gas and electric water heaters**, *Proc. Conf. on Major Home Appliance Technology for Energy Conservation*, Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, IN, Feb. 27-Mar. 1, 1978, D. R. Tree, G. E. Courville, V. O. Haynes, and H. Phillips, Eds., pp. 110-120 (Available as CONF-780238 from the National Technical Information Service, Springfield, VA 22161, 1978).

Key words: energy; insulation; temperature reduction; usage patterns; water heaters.

The results of a field experiment for assessing the performance of gas and electric residential storage water heaters are presented. Energy requirements for hot water supply, hot water consumption and usage pattern data are presented and analyzed using statistical techniques in order to obtain average load curves and variations from the average. The effects of various retrofit measures such as wrapping the water heater with additional insulation and reducing the hot water temperature are assessed under actual usage conditions.

- 19141.** Faller, J. E., Rinker, R. L., Zumberge, M. A., **Report on the development of a portable absolute gravimeter**, (Proc. Int. Workshop on Monitoring Crustal Dynamics in Earthquake Zones, European Seismological Commission and the European Geophysical Society, Strasbourg, France, Aug. 29-Sept. 5, 1978), Paper in *Terrestrial and Space Techniques in Earthquake Prediction Research*, A. Vogel, Ed., pp. 359-362 (Friedr. Vieweg & Sohn, Braunschweig/Wiesbaden, Germany, 1979).

Key words: absolute-g; geodynamic; geophysical instrumentation; geophysics; gravity.

We are in the process of developing an absolute gravimeter with an accuracy goal of 1-3  $\mu\text{gal}$  and a set up and measurement time of only a few hours at any given site. We discuss the plans and progress to date on such an instrument which uses the method of free fall.

- 19142.** Smid, M. E., **Techniques for the implementation of the data encryption standard**, *Proc. Natl. Electronics Conf., Chicago, IL, Oct. 19-31, 1979*, pp. 318-321 (National Engineering Consortium, Inc., 1211 West 22d St., Oak Brook, IL 60521, 1979).

Key words: character set encryption; digital signatures; key notarization.

In 1977 the National Bureau of Standards published a well-defined encryption algorithm, known as the Data Encryption Standard (DES), which became a standard for federal agencies for uses not involving national security matters. Since its publication, several companies have produced hardware devices which implement the standard, and there has been an increased awareness that, in certain applications, encryption offers the only effective means of protecting data. This paper summarizes three techniques for implementing the DES: character set encryption, key notarization, and digital signatures.

- 19143.** Simiu, E., **Laboratory simulation of turbulent wind spectra**, *J. Eng. Mech. Div. Am. Soc. Civ. Eng.* **105**, No. EM6, 1050-1054 (Dec. 1979).

Key words: aerodynamics; buildings (codes); dynamics; structural engineering; towers; turbulence; wind (meteorology).

A discussion is presented of the implications of recent results of atmospheric boundary layer research for the wind tunnel simulation of the along-wind response of tall structures. It is shown, on the basis of similarity considerations and of recently developed models of the atmospheric flow structure, that the turbulent fluctuations which cause resonant amplification effects in tall buildings do not appear to be similar in long wind tunnels to the corresponding fluctuations in atmospheric flows. It is suggested that corrections to the laboratory along-wind measurements may be required in order to account for possible differences between turbulence spectra in the atmosphere and the measured turbulence spectra obtained in the wind tunnel.

- 19144.** Bender, P. L., **Effects of ground motions on amplitude interferometry**, (Proc. IAU Colloq. No. 50, University of Sydney, Australia, Aug. 30-Sept. 1, 1978), Paper in *High Angular Resolution Stellar Interferometry*, J. Davis and W. J. Tango, Eds., pp. 5-1-5-9 (University of Sydney Press, Sydney, Australia, Jan. 1979).

Key words: astronomy; astrophysics; crustal movements; geophysics; interferometry; stellar diameters.

Some examples are given of types of ground motion which have been observed with seismic and geodetic instruments. In general, away from sources of man-made noise, the amplitudes of ground strains and tilts in the microseism band with periods of a few seconds normally are of the order of a few times  $10^{-10}$ . Strain and tilt tides give amplitudes of a few times  $10^{-8}$ , and long term average strain and tilt rates at relatively good sites may be roughly  $10^{-7}/\text{yr}$ . Superposed on such relatively long wavelength motions can be larger local pier motions, which are likely to be irregular. However, very high ground stability has been demonstrated at a few sites. The limitations of ground motions on long term amplitude interferometer stability are serious if applications such as earth rotation and polar motion measurements are considered, but at shorter periods the environmental problems will be almost completely atmospheric.

- 19145.** Haan, S. W., **Dynamic behavior of pairs of atoms in simple liquids**, *Phys. Rev. A* **20**, No. 6, 2516-2520 (Dec. 1979).

Key words: diffusion; Lennard-Jones fluid; liquid rubidium; liquids; molecular dynamics; potential of mean force; relative motion of pairs; Smoluchowski's equation.

The microscopic dynamic behavior of some simple liquids has been investigated by observing the time evolution of the separation between members of pairs of atoms. The distribution function for this process was calculated in molecular-dynamics studies of several states of two model fluids: Lennard-Jones and simulated rubidium. The overall features of the results are described quite well by a simple model in which the distribution of pair separations satisfies Smoluchowski's equation with a potential of mean force. The model uses a nonlinear time scale determined from the single-particle motion.



**19146.** Bowman, C. D., Schrack, R. A., **Influence of vibrations of gas molecules on neutron reaction cross sections**, *Phys. Rev. C* **21**, No. 1, 58-64 (Jan. 1980).

Key words: Doppler effect; fission; gas target; molecular vibrations; neutron reactions;  $^{235}\text{U}$ .

The change in molecular vibrational energy upon absorption of a neutron by a nucleus bound in a free molecule can influence resonance shape and other aspects of neutron reaction cross sections. A formalism is developed for centrosymmetric molecules such as  $\text{UF}_6$  and applied to the shape of the 6.67 eV resonance in  $^{235}\text{U}$ . The ratio of the resonance shape for  $^{235}\text{UF}_6$  gas and for solid  $^{235}\text{U}_3\text{O}_8$  has been measured and compared with the calculation. Reasonable agreement is obtained indicating the validity of the calculation and the necessity to include vibration effects to avoid large errors in measurements and calculations on gas-containing systems.

**19147.** Burch, D. M., Contreras, A. G., Treado, S. J., **The use of low-moisture-permeability insulation as an exterior retrofit system—A condensation study**, (Proc. ASHRAE Annual Symp. on Field Measurements on Effectiveness of Thermal Retrofitting of Structures, ASHRAE Annual Meeting, Detroit, MI, June 25-27, 1979), *ASHRAE Trans.* **85**, Pt. 2, 547-562 (1979).

Key words: condensation in walls; effect of moisture on heat transmission; moisture within wood-frame cavity walls.

Laboratory and field studies were carried out to determine whether the use of low-moisture-permeability insulation as an exterior retrofit system increases winter moisture accumulation within the existing wood siding, sheathing, and cavity insulation. A full-scale insulated test wall was sandwiched between a hot and cold box apparatus in the laboratory. The exterior surface of one half of this test wall was fitted with a low-permeability insulation retrofit system. The exterior surface of the test wall was subsequently exposed to two consecutive steady-state winter conditions, while the interior surface was exposed to a typical indoor condition for a residence. The moisture accumulations within various components of the two halves of the test wall were compared. The moisture-transfer processes which occurred in the test wall were modeled with an ASHRAE diffusion model modified with a term to account for air leakage from the hot to the cold box. A limited field survey of several wall constructions was carried out to compare field observations of moisture conditions with laboratory results.

In addition, the effect of accumulated moisture of wall heat transmission was examined.

**19148.** Wallerstein, G., Brugel, E. W., **The absolute magnitude of the field population II, Cepheid XX Virginis**, *Astron. J.* **84**, No. 12, 1840-1845 (Dec. 1979).

Key words: cepheids; population II cepheids; XX Virginis.

A radial velocity curve from 38 Å/mm Palomar plates of XX Vir is presented. The velocity data are combined with *UBV* colors to derive the radius and  $M_v$ . The same method is also used to derive  $M_v$  for RR Lyrae. The results are  $M_v$  (RR Lyrae) = +0.6 and  $M_v$  (XX Vir) = -0.7. The luminosity for XX Vir places it among the cepheids of similar periods in globular clusters.

**19149.** Klais, O., Anderson, P. C., Laufer, A. H., Kurylo, M. J., **An upper limit for the rate constant of the bimolecular reaction  $\text{CH}_3 + \text{O}_2 \rightarrow \text{OH} + \text{H}_2\text{CO}$  at 368 K**, *Chem. Phys. Lett.* **66**, No. 3, 598-601 (Oct. 15, 1979).

Key words: atmospheric reactions; combustion; methyl radicals; modeling; oxidation; oxygen; rate constant.

An upper limit for the rate constant of the bimolecular reaction  $\text{CH}_3 + \text{O}_2 \rightarrow \text{OH} + \text{H}_2\text{CO}$  at 368 K has been measured by

monitoring OH using the flash photolysis—resonance fluorescence technique. Careful modeling of the system in conjunction with statistical analysis indicates an upper limit of  $k \leq 3 \times 10^{-16} \text{ cm}^3 \text{ molec}^{-1} \text{ s}^{-1}$ . The rate constant for the reaction of OH with azomethane has also been measured.

**19150.** Keller, R. A., Engleman, R., Jr., Zalewski, E. F., **Opto-galvanic spectroscopy in a uranium hollow cathode discharge**, *J. Opt. Soc. Am.* **69**, No. 5, 738-742 (May 1979).

Key words: electron temperature; hollow cathode; isotope ratio; opto-galvanic effect; oscillator strength; spectroscopy; uranium.

Laser induced impedance changes in a hollow cathode discharge containing sputtered uranium atoms were used for standard spectroscopic measurements, the determination of oscillator strengths, the measurement of the electron temperature of the discharge, isotope ratio analysis, and obtaining information about the sputtering process. Concentrations of uranium atoms as small as  $10^9/\text{cc}$  could be detected.

**19151.** Newbury, D. E., Heinrich, K. F. J., **Quantitative procedures in ion-probe microanalysis**, *Mikrochim. Acta Suppl.* **8**, 3-24 (1979).

Key words: ion probe microanalysis; local thermal equilibrium model; microanalysis; relative elemental sensitivity factors; secondary ion mass spectrometry; surface analysis.

Quantitative analysis procedures for the ion microprobe can be based on theoretical or empirical approaches. The local thermal equilibrium model is examined as a representative of the theoretical models, and the relative sensitivity factor method is taken as a representative of the empirical methods. A comparison of the accuracy of the analysis of multi-element glasses by the two techniques reveals that the sensitivity factor approach yields the most accurate results. Sources of error to which all quantitative procedures are subject include (1) errors in the description of the sputtering process, (2) lack of accurate values of physical parameters, and (3) instrumental effects. Instrumental factors are found to affect measured relative secondary ion yields by as much as a factor of 50 when the results from one instrument are compared with those from another and constitute one of the major difficulties for quantitative procedures. A combination of relative sensitivity factors measured on an instrument for which the matrix correction factors have been theoretically determined offers the most promise for practical analysis.

**19152.** Schumann, L. W., Wildman, D. W., Gallagher, A. C., **Electric discharge excitation of thallium in high-pressure xenon**, *J. Appl. Phys.* **50**, No. 12, 7965-7970 (Dec. 1979).

Key words: discharge; excimer; thallium.

We report data obtained in pulsed 1.5–280-MW/l electric discharges in thallium-doped xenon gas at thallium densities of  $(1.5\text{--}26) \times 10^{15} \text{ cm}^{-3}$  and xenon densities of  $(1\text{--}4) \times 10^{19} \text{ cm}^{-3}$ . Stable steady-state discharges were obtained without the use of preionization or sustainers. Steady-state  $E/N$ ,  $J/N$ , and  $T_l$  and Xe excited-state populations were determined for the positive column of the discharge. These measurements indicate an electron temperature of 0.45–0.65 eV, with the gas temperature remaining at  $\sim 0.1$  eV during the several-microsecond discharges. The thallium states lower in energy than  $\text{Tl}(8S_{1/2})$  generally show a higher excitation temperature than the states from  $\text{Tl}(8S_{1/2})$  to the thallium ionization limit, particularly at the higher current densities. The homogeneity of a 9-cm-long transverse discharge and the effects of this discharge on a laser beam propagating through the thallium-xenon medium were investigated. The implications of these results for a discharge-pumped Tl-Xe excimer laser are discussed.

**19153.** Cahn, J. W., **Stability of rods with anisotropic surface free energy**, *Scr. Metall.* **13**, No. 11, 1069-1071 (Sept. 1979).



Key words: composites; durability; eutectics; Rayleigh waves; stability; surface anisotropy.

The stability of a long single crystal rod with respect to thickness variations by diffusional redistribution of matter is strongly affected by surface free energy anisotropy. The implications for composite stability and for measurement of surface energy anisotropy is briefly discussed.

- 19154.** Wampler, R. H., **Algorithm 544 L2A and L2B, weighted least squares solutions by modified Gram-Schmidt with iterative refinement [F4],** *Assoc. Comput. Mach. Trans. Math. Software* 5, No. 4, 494-499 (Dec. 1979).

Key words: covariance matrix; curve fitting; iterative refinement; least squares solution; linear constraints; overdetermined system of equations; regression; statistics.

The Fortran subroutine L2 calculates a least squares solution to an overdetermined system of  $n$  linear equations in  $m$  unknowns through the use of modified Gram-Schmidt orthogonalization with iterative refinement. The algorithm is one known to provide maximum accuracy in the case of ill-conditioned problems. Written in PFORT, a portable subset of ANSI Fortran, the subroutine has been tested extensively on several computers. The program accepts problems with weighted observations as well as problems where the solution is subject to linear equality constraints. The covariance matrix of the solution vector is computed.

- 19155.** Wampler, R. H., **Solutions to weighted least squares problems by modified Gram-Schmidt with iterative refinement,** *Assoc. Comput. Mach. Trans. Math. Software* 5, No. 4, 457-465 (Dec. 1979).

Key words: covariance matrix; curve fitting; iterative refinement; least squares solution; linear constraints; overdetermined system of equations; regression; underdetermined system of equations.

A Fortran implementation of an algorithm for solving weighted least squares problems by modified Gram-Schmidt with iterative refinement is described. The algorithm is one known to provide maximum accuracy in the case of ill-conditioned problems. The types of problems which can be solved include overdetermined and underdetermined systems of linear equations, and problems where the solution is subject to linear equality constraints. The covariance matrix of the solution vector is computed.

- 19156.** Kusuda, T., **Engineering and the health sciences,** *ASHRAE J.* 21, No. 11, 78 (Nov. 1979).

Key words: air quality; contaminants from building materials; engineering and health effects; environmental contaminants; health science.

Recently, Section 2 of the ASHRAE R&T Committee is concerned with such health problems as Legionnaires' disease (possibly carried by cooling tower effluents), effects of glass fiber from duct linings, indoor radioactivity due to radon emanation from building materials, and various other organic and inorganic contaminants coming from building materials and HVAC systems. Energy conservation measures have also created new environmental problems. For example, airtight buildings increase humidity which increases condensation and subsequent deterioration of building materials and growth of microorganisms; low ventilation rates lead to increased concentration of radon from building materials and of such termite treatments as chlordane; new thermostat settings can significantly affect thermal comfort and productivity.

Although the biomedical or epidemiological aspects of environmental parameters are outside of the traditional ASHRAE members technical expertise, it is becoming increasingly imperative that Section 2 must deal with health and safety-related subjects.

- 19157.** Failey, M. P., Anderson, D. L., Zoller, W. H., Gordon, G. E., Lindstrom, R. M., **Neutron-capture prompt  $\gamma$ -ray activation analysis for multielement determination in complex samples,** *Anal. Chem.* 51, No. 13, 2209-2221 (Nov. 1979).

Key words: instrumental analysis; multielement analysis; neutron activation; neutron capture; prompt gamma rays; trace element analysis.

Gamma-ray spectra were taken up to 11 MeV from a wide range of samples and elemental standards while under neutron irradiation to determine the elements whose prompt  $\gamma$  rays are observable and can be used for analytical measurements. Up to 17 elements from among the set H, B, C, N, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Mn, Fe, Cd, Nd, Sm, and Gd are measurable in samples of coal, fly ash, orchard leaves, and bovine liver by neutron-capture prompt  $\gamma$ -ray activation analysis (PGAA). The combination of PGAA and instrumental neutron activation analysis (which uses the same equipment) can be used to measure concentrations of 40 to 50 elements in individual samples of many types of material. Concentrations are reported for the elements measurable by PGAA in National Bureau of Standards Standard Reference Materials: coals (SRMs 1632, 1632a, 1635), fly ashes (1633, 1633a), orchard leaves (1571), and bovine liver (1577).

- 19158.** Wampler, R. H., **Test procedures and test problems for least squares algorithms,** *J. Economet.* 12, 3-22 (1980).

Key words: algorithms; computer programs; least squares; regression; statistics; test problems.

Numerous test problems have been introduced in the past twenty years for the purpose of studying and comparing least squares algorithms and computer programs. This paper discusses and classifies some of the useful test problems which have appeared in the literature. A recent large scale test procedure is briefly summarized. Several neat, mathematical examples are displayed. One of these, first introduced by Läuchli, is modified so that it can be solved by the method of inverting a matrix of correlation coefficients. Comparative results from running two types of problems on several different algorithms are given which illustrate some of the factors affecting computational accuracy: choice of algorithm, scaling of the data, tolerance parameters, and iterative refinement.

- 19159.** Geltman, S., **Resonant multiphoton ionisation with intense monochromatic lasers,** *J. Phys. B: Atom. Molec. Phys.* 13, 115-133 (1980).

Key words: AC Stark shifts; AC Stark widths; cesium; hydrogen; intermediate resonances; laser pulses; monochromatic; multiphoton ionization; Rabi oscillation; sodium.

A theoretical procedure is presented for the evaluation of resonant multiphoton ionisation rates for atoms interacting with intense monochromatic lasers. The essence of the procedure is to treat first the strong coupling by solution of the truncated Schrödinger equation to obtain a time-dependent superposition state. This is then used as the lowest order approximation to iterate the full time-dependent Schrödinger equation to obtain the transition amplitude to the continuum. A model-atom study of the time evolution of the ionisation probability is carried out and the approach to rate behaviour in the long-time limit is demonstrated. Ionisation rates are evaluated for a variety of resonant processes in H, Na and Cs involving one or two lasers, as a function of intensities and detunings. Comparison with experiment is still in a fragmentary stage, and some large discrepancies are found to exist.

- 19160.** Pielert, J. H., Gross, J. G., **Technical evaluation needs for building rehabilitation,** *Proc. 2d Canadian Building Congress—Rehabilitation of Buildings, Toronto, Canada, Oct. 15-17, 1979,* pp. 93-99 (National Research Council of Canada, Ottawa, Canada, 1979).



**Key words:** building codes; building regulations; building technology; economics; rehabilitation.

The paper will review an aspect of the Building Rehabilitation Technology Program in the Center for Building Technology (CBT) of the National Bureau of Standards related to the development of performance evaluation methods needed to make rehabilitation decisions.

Generally, building codes for new construction written in a prescriptive format are the existing bases for regulating building rehabilitation. This approach presents difficulties since retroactive application of codes for new construction to existing buildings increases costs and discourages rehabilitation. There are currently several activities both at the U.S. Federal and State levels where model code provisions for alterations and additions to existing buildings are under development and implementation. The Housing and Community Development Act of 1978 calls on the Department of Housing and Urban Development "to develop model rehabilitation guidelines for the voluntary adoption by States and communities." New provisions for building rehabilitation have been incorporated into the Massachusetts State building code. Since the development of these provisions is intended to be in performance terms, there is a need for technical evaluation methods and guidelines for application of performance-based provisions. CBT is developing manuals which will include state-of-the-art listings of technical data for building components and specific health safety and general welfare attributes; e.g., strength and stability, accident safety, health and sanitation, and energy conservation. These manuals will cover: (1) test methods for destructive and nondestructive evaluation of existing construction, (2) methods of analyses to predict the performance of existing construction, (3) field inspection and evaluation methodologies, (4) data on the performance of systems no longer used, and (5) data on rehabilitation experiences.

The status of these various technical evaluation activities will be discussed, and an overview will be given of the other aspects of the CBT Building Rehabilitation Technology Program.

**19161.** Blackburn, D. L., Berning, D. W., **Reverse-bias second breakdown in power transistors**, *Proc. Electrical Overstress/Electrostatic Discharge Symp.*, Denver, CO, Sept. 24-27, 1979, Ordering No. EOS-1, pp. 116-121 (IIT Research Institute, Chicago, IL, 1979).

**Key words:** focusing, current; measurement, nondestructive; second breakdown, reverse-bias; transistor, power; turn-off, transistor.

The construction and operation of a unique facility for testing power transistors for reverse-bias second breakdown with minimal device degradation are described. Some experimental results obtained using the circuit are discussed. Reverse-bias safe operating limits that have been determined nondestructively are shown, a method for qualitatively observing the focusing (crowding) of current to the centers of the emitter fingers is described, and some observations on the focusing of the current during the collector current storage time are discussed.

**19162.** Galloway, K. F., Mayo, S., Roitman, P., **Radiation levels associated with advanced lithographic techniques**, *J. Electrochem. Soc.* **126**, No. 12, 2245-2248 (Dec. 1979).

**Key words:** electron-beam lithography; metal-oxide-semiconductor device; process-induced radiation damage; radiation damage; semiconductor devices; very large scale integration; x-ray lithography.

Estimates of the radiation absorbed dose in critical device oxide layers due to x-ray and direct-write electron beam lithography are developed. Layered structures of photoresist, aluminum, silicon dioxide, and silicon are used for explicit calculations. It is shown that radiation levels in the Megarad ( $\text{SiO}_2$ ) range can be expected for both of these advanced lithographic

techniques. The consequences of this process-induced radiation damage are briefly considered.

**19163.** Myers, D. R., Phillips, W. E., **Observation of unequal densities for sulfur defects in silicon predeposited by low fluence ion implantation**, *J. Electron. Mater.* **8**, No. 6, 781-788 (1979).

**Key words:** dynathermal capacitance responses; dynathermal current response; isotopes; silicon; sulfur; thermally stimulated measurements.

The dynathermal current and capacitance responses of two isotopes of sulfur,  $^{32}\text{S}$  and  $^{34}\text{S}$ , predeposited by low fluence ion implantation into silicon  $p^+-n$  junction diodes are presented. As opposed to all previous studies, in this work unequal densities are seen for the shallow and deep sulfur defects, for both the  $^{32}\text{S}$ - and  $^{34}\text{S}$ -related defects. Additionally, the dynathermal response of the deep  $^{34}\text{S}$  center is seen to exhibit a shift of 3 K from that of  $^{32}\text{S}$  at a fixed heating rate of  $9.5 \pm 0.1$  K/s, consistent with the isotope dependence of the thermal emission process observed earlier for these centers by isothermal capacitance measurements.

**19164.** Nyyssonen, D., **Spatial coherence: The key to accurate optical micrometry**, (Proc. Soc. of Photo-Optical Instrumentation Engineers, San Diego, CA, Aug. 29-30, 1979), Paper in *Applications of Optical Coherence* **194**, 34-44 (Society of Photo-Optical Instrumentation Engineers, Box, 10, Bellingham, WA 98225, 1979).

**Key words:** coherence; laser applications; microdensitometry; microlithography; micrometry; optical microscopy; partially coherent imaging.

The accurate measurement of micrometer-size linewidths on integrated-circuit photomasks and wafers requires more accurate edge detection techniques than traditional optical measuring systems can achieve. A scanning photometric optical microscope has the capability of determining edge location using an optical threshold with a resulting linewidth error much smaller than the Airy disc radius of the imaging objective. However, the threshold corresponding to edge location is dependent upon the spatial coherence of the illumination. Analysis using the theory of partial coherence has led to threshold equations with corrections for contrast and optical phase difference at the line edge. Both the theory and instrumentation which have been developed for measurements on both photomasks and wafers are described. Linewidths as small as  $0.5 \mu\text{m}$  can be measured with a sensitivity of  $0.01 \mu\text{m}$  and an estimated uncertainty of  $0.05 \mu\text{m}$ .

**19165.** Linholm, L. W., Carver, G. P., Russell, T. J., **The use of microelectronic test structures to characterize IC materials, processes, and processing equipment**, *Proc. Measurement Sciences Conf.*, San Luis Obispo, CA, Nov. 30, 1979, pp. 129-150 (1979).

**Key words:** circuit characterization; cross-bridge sheet resistor; electrical alignment test structure; gated diode; integrated test structure; microelectronic test structure; process validation wafer; random fault test structure; sheet resistor; test methods; test pattern; test structure.

With the increasing complexity of large scale integrated circuits, it is becoming more difficult to fully characterize circuit performance. Microelectronic test structures offer an important source of reliable data for circuit characterization. When properly designed, test structures can be used to evaluate material, process, process equipment, and device parameters to provide the necessary information for circuit characterization. The National Bureau of Standards is conducting a program to develop well-designed test structures and methods to test these structures. The test structures are modular and can be tested with computer-controlled data acquisition systems; they can be used



to obtain unambiguous information on the parameter the structure is intended to measure. Data from these test structures can be applied to circuit characterization, process control, technology assessment, and yield analysis. Examples of the test structures in some of these applications are presented.

- 19166.** Phillips, W. E., Koyama, R. Y., Buehler, M. G., **Suppression of measurement interferences from interface states and mobile ions in thermally stimulated current measurements in an MOS capacitor**, *J. Electrochem. Soc.* **126**, No. 11, 1979-1981 (Nov. 1979).

Key words: interface states; measurement interferences; mobile ions; MOS capacitor; silicon; thermally stimulated measurements.

A study was made of the effectiveness of different procedures for suppressing measurement interferences from interface states at the oxide-silicon interface and from mobile ions in the oxide layer of MOS capacitors during thermally stimulated current measurements. It was found that the interface states can be activated or deactivated by the choice of biasing sequences and that the interference of mobile ions can be suppressed by bias temperature stress procedures which move the mobile ions to the metal electrode.

- 19167.** Hoffman, J. D., **On the formation of polymer fibrils by flow-induced crystallization**, *Polymer* **20**, 1071-1077 (Sept. 1979).

Key words: crystallization theory flow induced crystallization; extended chain fibrils; polymer crystallization; shish kebabs.

A theory of the formation of the core fibril ("shish") that is produced by flow-induced crystallization in undercooled polymer solutions is given. Multiple nucleation events on a flow-elongated molecule produce an embryonic fibril that is a connected set of bundlelike nuclei. End surface stress resulting from the repulsion of the "amorphous" chains in the regions between these nuclei builds up cumulatively as the nuclei mature, leading ultimately to volume strain in the body of each crystallite in the core fibril. This causes the diameter and length of the crystallites to be limited in a thermodynamic sense. The dependence of this diameter and length are calculated in terms of the driving force for the crystallization. Annealing and melting effects are discussed. The theory leads to a thin ( $\sim 150$  to  $\sim 500$  Å) core fibril that is a set of concatenated and substantially extended-chain crystallites of stable diameter that is interrupted at long intervals ( $\sim 1000$  to  $\sim 3000$  Å) by short and highly strained amorphous regions. Most of the chain molecules pass through these amorphous zones from one crystallite to another. Expanded lattice spacings are predicted for the crystallites comprising the core fibril under certain circumstances.

- 19168.** Calvano, N. J., Berger, R. E., **Effects of selected test variables on the evaluation of football helmet performance**, *Med. Sci. Sports* **11**, No. 3, 293-301 (1979).

Key words: headform; headgear; head injury; helmet; impact; test method.

The most important variables in helmet test methods (headform, impact surface, velocity) were studied by systematically changing the test variables and measuring the effect of these changes on the output responses (peak acceleration and severity index) of helmeted headforms. The degree of correlation between variables was also measured. The metal headform yielded consistently higher results than the humanoid headform but the differences between the two were much greater during impacts at the back site. Also, correlation between humanoid and metal headforms was significantly higher for top impacts than for rear impacts. These discrepancies between top and rear impacts were attributed to difficulties in the neck mounting system with the humanoid headform which causes inordinate bending during

impacts. The soft impact surface yielded lower responses than the hard surface for both headforms, correlations between soft and hard surfaces were high in all cases. A small change in impact velocity (4.5 to 5 m/sec) resulted in a substantially higher output response. Correlation between velocities were much lower for the back impact site than the top.

- 19169.** Plumb, H. H., **International practical temperature scale**, *Metric Syst. Guide Bull. No. 11*, 1-5 (Sept. 1974).

Key words: Celsius; Fahrenheit; IPTS-68; Kelvin; temperature; temperature scale.

Many individuals and manufacturers of thermometers use the degree Fahrenheit as the unit of temperature. However, the trend, as judged by textbooks and courses at schools and universities, is to express temperature in degrees Celsius. The reason for this conversion is that the degree Celsius is used in international temperature scales, such as IPTS-68. This temperature scale and its relation to the Fahrenheit and Celsius scales are explained in this article.

- 19170.** Jones, F. E., Schoonover, R. M., Houser, J. F., **In-tank measurement of solution density**, *Proc. Symp. on Measurement Technology for Safeguards and Materials Control, Kiawah Island, SC, Nov. 26-30, 1979*, p. 42 (1979).

Key words: accountability tanks; differential pressure; in-tank density determination; nuclear process solutions; solution density.

This paper presents the results of an experiment which established the feasibility of in-tank determination of the density of nuclear process solutions in the field with an accuracy competitive with the precision claimed for the best laboratory determinations. The work also provided a calibration factor, with a precision (estimate of the relative standard deviation of the mean) of 2.2 parts in 10,000, which can be used to infer density from differential pressure measurements in the particular tank. The technique eliminates one error in the laboratory determination of density and minimizes another. It also can be used to indicate the homogeneity of the tank solution and thus determine when a sample should be taken for determination of the concentration of nuclear material in the solution.

- 19171.** Fletcher, R. A., Mulholland, G. W., Chabay, I., Bright, D. S., **Calibration of an optical particle counter by particle Doppler shift spectrometry in the 4-8  $\mu$ m range**, *J. Aerosol Sci.* **11**, 53-60 (1980).

Key words: aerosol size calibrations; optical particle counter; particle Doppler shift spectrometer; particle size distribution; settling velocity; Stokes law velocity; vibrating orifice aerosol generator.

The particle Doppler shift spectrometer (PDSS) can be used to make an internally calibrated size measurement of aerosol particles. For low number concentrations of spherical particles, an accurate size distribution can be determined for particles from 3-30  $\mu$ m diameter. In this work the PDSS is used to calibrate a commercial optical particle counter. Test aerosol samples with a very narrow size distribution are generated by a Berglund-Liu particle generator. The particle size as predicted by the particle generator parameters and the size measured by the optical particle counter are compared to the size determined by the PDSS.

- 19172.** Siedle, A. R., Hubbard, C. R., Mighell, A. D., Doherty, R. M., Stewart, J. M., **Platinum thiotungsten compounds. Crystal and molecular structure of bis(triethylphosphine)platinum tetrathiotungsten**, *Inorgan. Chim. Acta* **38**, 197-202 (1980).

Key words: molecular structure; Pt-W complex; single crystal; ternary metal sulfide; x-ray diffraction;  $[\text{Et}_3\text{P}]_2\text{PtWS}_4$ .



Reaction of  $(\text{Ph}_3\text{P})_2\text{PtCl}_2$  with  $\text{Ph}_3\text{P}$  and  $(\text{Ph}_3\text{-PCH}_3)_2\text{WO}_2\text{S}_2$  produced  $(\text{Ph}_3\text{P})_2\text{PtWS}_4$  and  $(\text{Ph}_3\text{P})_2\text{-PtWOS}_3$ .  $[(\text{C}_2\text{H}_5)_3\text{P}]_2\text{PtWS}_4$  was similarly synthesized from  $[(\text{C}_2\text{H}_5)_3\text{P}]_2\text{PtCl}_2$  and its structure determined by x-ray diffraction ( $R = 0.026$ ). Crystal data:  $P2_1/n$ ,  $a = 9.081$ ,  $b = 14.516$ ,  $c = 16.819$  Å,  $\beta = 82.33^\circ$ ,  $Z = 4$ . The molecule consists of an approximately tetrahedral  $\text{WS}_4$  unit bridged on one edge by  $[(\text{C}_2\text{H}_5)_3\text{P}]_2\text{Pt}$ .

**19173.** Doherty, R., Hubbard, C. R., Mighell, A. D., Siedle, A. R., Stewart, J., Synthesis and crystal and molecular structure of  $[(\text{C}_7\text{H}_7)_3\text{P}]_4\text{Cu}_4\text{W}_2\text{O}_6\text{S}_6$ , a dimer of bis(tri-*p*-tolylphosphine)copper oxotritungsten, *Inorganic*, pp. 2991-2995 (Nov. 1979).

Key words: coordination complex; metalloenzymes, single crystal; 12-membered cage, x-ray diffraction;  $[(\text{C}_7\text{H}_7)_3\text{P}]_4\text{Cu}_4\text{W}_2\text{O}_6\text{S}_6$ .

Reaction of tri-*p*-tolylphosphine, cuprous chloride, and  $(\text{Ph}_3\text{PCH}_3)_2\text{WO}_2\text{S}_2$  produced  $[(\text{C}_7\text{H}_7)_3\text{P}]_4\text{Cu}_4\text{W}_2\text{O}_6\text{S}_6$  and  $[(\text{C}_7\text{-H}_7)_3\text{P}]_4\text{Cu}_4\text{W}_2\text{O}_6\text{S}_6$ . The oxotritungsten derivative crystallizes in monoclinic space group  $P2_1/n$  with  $a = 13.164(5)$  Å,  $b = 25.613(16)$  Å,  $c = 13.823(6)$  Å,  $\beta = 97.25(4)^\circ$ , and  $Z = 2$ . The x-ray structure ( $R = 0.067$ ) revealed a 12-atom  $\text{Cu}_4\text{W}_2\text{O}_6\text{S}_6$  cage which may be viewed as consisting of two approximately tetrahedral  $\text{WOS}_3$  units bridged on adjacent edges by  $[(\text{C}_7\text{H}_7)_3\text{PCu}]$  groups.

**19174.** Chatham, R. H., Gallagher, A., Lewis, E. L., Broadening of the sodium D lines by rare gases, *J. Phys. B* **13**, L7-L11 (1980).

Key words: line broadening; sodium.

Broadening of the sodium resonance lines by noble gases has been measured by observing fluorescence while scanning a laser across the lines. The impact-broadened Lorentzian linewidth is determined from the normalised absorption, detected as fluorescence, in the 5-20 GHz region of the line wings. Comparison with theory indicates reasonable overall agreement, but the increased precision of these measurements indicates many discrepancies of as much as 25%.

**19175.** Jones, D. E., Hill, J. E., An evaluation of ASHRAE standard 94-77 for testing pebble-bed and phase-change thermal energy storage devices, (Proc. ASHRAE Annual Meeting, Detroit, MI, June 1979), *ASHRAE Trans.* **85**, Pt. 2, 607-629 (1979).

Key words: ASHRAE standard 94-77; Glauber's salt; latent heat storage; pebble-bed; phase-change unit; solar energy storage; thermal storage device.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has recently adopted ASHRAE Standard 94-77—Methods of Testing Thermal Storage Devices Based on Thermal Performance. Experiments have been completed at the National Bureau of Standards in which a 7 m<sup>3</sup> (250 ft<sup>3</sup>) pebble bed and a similarly-sized 264 MJ (250,000 Btu) phase-change unit utilizing sodium sulfate decahydrate, both using air as the transfer fluid, were tested in accordance with this Standard. A description of the test procedure, test apparatus, and detailed test results are given. Some problems were encountered in using the Standard for these kinds of thermal storage devices, and modifications to the Standard are recommended based on these experiments.

**19176.** Rhodin, T. N., Gadzik, J. W., Electron spectroscopy and surface chemical bonding, Chapter 3 in *The Nature of the Surface Chemical Bond*, G. Ertl and T. N. Rhodin, Eds., pp. 113-273 (North Holland Publ. Co., Amsterdam, The Netherlands, 1979).

Key words: AES; chemisorption; EELS; electron spectroscopy; photoemission; UPS; XPS.

The theory of four electron spectroscopies, widely used in the study of chemical bonding of adsorbates to solid surfaces, is outlined here. Both single electron (matrix element) and many-body aspects of ultraviolet and x-ray photoemission, Auger electron, and electron energy loss spectroscopies are dealt with.

**19177.** Rosenstock, H. M., Stockbauer, R., Parr, A. C., Kinetic shift in chlorobenzene ion fragmentation and the heat of formation of the phenyl ion, *J. Chem. Phys.* **71**, No. 9, 3708-3714 (Nov. 1, 1979).

Key words: chlorobenzene; coincidence; fragmentation; ion energetics; phenyl ion; photoionization.

The fragmentation of chlorobenzene ion has been studied by photoelectron-photoion coincidence techniques. By varying the residence time it is possible to obtain breakdown curves as a function of residence time. The parent-daughter transition region shifts to lower energies as the residence time is increased (kinetic shift). The shift is of the order of 0.4 eV in going from 0.7 to 8.9 μs. A systematic analysis of the breakdown curves and residence time effects has been carried out using quasiequilibrium theory. The experimental results and analysis lead to  $\Delta H_0^\circ(\text{phenyl ion}) = 275 \pm 1$  kcal/mol ( $1151 \pm 4$  kJ/mol). The systematic analysis shows that this experiment leads to a quite accurate rate-energy curve in the range of  $10^4$ – $10^6$  s<sup>-1</sup>. The sensitivity of the QET model has been studied, and the limitations to the determination of activated complex parameters is critically discussed. The parameters obtained in this work are rather similar to those of an analogous neutral process, i.e., thermal decomposition of bromobenzene.

**19178.** Sekerka, R. F., Coriell, S. R., Influence of the space environment on some materials processing phenomena, *Proc. 3d European Symp. on Material Science in Space, Grenoble, France, Apr. 24-27, 1979*, ESA SP-142, pp. 55-65 (June 1979).

Key words: crystal; double-diffusive convection; floating zone; materials processing; microgravity; morphological stability; similarity principle.

The influence of the space environment on some materials processing phenomena is studied by applying the principles of physical similarity to a system E on earth and a system S in the microgravity environment of space. If these systems can be characterized by a set of dimensionless groups  $N_1 \dots N_q$ , then they are similar if corresponding members of the set are equal for E and S. Similarity is often impractical or impossible if  $Q$  is larger than a few. For example, there is a simple law of similarity for an isothermal liquid zone floating between inert solids; however, similarity is lost if the zone becomes nonisothermal. A molten zone during crystal growth is so complex that a complete set of  $N_i$  cannot be identified with certainty. A second example is double-diffusive convection during unidirectional solidification of a binary alloy. Buoyancy driven fluid dynamical instabilities couple with constitutionally related instabilities quite differently in E and S.

**19179.** Bialkowski, S. E., King, D. S., Stephenson, J. C., The determination of mass transport coefficients and vibrational relaxation rates of species formed in laser photolysis experiments, *J. Chem. Phys.* **72**, No. 2, 1156-1160 (Jan. 15, 1980).

Key words: diffusion; energy transfer; laser-excited fluorescence; laser-induced chemistry; mass transport; multiphoton processes; vibrational relaxation.

A simple analytical solution of the equations which govern the formation, collisional relaxation, and mass transport rates of species produced in radially symmetric laser-induced processes is given. These equations are specifically applied to the  $\text{CO}_2$  laser-induced dissociations of  $\text{CF}_2\text{HCl}$  and  $\text{C}_2\text{F}_3\text{Cl}$  dilute in argon. The concentration of the vibrational ground state of the  $\text{CF}_2$  radical product was probed as a function of time and pressure both during and after the photolyzing laser pulse by



the laser-excited fluorescence technique. From these measurements, the vibrational relaxation rate of  $\bar{X}$  CF<sub>2</sub> in argon was determined to be  $k_{VT} = 2.0 \times 10^{-15} \text{ cm}^3 \text{ sec}^{-1}$  and its diffusion coefficient was found to be  $D = 90 \text{ cm}^2 \text{ Torr sec}^{-1}$  in argon.

**19180.** Evans, D. J., Hanley, H. J. M., **Viscosity of a mixture of soft spheres**, *Phys. Rev. A* **20**, No. 4, 1648-1654 (Oct. 1979).

Key words: computer simulation; conformal solution theory; mixing rules; mixture; nonequilibrium molecular dynamics; Van der Waals I theory; viscosity.

The viscosity of a 50% mixture of soft spheres (i.e., particles which interact according to the force law  $\phi = d/r^{12}$ ) has been simulated by applying nonequilibrium molecular dynamics to a system of 108 particles. Results for several size (actually  $d$ ) and mass differences are given and compared with the predictions of a conformal-solution Van der Waals I theory. To construct this theory, it was necessary to derive a mixing rule for the mass. Overall, agreement between theory and simulation is satisfactory to size differences of about 14% and to mass differences of about 5%. It is pointed out that nonequilibrium molecular dynamics is a powerful technique and appears well suited to this particular application: The simulated viscosity of the mixture can be obtained to within about 5% accuracy for the 108-particle system by applying a shear to the system and following its behavior for about 7000 time steps.

**19181.** Aronson, E. B., Ware, R. H., Bender, P. L., **Modelling of solar quiet magnetic field variations near a conductivity anomaly**, *Geophys. J.* **59**, No. 1, 539-552 (1979).

Key words: conductivity anomalies; differential magnetic measurements; geomagnetism; induced currents; Sq current system variations; tectonomagnetism.

A simplified model of the solar quiet-time ionospheric current system is used to calculate the induced currents in a model earth. The conductivity is assumed to be constant below a depth of about 400 km and zero above that depth. The current induced in the north-south conductivity anomaly under the Rocky Mountains is then estimated from the time-varying potential difference between points at 30 and 45° latitude at the surface of the conducting sphere. The purpose of these calculations is to investigate whether variations in the latitude of the northern hemisphere current system vortex will substantially alter the relationship between the observed magnetic field components at the Earth's surface and the local magnetic field gradient caused by the conductivity anomaly. We find that a 10° shift in the latitude of the ionospheric current focus causes a change of 6 percent or less in the transfer function from the field components to the gradient in the total field. Thus such latitude shifts cannot explain much of the magnetic field gradient variation at periods near 24 hr that has been observed near Boulder, Colorado.

**19182.** Stockbauer, R., McCulloh, K. E., Parr, A. C., **The ionization potential of allene**, *Int. J. Mass Spectrom. Ion Phys.* **31**, 187-189 (1979).

Key words: allene; ionization potential; low temperature photoionization; mass spectrometry; photoelectron spectra; photoionization; threshold photoelectron spectra.

Nonuniform vibrational spacings in the threshold photoelectron spectra (IPES) and a large population of thermally excited neutral allene molecules suggest that the first one or two peaks in the photoelectron spectra may be due to thermally excited molecules. If so, then the ionization potential taken as the first peak in the TPES is in error. To investigate this possibility, the photoionization spectra was obtained at two different temperatures. The near identity of the two spectra indicate that the first peak in the TPES is indeed the 0-0 transition and after correction for peak shift may be used as the adiabatic ionization potential ( $9.692 \pm 0.002 \text{ eV}$ ).

**19183.** Stockbauer, R., **Threshold photoelectron spectra of atmospheric molecules. 1. Description of method and application to H<sub>2</sub>, D<sub>2</sub>, and N<sub>2</sub>**, *J. Chem. Phys.* **70**, No. 5, 2108-2114 (Mar. 1, 1979).

Key words: autoionization; deuterium; Franck-Condon Factors; hydrogen; nitrogen; photoelectron spectra; spectroscopy; threshold photoelectron spectroscopy.

Threshold photoelectron spectra (TPES) are presented for H<sub>2</sub>, D<sub>2</sub>, and N<sub>2</sub> with a resolution of 28 meV full width at half maximum. The results are compared with Franck-Condon transition probabilities, previous TPES and electron attachment threshold photoelectron spectra. Peaks in the TPES not predicted by Franck-Condon calculations are explained by autoionization processes. These processes in N<sub>2</sub> make possible the observation of vibrational levels of the ions not visible spectroscopically or in photoelectron spectra. Peaks between the  $v = 0$  and  $v = 1$  vibrational levels of the  $X^2\Sigma_g^+$  state of N<sub>2</sub><sup>+</sup> consist of near monoenergetic electrons implying little or no change in the rotational quantum number in the autoionization process.

**19184.** Stockbauer, R., Cole, B. E., Ederer, D. L., West, J. B., Parr, A. C., Dehmer, J. L., **Effects of shape resonances on vibrational intensity distributions in molecular photoionization**, *Phys. Rev. Lett.* **43**, No. 11, 757-761 (Sept. 10, 1979).

Key words: carbon monoxide; CO; Franck-Condon factors; ion; photoelectron spectra; photoionization; shape resonance; synchrotron radiation; vibrational intensity distribution.

We report striking non-Franck-Condon vibrational intensity distributions associated with the shape resonance in the  $5\sigma$  photoionization channel of CO. This example confirms the recent theoretical prediction that shape resonances will couple significantly with vibrational motion, leading to different resonance energies and profiles, and non-Franck-Condon intensities in alternative vibrational channels. Analogous effects are expected in connection with the widespread occurrence of shape resonances in both inner-shell and outershell molecular photoionization spectra.

**19185.** Yates, J. T., Jr., Williams, E. D., Weinberg, W. H., **Does chemisorbed carbon monoxide dissociate on rhodium?**, *Surf. Sci.* **91**, 562-570 (1980).

Key words: carbon; carbon monoxide; dissociated chemisorption; isotopic mixing; rhodium.

Isotopic exchange measurements have shown that at surface temperatures below 800 K, the *upper limit* on the probability of dissociation/recombination of CO on Rh(111) is approximately  $10^{-3}$ . Related Auger spectroscopic measurements, monitoring the accumulation of atomic carbon on the surface, have shown that the maximum probability of dissociation of CO per collision with the Rh surface in a temperature range between 300 and 870 K is  $10^{-4}$ . Hence, it has been demonstrated that the probability of dissociation of CO on Rh(111) is negligible compared to the probability of molecular desorption, in contrast to recent reports in the literature concerning both polycrystalline Rh and stepped surfaces of Rh.

**19186.** Sattler, J. P., Worchesky, T. L., Ritter, K. J., Lafferty, W. J., **Technique for wideband, rapid, and accurate diode-laser heterodyne spectroscopy: Measurements on 1,1-difluoroethylene**, *Opt. Lett.* **5**, No. 1, 21-23 (Jan. 1980).

Key words: diode laser spectroscopy; heterodyne measurement; high-precision; line assignments; line frequencies; rapid measurement technique; 1,1-difluoroethylene.

Refinements in the instrumentation of a diode-laser heterodyne spectrometer permit the rapid and routine measurement of infrared absorptions lying within 6.5 GHz of a CO<sub>2</sub> laser emis-



sion to a precision and accuracy well within 10 MHz. Measurements on 1,1-difluoroethylene, which is used in optically pumped submillimeter-wave lasers, illustrate the technique.

- 19187.** Stevens, W. J., **Cd\*<sub>2</sub> as a 470-nm absorber**, *Appl. Phys. Lett.* **35**, No. 10, 751-752 (Nov. 15, 1979).

**Key words:** excimer laser; excited state absorption; group II dimer.

Multiconfiguration self-consistent-field calculations have been carried out on all the valence states, low-lying Rydberg states, and charge-transfer states of Cd<sub>2</sub>. Like the other Group IIb dimers studied thus far, the lowest excimer level was found to be a <sup>3</sup>Π<sub>g</sub> metastable state that acts as a reservoir for molecular excitation energy. Strong absorptions between this reservoir state and a bound <sup>3</sup>Π<sub>u</sub> charge-transfer state are predicted in the vicinity of 470 nm. Weaker, but still significant absorptions, are predicted between the laser state (<sup>3</sup>Σ<sub>u</sub><sup>+</sup>) and a repulsive <sup>3</sup>Σ<sub>g</sub><sup>+</sup> state at the same wavelength. The predicted absorptions could seriously impair laser applications of Cd\*<sub>2</sub> and CdHg\*.

- 19188.** Sanders, D. M., Haller, W. K., **Influence of P<sub>02</sub> on vaporization of sodium disilicate at 1345 °C**, *J. Am. Ceram. Soc.* **62**, No. 7-8, 424-425 (July-Aug. 1979).

**Key words:** glass; oxygen dependence; sodium disilicate.

The dependence of sodium vapor density on oxygen partial pressure was determined for sodium disilicate glass at 1345 °C. It was found this density varied with P<sub>02</sub><sup>-1.25</sup> suggesting that sodium oxide dissociates on vaporization.

- 19189.** Basri, G. S., Linsky, J. L., **Outer atmospheres of cool stars. II. Mg II flux profiles and chromospheric radiative loss rates**, *Astrophys. J.* **234**, No. 3, 1023-1035 (Dec. 15, 1979).

**Key words:** emission; stars; stars, chromospheres; stars, corona; stars, late-type; stars, RS CVn-type; ultraviolet.

We present *International Ultraviolet Explorer* high-resolution spectra of the Mg II λλ2796, 2803 lines in 15 stars of spectral type G2-M2 including a wide range of luminosities. These spectra are calibrated in absolute flux units at Earth and at the stellar surface, and the chromospheric radiative loss rates in the Mg II lines are compared with corresponding rates in the Ca II H, K, and λ8542 lines. We find that the ratio of Mg II surface flux to total surface flux is independent of stellar luminosity and thus gravity, may decrease slowly with decreasing effective temperature, and increases with decreasing period among RS Canum Venaticorum binaries. The factor of 10 range in this ratio at each effective temperature may be due to differences in the fractional surface area covered by plages and may indicate that stars of all luminosity classes have chromospheric plages. In our small data sample we find no evidence that the Mg II line surface fluxes indicate whether a star possesses a transition region and hot corona.

- 19190.** Fickett, F. R., Reed, R. P., Dalder, E. N. C., **Structures, insulators and conductors for large superconducting magnets**, *J. Nucl. Mater.* **85 & 86**, 353-360 (1979).

**Key words:** alloys; magnets; materials; nonmetallics; review; stainless steel; superconductors.

As the size of superconducting magnet systems increases, the structural aspects become of increasing importance. Because the stresses increase rapidly with size and field, magnets of the type proposed for new devices will be largely structure. We are engaged in a program to acquire low temperature mechanical and physical property data on a wide range of materials. The present status of this data base is reviewed and results from our test program are described. We have placed emphasis on the austenitic stainless steels as the primary structural material, although data have also been acquired on a few aluminum alloys. Particular stress has been placed on the fracture characteristics

of both the base metal and weldments where appropriate. Achieving a good match between weld and base metal at 4 K is proving to be a difficult task. Several industrial fiberglass-epoxy laminates of fixed composition have been produced as a result of this program. These materials, G10 CR, G11 CR, and G11 CR(BF) have been tested at 4 K and the results are presented. Recent measurements on the effect of stress and fatigue on matrix materials for superconductor stabilization are also briefly reviewed. A new handbook of data on the properties of structural materials for superconducting magnet systems is described.

- 19191.** Cohen, J., **Life cycle performance of clothes dryers**, *Proc. Annual Reliability and Maintainability Symp., San Francisco, CA, Jan. 22-24, 1980*, pp. 91-94 (Institute of Electrical and Electronics Engineers, New York, NY, 1980).

**Key words:** consumer product; laboratory-test development; life cycle; performance; reliability.

Laboratory tests were made of the life cycle performance of two popular makes of clothes dryer, with a view towards determining the feasibility of life testing major consumer products in general. The dryers were comparatively tested up to an age equivalent to 17 years of life in the field, and little or no significant differences in either reliability or energy efficiency were observed. Because of the small sample size and difficulties in correlation, these results are not final. Elements of the laboratory test planning and procedure are given, as are some of the problems and difficulties in testing, especially of a generic product (heterogeneous sample), and some remarks are made concerning the feasibility of life testing consumer products.

- 19192.** Clinton, W. L., **Reneutralization in electron stimulated desorption**, *Surf. Sci.* **75**, L796-L799 (1978).

**Key words:** desorption; electron stimulated.

A comment on the non-adiabatic curve crossing interpretation of reneutralization in electron stimulated desorption.

- 19193.** Clinton, W. L., **Quantum scattering theory of electron-stimulated desorption: Ion angular distributions**, *Phys. Rev. Lett.* **39**, No. 15, 965-968 (Oct. 10, 1977).

**Key words:** adsorption; electron stimulated desorption; ion angular distribution; quantum scattering theory; surface.

This Letter presents a quantum scattering theory of electron stimulated desorption and applies it to recent observations of ion angular distributions. The Franck-Condon desorption cross section is calculated in a three-dimensional reflection approximation. It is shown that the adsorption models suggested by Madey, Czyzewski, and Yates, which attribute anisotropy in the angular distributions to initial-state effects, are consistent with the theory and the data.

- 19194.** Rainwater, J. C., **Softness expansion of gaseous transport properties. 1. Dilute gases**, *J. Chem. Phys.* **71**, No. 12, 5171-5182 (Dec. 15, 1979).

**Key words:** classical scattering angle; dilute gases; inverse power potential; logarithmic terms; softness expansion; thermal conductivity; viscosity.

Transport properties of dilute gases are studied both analytically and numerically for an inverse power interparticle potential. The mathematical dependence of transport properties on the softness parameter  $x = n^{-1}$  is emphasized, and nonanalytic dependences in  $x$ , of the form  $x^2 \ln x$ , are found. The derivation uses Gislason's series expansion for the scattering angle, and confirms and extends a previous result of Baroody. Equilibrium properties are also shown to be nonanalytic in  $x$ , but there the nonanalytic contributions are normally insignificant. The results cast doubt on the utility of effective hard-sphere diameter methods for transport theory. In addition, new insight is gained into classical scattering by inverse power potentials.



**19195.** Madey, T. E., Yates, J. T., Jr., Bradshaw, A. M., Hoffman, F. M., Evidence for "inclined" CO on Pd(210), *Surf. Sci.* **89**, 370-380 (1979).

Key words: carbon monoxide; chemisorption; electron stimulated desorption; molecular orientation; palladium (210); surface science.

The ESDIAD method (Electron Stimulated Desorption Ion Angular Distributions) has been used to verify an unusual bonding configuration for CO adsorbed on the rather open Pd(210) surface. In a previous IR reflection-absorption study of CO on Pd(210) (where top layer atoms with the nearest neighbor distance of 2.73 Å do not exist) the results indicated that CO was bridge-bonded to two Pd atoms via the carbon atom. Such bridge-bonding can only occur in several distinct sites between atoms in the first and second atom layers, so that the axes of adsorbed CO molecules are expected to be inclined away from the normal by  $\sim 18^\circ$ . The ESDIAD data are consistent with the infrared observations at low coverages (two-fold symmetric triangular ESDIAD patterns dominated by off-normal ion emission in appropriate symmetry directions). Furthermore, the ESDIAD results indicate that the bending vibrational amplitudes in orthogonal directions for bridge-bonded CO are different, in agreement with recent calculations. At the saturation CO coverage at 90 K, the data indicate that CO is bonded normal to the surfaces. The relative yields of  $O^+$  and  $CO^+$  ions are sensitive to the bonding mode, with  $O^+$  alone seen for bridge-bonded CO at low coverages and both  $O^+$  and  $CO^+$  ions observed at higher coverages.

**19196.** Parr, A. C., Jason, A. J., Stockbauer, R., McCulloh, K. E., Photoionization and threshold photoelectron-photoion coincidence study of propyne from onset to 20 eV, *Int. J. Mass Spectrom. Ion Phys.* **30**, 319-330 (1979).

Key words: coincidence; cyclopropene; fragmentation; mass spectrometry; photoionization; threshold photoelectron spectroscopy; time of flight mass spectrometry.

Photoionization efficiency curves are obtained for propyne and its fragments  $C_3H_3^+$ ,  $C_3H_2^+$ , and  $C_3H^+$  from threshold to 20 eV. Threshold photoelectron spectra and breakdown curves are given over the same energy range. The adiabatic ionization potential of the parent molecule, the appearance potentials of the fragments and the derived heats of formation of the ionic species are determined. The breakdown curve is almost identical to that obtained previously for allene when the different heats of formation of the neutral molecules are taken into account. This suggests that the propyne ion isomerizes to the allene ion before fragmentation.

**19197.** Stevens, W. J., Molecular anions: The ground and excited states of LiF, *J. Chem. Phys.* **72**, No. 3, 1536-1542 (Feb. 1, 1980).

Key words: autodetachment; charge transfer; electron affinity; electron scattering resonances;  $LiF^-$ ; molecular anions; polarizability.

*Ab initio* single configuration self-consistent-field calculations have been carried out for the electronic states of  $LiF^-$  arising from the  $Li(^2S) + F(^1S)$  and  $Li(^2P) + F(^1S)$  asymptotes. The  $^2\Sigma^+$  ground state is found to be stable by 0.35 eV with respect to detachment to form  $LiF(^1\Sigma) + e^-$ . The excited  $^2\Sigma^+$  and  $^2\Pi$  states are unstable and lie in the continuum of the  $^1\Sigma^+$  neutral. However, stabilized SCF solutions for the excited states have been obtained in an energetic region in which electron scattering resonances have recently been predicted. The possible basis set dependence of this result is discussed. The  $LiF^-$  states are compared to a lithium atom polarized by a point negative charge.

**19198.** Nesbitt, D. J., Leone, S. R., Laser-initiated chemical chain reactions, *J. Chem. Phys.* **72**, No. 3, 1722-1732 (Feb. 1980).

Key words: chain reaction; combustion; laser; photochemistry; radical.

A detailed kinetic and experimental analysis is presented for chemical reaction processes initiated by well-controlled, low power laser pulses. Realtime evolution of the chain reaction is followed by direct detection of infrared chemiluminescence from vibrationally excited HCl product molecules produced by one of the propagation reactions in the chain. By appropriate choice of conditions, the chain reactions may be analyzed separately for pseudofirst-order, radical-reagent processes as well as for second-order, radical-radical events. The pulsed laser initiation technique is applied to three sample chain systems which exhibit distinctly different chain lengths, rates, and termination behaviors. These systems are  $Cl_2/H_2S$ ,  $Cl_2/H_2$ , and  $Cl_2/CH_3SH$ . In the case of  $Cl_2/H_2S$ , detailed rate constant data are obtained for the fundamental chain propagation steps, and appropriate chain termination steps are assigned from the observations. The results demonstrate a new, general technique for the quantitative study of chemical chain reactions and related combustion processes.

**19199.** Fickett, F. R., Space applications of superconductivity: High field magnets, *Cryogenics* **19**, No. 12, 691-701 (Dec. 1979).

Key words: aerospace; magnetic field; magnets; materials; superconductor.

This is the second of a seven part series on the potential applications of superconductivity in space. A very general review of superconducting magnet technology is given, followed by a description of proposed magnet applications in space. The few programmes which actually flew magnets are also described. We conclude that many interesting possibilities exist for the future, but that their early realization will require a new direction for magnet research—toward very light, often very large structures with large amounts of stored energy.

**19200.** Peterson, R. L., Hamilton, C. A., Analysis of threshold curves for superconducting interferometers, *J. Appl. Phys.* **50**, No. 12, 8135-8142 (Dec. 1979).

Key words: interferometers; Josephson junctions; superconductivity; threshold curves.

Threshold curves for multijunction superconducting interferometers have been calculated previously, showing general agreement with observed features, especially in symmetric cases. We here add some more details to the analysis, paying particular attention to the effects of asymmetries in coupling, inductance, or critical currents. Feed-loop inductance and flux quantization in the feed loop can be important. A changing lobe pattern over many periods, asymmetries within a period, shifting patterns between runs spanning a warm-up, and sudden changes in pattern because of noise in the environment are all quantitatively explainable on the basis of this model. By use of a single "calibration curve," the inductance for symmetric two- or three-junction interferometers can be obtained immediately.

**19201.** Madey, T. E., Goodman, D. W., Kelley, R. D., Surface science and catalysis: The catalytic methanation reaction (Abstract), *J. Vac. Sci. Technol.* **16**, No. 2, 433-434 (Mar./Apr. 1979).

Key words: catalyst; Fischer-Tropsch synthesis; hydrogenation; methanation; nickel; poisoning.

A review of recent NBS work related to catalytic methanation over single crystals of Ni is presented.



**19202.** 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 I. ESCA results, *J. Electron. Spectrosc. Relat. Phenom.* 17, 361-403 (1979).**

Key words: binding energies; copper; ESCA; gold; relative intensities; round robin; x-ray photoelectron spectroscopy.

We report results of a round robin involving binding-energy (BE) and relative-intensity measurements on high-purity samples of gold and copper by x-ray photoelectron spectroscopy. These results were obtained on 38 different instruments manufactured by 8 companies. We found that the spread in reported BE values was typically greater than 2 eV while the spread in intensity ratios from cleaned samples was typically a factor of ten. We have analyzed the observed trends and have developed a procedure to show the contributions of systematic errors, random errors, and mistakes on BE and intensity measurements made with different individual instruments. This procedure, which leads to a plot of instrumental response as a function of electron energy, can be used by any user to compare the performance of his instrument with those reported here and to monitor performance as a function of time. At least part of the observed spreads in the reported BE and intensity data can be ascribed to erratic instrumental performance. The results of this round robin clearly demonstrate the need for improved calibration methods and operating procedures to ensure that data of known accuracy can be obtained routinely.

**19203.** Zimmerman, J. E., **Space applications of superconductivity: Low frequency superconducting sensors, *Cryogenics* 20, No. 1, 3-10 (Jan. 1980).**

Key words: aerospace; amplifier; Josephson junction; magnetic gradiometer; magnetometer; quantum interference; superconductivity.

This is the third of a seven part series on the potential applications of superconductivity in space. Superconducting quantum interference devices (SQUIDS) are used in highly-sensitive magnetometers and gradiometers. They are superior to all other magnetic sensors in sensitivity, frequency response, range, and linearity. They are potentially useful for measuring low-level magnetic field variations in space, such as fluctuations in the solar wind and small- or large-scale spacial anomalies of planetary fields. They are useful also as galvanometers and amplifiers, particularly for applications requiring extreme voltage sensitivity such as, for example, low-impedance bolometer amplifiers. In connection with low-frequency sensors, superconductivity provides some adjunct devices, namely perfect magnetic shields and flux transformers, the latter being used for a number of purposes including construction of fairly elaborate gradiometer pickup-loop arrays.

**19204.** Goodwin, R. D., **The nonanalytic equation of state for pure fluids applied to propane, (Proc. Conf. Equations of State in Engineering and Research, Miami Beach, FL, Sept. 10, 1978), Paper 19 in *Advances in Chemistry Series No. 182. Equations of State in Engineering and Research*, K. C. Chao and R. L. Robinson, Jr., Eds., pp. 345-362 (American Chemical Society, Washington, DC, 1979).**

Key words: coexistence boundary; critical point; densities; equation of state; fluids; orthobaric densities; propane; specific heats; thermodynamic properties; vapor pressures.

An isochoric equation is designed for computing thermodynamic functions of fluids. It has its origin on the liquid-vapor coexistence boundary, and it yields a maximum in isochoric specific heats at the critical point. Its basic structure is similar to that of the Beattie-Bridgeman equation. With only five least-squares coefficients, it describes a  $P(\rho, T)$  surface free of irregularities. A modified function in the equation is presented, for the problem of behavior in the limit of low densities, especially as

required for integration of the thermodynamic equation of state, to obtain the change of internal energy along isotherms. Recently derived vapor pressures for propane at low temperatures also have been introduced. Constants are reported for all equations, as needed for computations on propane.

**19205.** Kelley, R. D., Rush, J. J., Madey, T. E., **Vibrational spectroscopy of adsorbed species on nickel by neutron inelastic scattering, *Chem. Phys. Lett.* 66, No. 1, 159-164 (Sept. 15, 1979).**

Key words: hydrogen; neutron; nickel; spectroscopy; surface.

In a test of the utility of neutron inelastic spectroscopy (NIS) for studying molecular vibrations in surface reactions, we have examined the adsorption, co-adsorption, and reaction of hydrogen and carbon monoxide on Raney nickel catalysts.

**19206.** Gadzuk, J. W., **Coupled-harmonic-oscillator model for the vibrational modes of an adsorbed diatomic molecule, *Phys. Rev. B* 19, No. 10, 5355-5359 (May 15, 1979).**

Key words: adsorption; CO; diatomic molecules; electron energy loss spectroscopy; vibrational spectroscopy.

The normal vibrational modes for a diatomic molecule adsorbed on a surface are obtained in terms of the free-space intramolecular and bound-rigid-molecule surface modes. The consequences on both eigenfrequencies and damping rates of surface-induced coupling of these modes are pointed out. A set of self-consistency conditions relating the line positions and widths are derived. With these relations, it is demonstrated how shifts in intramolecular vibrational energies due to chemisorption bond formation can be extracted from total observed shifts resulting from both bond formation and coupling with the rigid-molecule modes. Electron-energy-loss data due to Andersson for CO adsorbed on Ni are analyzed in the light of the ideas put forth here.

**19207.** Gadzuk, J. W., **Relaxation shifts, satellites and sum rules in electron spectroscopies of adsorbed atoms, *Surf. Sci.* 86, 516-528 (1979).**

Key words: adsorption; electron spectroscopy; photoemission; relaxation effects.

Further ramifications of a recently proposed model treating the electronic relaxation processes associated with core level photoelectron spectroscopy of atoms or molecules adsorbed on metal surfaces are explored. Extra-atomic relaxation occurs via two mechanisms, displacement and excitation of surface plasmons (image potential screening) and substrate to adparticle electron transfer into unfilled orbitals of the adparticle. Both processes are treated on an equal footing here. Model photoelectron spectra presented for combinations of parameters likely to be relevant for real adsorbate-substrate systems and the relative importance of the two screening mechanisms is assessed.

**19208.** Domen, S. R., **Thermal diffusivity, specific heat, and thermal conductivity of A-150 plastic, *Phys. Med. Biol.* 25, No. 1, 93-102 (Jan. 1980).**

Key words: A-150 plastic; calorimeter; density; thermal properties; tissue equivalent plastic.

Some thermal properties of A-150 tissue-equivalent plastic have been determined. The results are: thermal diffusivity,  $2.72 \times 10^{-3} \text{ cm}^2 \text{ s}^{-1} \pm 0.4\%$ ; specific heat,  $1.72 \text{ J g}^{-1} \text{ K}^{-1} \pm 1.3\%$ ; and thermal conductivity,  $5.3 \times 10^{-3} \text{ W K}^{-1} \text{ cm}^{-1} \pm 1.4\%$ . The significance of the measurements for the design of a calorimeter core calibration heater is briefly described.

**19209.** Gadzuk, J. W., **Vibrational excitation, hole delocalization, and photoelectron line shapes of molecules, *Phys. Rev. B* 20, No. 2, 515-528 (July 15, 1979).**



Key words: adsorption; Franck-Condon; lineshapes; photoelectron spectroscopy; x-ray spectroscopy.

Certain aspects of hole dynamics in electron spectroscopies of quasilocated states in the condensed phase define the area of concern in this paper. Of special interest are the possible interference effects between low-energy shakeup satellite (electron-hole pairs, phonons, etc.) production and hole decay processes which determine the observed line shapes. As a specific example, the role and interplay of gas-phase Franck-Condon factors and substrate-induced hole delocalization in determining the photoemission line shape from nonchemisorption bonding-valence orbitals in adsorbed and free-space molecules are considered here. The present theory is discussed in the light of recent theoretical work on phonon broadening and hole decay in core-level x-ray emission, absorption, and photoelectron spectroscopy.

19210. Sakurai, T., Culbertson, R. J., Melmed, A. J., **Photoillumination effect on silicon field ion microscopy**, *J. Vac. Sci. Technol.* **16**, No. 2, 626-628 (Mar./Apr. 1979).

Key words: field ion microscopy; photoillumination effect; silicon.

The photoillumination effect which occurs during the field ion microscopy of silicon is investigated in detail using an UHV magnetic-sector atom-probe field ion microscope equipped with a retarding potential energy analyzer. It is shown that the observed enhancement of image intensity and field evaporation rate which occurs upon illumination with red light is due to the presence of an oxide layer. Measurements of energy deficits indicate that (1) the oxide layer causes a large potential drop at the emitter cap and (2) red light illumination drastically reduces or completely eliminates the reduction in potential.

19211. Rasmussen, A. L., Sanders, A. A., **Measurement of low level laser pulses at 1.064  $\mu\text{m}$** , (Proc. SPIE Conf. Proc. San Diego, CA, Aug. 29, 1979), *SPIE Meas. Opt. Radiat.* **196**, 96-103 (1979).

Key words: calibration; laser measurements; laser metrology; laser standards; transfer standards.

A system has been developed for measuring 1.064  $\mu\text{m}$  laser pulses of about  $10^{-15}$  J. The overall uncertainty of the system has been evaluated and is less than  $\pm 15\%$ . The details of the measurement system, its documentation relative to the NBS absolute reference calorimeters, and the associated uncertainties of measurements are discussed. Several silicon avalanche and PIN photodiodes have been evaluated. Measurements have been performed utilizing cw lasers, and laser pulses of about 30 and 200 ns. These measurements have demonstrated the feasibility of characterizing transfer standards for these low level energies by means of cw laser measurements and acousto-optic modulators. Such a system is discussed. The results of these evaluations and work towards realizing well documented transfer standards are also discussed.

19212. Ledbetter, H. M., **Orthotropic elastic stiffnesses of a boron-aluminum composite**, *J. Appl. Phys.* **50**, No. 12, 8247-8248 (Dec. 12, 1979).

Key words: boron-aluminum; composite; elastic constants; sound velocity.

Measuring 18 separate ultrasonic velocities in a uniaxial boron-fiber-reinforced aluminum-matrix composite by a 10-MHz pulse-echo technique reveals orthotropic symmetry and provides nine independent elastic-stiffness constants, which compare favorably with those measured previously by a resonance method at lower frequency.

19213. Scace, R. I., **Technology of semiconductor manufacturing, product development, and product types**, Appendix in *DIBA*

*Publ., U.S. Semiconductor Industry*, pp. 105-129 (U.S. Department of Commerce, Industry and Trade Administration, Washington, DC, Sept. 1979).

Key words: semiconductor devices; semiconductor materials; semiconductor processing; semiconductor technology; silicon.

A presentation is made of the technological basis of the semiconductor industry, in non-technical terms. The materials, processes, and principal types of devices commonly encountered are described. Significant technical problems are briefly mentioned, as is the annual sales volume for the various kinds of products.

19214. Berger, H., Lapinski, N. P., Reimann, K. J., **Neutron laminagraphy for inspection of nuclear fuel subassemblies**, *Proc. Int. Symp. New Methods of Non-Destructive Testing of Materials and Their Application Especially in Nuclear Engineering*, Saarbrücken, West Germany, Sept. 17-19, 1979, pp. 275-282 (Deutsche Gesellschaft für Zerstörungsfreie Prüfung e.V., Unter den Eichen 87, 1000 Berlin 45, West Germany, Mar. 1980).

Key words: fast neutrons; laminagraphy; neutrons; radiography; reactor fuel subassemblies; resonance neutrons; thermal neutrons; three-dimensional radiography.

Multiple-film laminagraphy to display individual object planes within a complex, reactor fuel subassembly is described. Neutron radiography methods in the thermal, resonance and fast energy ranges are shown to be capable of good laminagraphic results. Spatial resolution in individual object planes is 0.5 mm for thermal and resonance neutrons and is projected to be 1 to 2 mm for 14 MeV neutrons.

19215. Guildner, L. A., **Accuracy of realizing thermodynamic temperatures by gas thermometry**, *PTB Mitt.* **90**, No. 1/80, 41-47 (1980).

Key words: gas thermometry; International Practical Temperature Scale; platinum resistance thermometers; temperature scales; thermodynamic temperature.

The status of gas thermometry as a means of accurately realizing thermodynamic temperatures is considered in terms of the NBS gas thermometer. Following a discussion of the accuracies attained over the present temperature range, an appraisal of the optimum conditions for operating the gas thermometer up to the gold point and of the resulting uncertainties is given.

19216. Wenzel, J. T., Blackburn, D. H., Haller, W. K., Stokowski, S., Weber, M. J., **Development of fluorophosphate optical glasses**, *SPIE Phys. Prop. Opt. Mater.* **204**, 59-65 (1979).

Key words:  $\text{Al}(\text{PO}_3)_3$ - $\text{AlF}_3$ -MF-RF<sub>1</sub> system; fluoride glass; fluorophosphate glass; laser glass; low-dispersion glass; optical glass.

The requirements of high-energy laser systems have stimulated the development of low-refractive index, low-dispersion optical glasses, thus extending the range of available glasses in the Abbe diagram. Fluorophosphate glasses are the prime candidates to meet these requirements, but their preparation is complicated by fluorine volatilization on melting and devitrification and cracking on casting. The latter difficulties are caused by low viscosity at the crystallization temperature and by high thermal expansion. Exploration of glassforming regions and simultaneous optimization of the optical properties has led to the identification of compositions with commercial potential. A representative 100-gram melt contained 60 mol %  $\text{RF}_2$  (R = Mg, Ca, Sr, Ba), 36.7 mol %  $\text{AlF}_3$ , 3.3 mol %  $\text{Al}(\text{PO}_3)_3$ , with  $n_D = 1.439$  and  $v_D = 95$ . After annealing it was optically homogeneous and strain-free.

19217. Hatcher, P. G., VanderHart, D. L., Earl, W. L., **Use of solid-state  $^{13}\text{C}$  NMR in structural studies of humic acids and**



humin from Holocene sediments, *Organ. Geochem.* **2**, 87-92 (1980).

Key words: carbon-13 NMR; humic acids; humin; magic angle sample spinning.

Carbon-13 NMR spectra of solid humic substances in Holocene sediments have been obtained using cross polarization with magic-angle sample spinning techniques. The results demonstrate that this technique holds great promise for structural characterizations of complex macromolecular substances such as humin and humic acids. Quantifiable distinctions can be made between structural features of aquatic and terrestrial humic substances. The aliphatic carbons of the humic substances are dominant components suggestive of input from lipid-like materials. An interesting resemblance is also noted between terrestrial humic acid and humin spectra.

**19218.** Hunt, C. M., Ventilation measurements in the Norris Cotton Federal Office Building in Manchester, NH, (Proc. ASHRAE Semi Annual Meeting Symposium on Air Leakage, Philadelphia, PA, Jan. 1979), *ASHRAE Trans.* **85**, Pt. 1, 828-839 (June 1979).

Key words: ASHRAE Standard 62-73; building ventilation; carbon dioxide and ventilation; energy-efficient building.

Winter ventilation measurements were made in the Norris Cotton Building in Manchester, NH. Air exchange rates, averaged for the entire building, were of the order of 0.7 to 0.8 air changes per hour by the SF<sub>6</sub> tracer technique. This was obtained with outside air dampers closed. From this estimate and from counts of the number of occupants, ventilation rates of the order of 41 to 58 cfm (0.95 to 1.34 m<sup>3</sup>/min) per person were calculated.

The use of measured CO<sub>2</sub> concentration as an index of ventilation was reexamined. About 65 percent of the concentrations in selected rooms on each floor were between 700 to 1200 ppm. In one room where 11 people were taking an examination, 2440 ppm CO<sub>2</sub> was found. Ventilation rates per person, calculated from CO<sub>2</sub> concentrations, were less than those estimated from the overall building ventilation rate, but nevertheless met the requirements in the ASHRAE Ventilation Standard 62-73 when the building was operated with the outside air dampers closed.

**19219.** Dunn, G. H., Electron-ion collisions: Experimental, *Proc. Nagoya Seminar on Atomic Processes in Fusion Plasma*, Nagoya, Japan, Sept. 5-7, 1979, Y. Itikawa, T. Kato, Eds., pp. 57-65 (Institute of Plasma Physics, Nagoya University, Nagoya, Japan, 1979).

Key words: dielectronic recombination; electron-ion collisions; excitation; ionization.

Electron-ion collisions have long been of interest because of the application to non-local thermodynamic equilibrium modeling of astrophysical phenomena. Significant further impetus has arisen in the past several years as the understanding of such collisions has been recognized as necessary in the development of controlled thermonuclear fusion. Despite the long interest and the importance, the experimental study of these processes is recent. In 1961 Dolder *et al.* published their measurement of electron-He<sup>+</sup> ionization, and since that time about 100 papers have appeared on electron-ion ionization and excitation cross sections and rates. Seaton has recently reviewed the field with primary emphasis on the theory. Dolder and Peart have written an excellent review covering the experimental cross-section work through about 1975. The bibliographies in those reviews as well as several other bibliographies serve as good guides to the primary literature.

The purpose of this brief paper will not be to repeat or try to improve upon recent reviews, but rather to look at work done since they were published and, where possible, to make unifying or speculative comments about the data. Because of the focus

on very hot plasmas (fusion), attention will be limited to atomic ions; though there is a significant literature for electron-molecular ion collisions, especially for dissociative recombination.

**19220.** Eberly, J. H., Kunasz, C. V., Wødkiewicz, K., Time-dependent spectrum of resonance fluorescence, *J. Phys. B: Atom. Molec. Phys.* **13**, 217-239 (1980).

Key words: fluorescence spectrum; laser excitation; multiphoton processes; non-stationary processes; resonance fluorescence; strong laser field; time-dependent spectrum; transient spectrum.

Time-dependent features of the resonance fluorescence spectrum are studied. Attention is focused on the dynamic evolution of the emission spectrum following abrupt excitation of a near-resonant two-level absorber by a strong laser field. The multiphoton character of the absorption-emission process is evident in the AC Stark splitting of the spectrum, which begins approximately half an atomic lifetime after excitation, if the laser field is strong enough.

Use of the Eberly-Wødkiewicz counting-rate definition of the spectrum allows the influence of the spectral analyser (a Fabry-Perot interferometer in this example) to be exhibited for the first time. The Page-Lampard and Wiener-Khinchine power spectra are also shown in one case for comparison with the counting rate spectrum. Analytic expressions for these spectra are given for arbitrary laser field strength, atomic lifetime, laser-atom detuning, and the bandwidth of the spectrometer used to analyse the spectrum. Selected graphs are included to illustrate various time-dependent features of the spectrum.

The influence on the transient spectrum of three different states of atomic excitation prior to laser irradiation and the effect on the spectrum of irradiation by a phase-noisy laser are also considered. Comparison of the transient spectra from atoms initially prepared in  $\pi/2$  and  $3\pi/2$  states shows clearly that phase relationships between the irradiating field and the emitting dipole are important even in fluorescence. Concepts familiar in photon echo studies are useful in discussing these spectra. Finally, irradiation by a noisy laser is shown to produce spectra that, even in steady state, are closely similar to the early-time transient spectra obtained from irradiation by a monochromatic laser. An appendix is devoted to the transient spectrum of purely spontaneous fluorescence.

**19221.** Danos, M., Williams, H. T., Shell model for the interaction of the  $\Delta_{33}$  with the nucleus, *Phys. Lett.* **89B**, No. 2, 169-172 (Jan. 14, 1980).

Key words: baryon resonances; delta-nucleus interaction; nuclear structure; pion absorption; pion nucleus interaction; pion scattering.

We propose that the interaction of a  $\Delta_{33}$  baryon resonance with a nucleus can be described by an effective shell-model potential. This hypothesis is tested by computing in a simple manner the pion-nucleus scattering in the  $\Delta_{33}$  resonance region. A value of 150 MeV is found for the depth of the  $\Delta_{33}$  potential well.

**19222.** Cash, W., Charles, P., Bowyer, S., Walter, F., Ayres, T. R., Linsky, J. L., Discovery of x-rays from the 40 Eridani system, *Astrophys. J.* **231**, No. 3, L137-L140 (Aug. 1, 1979).

Key words: individual, x ray; sources; stars, corone-stars.

We report the detection of a new point source of soft x-rays (H0405 - 08) consistent with the position of the nearby triple star system 40 Eridani. The source, which has a temperature near 10<sup>7</sup> K, has a flux of  $3 \times 10^{-11}$  ergs cm<sup>-2</sup> s<sup>-1</sup> at Earth, implying a luminosity of  $9(\pm 3) \times 10^{28}$  ergs s<sup>-1</sup> at the distance of 40 Eridani. We discuss whether the likely source of the bulk of the x-rays is the K1 dwarf, the DA white dwarf, the dwarf M4 flare star, or accretion onto the white dwarf.



**19223.** Carroll, J. J., Klein, R., Melmed, A. J., **Thorium field ion microscopy**, *Surf. Sci. Lett.* **93**, L93-L97 (1980).

Key words: field emission microscopy; field ion microscopy; surface atomic structure; thorium.

A method of preparing and imaging thorium specimens for field ion microscopy is presented. Micrographs indicate that impurity constituents of the 99.9% material are readily imaged. Application of the electrotransport purification technique significantly reduces the concentration of imaged impurity constituents. Field electron emission micrographs obtained from previously field evaporated surfaces at 30 K demonstrate feasibility of field emission studies involving surface adsorption and migration.

**19224.** Arens, E. A., Nall, D. H., Carroll, W. L., **The representativeness of TRY data in predicting mean annual heating and cooling requirements**, (Proc. ASHRAE Semi Annual Meeting Symposium on Air Leakage, Philadelphia, PA, Jan. 1979), *ASHRAE Trans.* **85**, Pt. 1, 707-721 (June 1979).

Key words: building energy calculations; hourly climate data; test reference (TRY).

The report assesses 'Test Reference Year' (TRY) hourly climate data tapes to determine how well they represent long term average climate when used for estimating average annual heating and cooling requirements. A method is presented to adjust the heating and cooling requirements of a typical building type that have been computed using TRY data, in order to make them represent long term average heating and cooling requirements.

**19225.** Uehara, K., Hall, J. L., **Hyperfine splitting of the  $^{13}\text{CH}_4$  line at 3.39  $\mu\text{m}$  observed by laser-saturated absorption**, *Opt. Lett.* **4**, No. 7, 214-215 (July 1979).

Key words: hyperfine structure; methane; nonlinear spectroscopy; ultra resolution laser spectroscopy.

The hyperfine splitting and the recoil doubling of the  $F_2^{(2)}$  component in the  $P(6)$  line of the  $\nu_3$  band of  $^{13}\text{CH}_4$  was resolved with a narrow linewidth of less than 1 kHz (HWHM). Positions of the hyperfine components were precisely determined and related to the absolute frequency frame.

**19226.** Seltzer, S. M., **Electron, electron-bremsstrahlung and photon depth-dose data for space-shielding applications**, *IEEE Trans. Nucl. Sci.* **NS-25**, No. 6, 4896-4904 (Dec. 1979).

Key words: bremsstrahlung; dose; electrons; proton; shielding; spacecraft.

A data set has been developed, consisting of depth-dose distributions for omni-directional electron and proton fluxes incident on aluminum shields. The principal new feature of this work is the accurate treatment, based on detailed Monte Carlo calculations, of the electron-produced bremsstrahlung component. Results covering the energy region of interest in space-shielding calculations have been obtained for the absorbed dose (a) as a function of depth in a semi-infinite medium, (b) at the edge of slab shields, and (c) at the center of a solid sphere. The dose to a thin tissue-equivalent detector was obtained as well as that in aluminum. Various results and comparisons with other work are given.

**19227.** Rosenberg, L., **Sum rule and classical limit for scattering in a low-frequency laser field**, *Phys. Rev. A* **20**, No. 4, 1352-1358 (Oct. 1979).

Key words: multiphoton transitions; scattering in a laser field; stimulated bremsstrahlung.

A previously derived low-frequency approximation for scattering in a laser field represents the amplitude for scattering with the absorption or emission of a specified number of pho-

tons in terms of the physical field-free scattering amplitude, a result which holds even with the inclusion of a correction term of first order in the frequency of the field. In the general case, where the polarization of the field is arbitrary and the dipole approximation is not assumed, the cross section depends on the phase as well as the magnitude of the field-free scattering amplitude. It is shown here that this phase dependence disappears when the cross section is summed over all possible final states of the field. The result of this summation is identical (within the limits set by the domain of validity of the low-frequency approximation itself) to that which would be predicted from a classical description of the motion of the electron in the field, the collision taking place instantaneously and without influence from the field. This sum rule and its classical interpretation, obtained here in a nonrelativistic potential scattering model, is of the form derived some time ago by Brown and Goble on the basis of general field-theoretic considerations.

**19228.** Niemax, K., Movre, M., Pichler, G., **Near-wing asymmetries of the self-broadened first Rb and Cs resonance lines**, *J. Phys. B* **12**, No. 21, 3503-3509 (1979).

Key words: asymmetries; quasistatic wings; resonance lines; self-broadening of alkali lines.

We have measured small asymmetries in the near wings of the self-broadened first resonance lines of Rb and Cs. The transitions from the impact to the quasi-static profile were observed. A comparison with recent calculations by Movre and Pichler reveals satisfactory agreement.

**19229.** Rubinstein, M., Swartzendruber, L. J., Bennett, L. H., **Nuclear magnetic resonance in  $\text{LaNi}_5$** , *J. Appl. Phys.* **50**, No. 3, 2046-2048 (Mar. 1979).

Key words: diffusion; hydride; hydrogen; lanthanum; nickel; nuclear magnetic.

Proton and  $\text{La}^{139}$  nuclear magnetic resonance measurements have been performed on  $\text{LaNi}_5$ ,  $\text{LaNi}_5$  hydrides, and  $\text{LaNi}_5\text{H}_x$  with ternary additions. With ternary additions, the activation energy for proton diffusion remained unchanged, but the motionally narrowed linewidth broadened. The quadrupole interaction on the La site has been determined in  $\text{LaNi}_5$  and  $\text{LaNi}_5\text{H}_x$ .

**19230.** Rabinow, J., **Another inventor's view on innovation**, *CHEMTECH* **10**, No. 3, 144-148 (Mar. 1980).

Key words: conglomerates; innovation; invention; large corporations; productivity; small business.

Innovation in the United States is suffering because our corporations are getting too large so that it is difficult for top management to be expert in all phases of the industry in which it is engaged. In the case of the conglomerates, the problems are even worse. Most of the great innovations have been made outside of our large organizations and the writer is pessimistic because he believes that it is not likely that the trend to larger and larger sizes can be reversed.

**19231.** Myers, D. R., Koyama, R. Y., Phillips, W. E., **An implantation predeposition technique for the introduction of deep-level chemical impurities**, *Proc. Conf. Ion Beam Modification of Materials, Budapest, Hungary, Sept. 4-8, 1978*, pp. 439-448 (1979).

Key words: chemical impurities; deep level studies; ion implantation; predeposition technique; sulfur impurities in silicon; thermally-stimulated measurements.

The characterization of deep-level chemical impurity centers in semiconductors requires the controlled introduction of known impurities. A technique is described which employs ion implantation as a predeposition step for the introduction of deep-level chemical impurities into silicon, yet prevents implantation-related damage from interfering with the measured deep-level re-



sponse of the implanted species. The utility and versatility of this method are demonstrated by its application to the characterization of sulfur defect centers in silicon.

- 19232.** Myers, D. R., Wilson, R. G., **Alignment effects on implantation profiles in silicon**, *Proc. Conf. Ion Beam Modification of Materials, Budapest, Hungary, Sept. 4-8, 1978*, pp. 103-111 (1979).

Key words: capacitance-voltage profiling; controlled doping profile; critical channeling angle; crystallographic orientation effects; ion channeling; random equivalent implants.

Ion implantation is commonly used for the fabrication of fine geometry semiconductor devices. The need for shallower active layers in these devices requires that the extent of ion channeling be minimized to reduce the formation of deeply penetrating tails in the dopant distribution. In this paper, ion channeling in silicon is experimentally examined for a range of ion atomic numbers and implant energies characteristic of semiconductor device fabrication. Implantation profiles were obtained by 1 MHz differential capacitance-voltage (C-V) profiling for silicon substrates implanted at angles from accurately channeled alignment to "random equivalent" orientation. The critical angle for channeling, as calculated from an existing computer fit to the Moliere continuum potential, was used to scale the angular dependence of the implantation profiles. The results of this study indicate that to minimize the extent of unintentional channeling, alignment of the ion beam to the nearest low-index crystallographic direction must be at angles exceeding twice the critical angle.

- 19233.** Steinberg, H. L., **NBS conducts study for OSHA, requests information from public**, *Occup. Saf. Health Rep.* 5, No. 39, 1278 (Feb. 1976).

Key words: accident data; fall arresting systems; industrial and construction industries; occupational safety; safety belts; scaffolding.

This article is, basically, a request for data on accidents in which the use, or misuse, of fall-restraint or fall-arrest equipment played a significant role. "Fall-restraint/fall-arrest equipment" is taken to include: safety (body) belts, lanyards, drop lines, safety lines, life lines, linemen's belts, body and chest harnesses, rope-grabbing and shock absorbing devices and associated hardware. "Accidents" are defined to include "near misses" (i.e., mishaps where no lost-time injury occurred).

The motivation for this request is briefly explained for the purpose of enhancing response probability.

- 19234.** Placious, R. C., Moser, E. S., Holland, R. S., Masi, F., **Status report: A standard method for determining the efficacy of fluorescent x-ray intensifying screens**, (Proc. SPIE/SPSE Application of Optical Instrumentation in Medicine VI, Boston, MA, Sept. 25-27, 1977), *J. Appl. Photogr. Eng.* 5, 157-159 (1979).

Key words: fluorescent screens; intensifier screen standards; radiographic intensifier screen efficiency; screen evaluations; sensitivity of screens; spectroradiometry of screens; x-radiation of intensifier screens.

A proposed ANSI standard for classifying radiographic intensifying screens has been under test at the National Bureau of Standards. This standard establishes procedures for characterizing, on an absolute basis, the optical spectral output of fluorescent screens per unit of incident x-ray exposure. The testing procedure has undergone revision since an earlier status report was given. Calcium tungstate screens, however, still form the basis of comparison in this procedure because of the long acceptability and stable output qualities of this screen. The nature of the revisions and current output data on the screens will be described.

- 19235.** Weber, S. F., **Economic analysis of alternative envelope designs for new residences in the United States**, (Proc. Second Int. Symp. on Energy Conservation in the Built Environment, Copenhagen, Denmark, May 1979), *Energy* 5, No. 1, 63-68 (1980).

Key words: building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating.

An economic evaluation is conducted for selected energy-conservation investments in the envelope design of new single-family housing in the U.S. Alternative investment levels in the four major components of the building envelope are evaluated: (1) attic, (2) walls, (3) floor, and (4) windows. The analysis is conducted for five cities of widely diverse climate conditions and for the major forms of energy used for heating and cooling in the U.S. For each investment level, the internal rate of return (IRR) is calculated on an incremental basis, that is, in comparison with the next lowest level of investment for that component. This marginal IRR is used to rank alternative levels of investment for all four components so that economically optimal envelope designs can be selected for each city and energy type. Two points of view are considered in the selection of optimal designs: that of an individual homebuyer and that of a public policy planner.

- 19236.** Van Degrift, C. T., Bowers, W. J., Jr., Wildes, D. G., Pipes, P. B., **A small gas thermometer for use at low temperatures**, (Proc. ISA/78 Int. Conf., Philadelphia, PA, Oct. 16-18, 1978), *ISA Trans.* 19, No. 1, 15-19 (1980).

Key words: gas thermometers; low temperature; microwave temperature sensor; temperature transducer; thermometer; tunnel diode oscillators.

This paper describes a 2-cm dia  $\times$  5-cm long gas thermometer that uses an extremely stable tunnel diode oscillator. When biased with a dc current of 114  $\mu$ A (15  $\mu$ W), it emits a frequency between 456 and 463 MHz, depending on the pressure of its 0.39 ml sample of permanently trapped He<sup>3</sup> gas. Measurements of the dependence of its frequency on temperature and magnetic field are presented, as well as preliminary tests of its drift and noise.

- 19237.** Holton, J. K., **Updating solar performance criteria and standards**, *Proc. 1978 Annual Meeting of the American Section of the Int. Solar Energy Soc., Inc., Denver, CO, Aug. 28-31, 1978*, pp. 514-521 (Office of American Section, International Solar Energy Society, Inc., McDowell Hall, University of Delaware, Newark, DE, 1978).

Key words: solar performance criteria; solar standards; updating criteria.

The two solar performance criteria, "HUD Intermediate Minimum Property Standards (S/MPS)" and the "Interim Performance Criteria (IPC)" both residential and commercial, were developed by the National Bureau of Standards (NBS) early in the federal solar demonstration program to be of assistance in promoting the manufacture and widespread use of solar energy systems. Considerable experience has been gained from the demonstration program and other sources that has revealed the actual problems that can occur in the manufacture, installation and use of solar energy systems and components. In order to keep the S/MPS and IPC reasonable and useful standards, they are continually being updated based on current experience. Findings are presented from the residential and commercial demonstration program and from a public commentary process that have led to the updating of numerous sections of the criteria and standards. A comparison is presented of the original criteria, the practical problems and the revised criteria. Topics covered include: system performance covering thermal losses,



operating energy, system back-up, thermosyphoning, flow balancing, controls, safety, maintenance and check-out procedures; and component performance covering freeze protection, stratification, stagnation, materials deterioration, and heat transfer fluid quality.

- 19238.** Kotter, F. R., **Characterization of the electric environment under HVDC transmission lines: Instrumentation and measurement**, (Proc. Workshop on Electrical and Biological Effects Related to HVDC Transmission, Richland, WA, Oct. 19-20, 1978), Paper *PNL-3121, UC97a*, pp. 2.1-2.29 (Pacific Northwest Laboratory, Operated for the U.S. Department of Energy by Battelle Memorial Institute, Richland, WA, Aug. 1979).

Key words: air ions currents; atmospheric electricity; charge density; direct-current transmission; electric field strength; high-voltage transmission lines.

The instrumentation and measurement techniques used in atmospheric electricity research which have possible application for use in studying conditions in the vicinity of high-voltage direct-current transmission lines are reviewed. Thirty-four references are given.

- 19239.** Jenkins, J. P., Hill, J. E., **A comparison of test results for flat-plate water-heating solar collectors using the BSE and ASHRAE procedures**, *J. Sol. Energy Eng.* **102/1**, pp. 2-15 (Feb. 1980).

Key words: collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance.

Five solar collectors were tested according to the BSE and ASHRAE test procedures and the results compared. All five collectors tested were modular, flat-plate, water heating, and included single- and double-glazed designs with and without selectively coated absorbers. In both procedures, collector efficiency curves are determined. 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's optical and thermal loss characteristics, respectively. During the indoor testing in this study, the environmental test conditions were controlled and regulated by use of specially built environmental simulators to investigate the effect of wind speed and "sky" temperature on the thermal loss characteristics of the collectors.

- 19240.** Kaplan, S. B., **Acoustic matching of superconducting films to substrates**, *J. Low Temp. Phys.* **37**, Nos. 3/4, 343-365 (1979).

Key words: acoustic mismatch; effective recombination time; nonequilibrium phenomena; phonon-trapping; quasiparticle; superconductor.

Acoustic mismatch theory is used to estimate phonon transmission coefficients for various superconductor/substrate interfaces. It is shown that the conventionally employed substrates offer the largest acoustic mismatch to many of the commonly studied superconductors, thereby leading to unnecessarily large phonon-trapping and other nonequilibrium effects. Most available experimental results are shown to be in reasonable agreement with the theoretical estimates.

- 19241.** Klein, R., Siegel, R., **Interaction of nitrous oxide with ruthenium (10 $\bar{1}$ 0)**, *Surf. Sci.* **92**, 337-349 (1980).

Key words: chemisorption; nitrous oxide; ruthenium; surface reaction; thermal desorption.

The reactions of nitrous oxide with ruthenium as observed on the Ru(10 $\bar{1}$ 0) surface occur in two modes. Scission of the O—N<sub>2</sub>

bond with chemisorption of oxygen and release of molecular nitrogen to the gas phase is one, and breaking of both the O—N and N—N bonds in O—N—N with chemisorption of both O and N is the other. Energetic considerations lead to the conclusion that the latter mode is a concerted reaction. Site exclusion by preadsorption of oxygen or carbon monoxide inhibits the reaction, and where sufficient amounts of either of these two adsorbates are present, the activity of the surface can be reduced to zero. N<sub>2</sub>O can produce ruthenium oxide on the surface at sufficiently high temperatures, pressures, and contact times.

- 19242.** Lyon, G., **Batch scheduling from short lists**, *Inf. Process. Lett.* **8**, No. 2, 57-59 (Feb. 15, 1979).

Key words: hashing; resource allocation; scatter tables.

Almost all of  $m$  appointment slots can be assigned nearly optimally in  $O(m)$  provided appointment preferences are sufficiently random. And while there may be hundreds of appointments, each client need only indicate a set of five or six preferred times. These results are in sharp contrast to the standard assignment solution that costs  $O(m^{**3})$  in the worst-case and demands that each client provide a preference order for all  $m$  slots.

- 19243.** MacDonald, D. E., **An atomic model of strain induced martensitic transformations**, *Proc. Int. Conf. on Martensitic Transformations ICOMAT 1979, Cambridge, MA, June 24-29, 1979*, pp. 325-330 (Massachusetts Institute of Technology, Cambridge, MA, Mar. 1980).

Key words: criteria; finite; jellium; martensite; model; stability; strain; transformation.

A jellium model of the alkali metals applicable to finite deformation is employed in the determination of the uniaxial extensions and contractions which trigger the martensitic transformation (bcc  $\rightarrow$  fcc) and the reverse transformation (fcc  $\rightarrow$  bcc). A Born stability criteria based on infinitesimal elasticity is used to detect the onset of the transformation during a homogeneous deformation along [001]. For the (bcc  $\rightarrow$  fcc) transformation, the effective elastic coefficient  $(V_{11} - V_{12})$  vanishes at  $c/a(\text{bcc}) \approx 0.90$  while the minor  $V_{33}(V_{11} + V_{12}) - 2V_{13}^2$  vanishes at  $c/a(\text{bcc}) \approx 1.05$ . For the (fcc  $\rightarrow$  bcc) transformation, the effective elastic coefficient  $V_{66}$  vanishes at  $c/a(\text{fcc}) \approx 0.66$  and the coefficient  $(V_{11} - V_{12})$  vanishes at  $c/a(\text{fcc}) \approx 1.04$ . The symmetry and lack of it between the (bcc  $\rightarrow$  fcc) transformation and its reverse is explained in terms of the effect of the deformation on the volume and structure dependent terms in the expressions for the effective elastic coefficients. The finite values found for the uniaxial strains necessary for the transformations substantiates the need for a model which can sustain such deformations. While the present stability criteria falls in the area of infinitesimal deformations superimposed on finite deformations, it is pointed out that a criteria based on finite excursions from equilibrium may be more appropriate and physically meaningful.

- 19244.** Buehler, M. G., **Comprehensive test patterns with modular test structures: The 2 by N probe-pad array approach**, *Solid State Technol.* **22**, No. 10, 89-94 (Oct. 1979).

Key words: integrated circuit; process control; reliability; test pattern; test structure; transistors; yield.

Industrial microelectronic test patterns have a multiplicity of probe-pad arrangements which make standard test structure design difficult. A useful arrangement was found to be the 2 by N probe-pad array where N is an arbitrary positive integer. The use of this arrangement is compared to the peripheral probe-pad array approach and is illustrated by a variety of test structures.

- 19245.** Unassigned.

- 19246.** Ledbetter, H. M., Frederick, N. V., Austin, M. W., **Elastic-constant variability in stainless-steel 304**, *J. Appl. Phys.* **51**, No. 1, 305-309 (Jan. 1980).



Key words: bulk modulus; elastic constants; physical-property variability; Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus.

Variability of elastic constants in stainless-steel 304 was determined by measuring longitudinal and transverse ultrasonic velocities in 20 samples acquired randomly. Three kinds of variations—sample to sample, directional within a sample, and repeated measurements on a single sample—are reported for four elastic constants: the bulk modulus, Young's modulus, shear modulus, and Poisson's ratio. Because of surprisingly small variations, 1% or less, the principal problem became measurement sensitivity and reproducibility. To overcome this problem, a high-resolution measurement system was devised using general-purpose equipment augmented with a very simple impedance-transforming amplifier and an FET transmission gate. With this system the often-reported troublesome transit-time correction disappeared. Effects due to frequency and directionality were negligible.

- 19247.** Waterstrat, R. M., **Optimizing creep and corrosion properties in a dispersant amalgam using manganese**, *J. Dent. Res.* **57**, No. 9-10, 873-875 (Sept.-Oct. 1978).

Key words: copper alloys; corrosion behavior; creep properties; dental amalgam; manganese alloys; marginal stability; silver alloys.

It is shown that the creep behavior of a commercial dispersant-amalgam containing copper is improved by the addition of a manganese-containing alloy. This improvement is apparently obtained without any serious changes in corrosion resistance, provided that no more than 20% of the Mn alloy is added.

- 19248.** O'Connell, J. S., **Coincidence experiments with GEV electron beams**, *Nucl. Phys. A* **355**, 563-569 (1980).

Key words: accelerators; coincidence measurements; electrons; linac; nuclear reactions; superconducting.

Coincidence measurements with electron scattering at high momentum and energy transfer to the nucleus are examined from the point of view of determining the basic hadron-hadron interaction parameters. Electron beam characteristics and possible accelerators to produce 100% duty factor beams are discussed.

- 19249.** Yaghjian, A. D., **Electric dyadic Green's functions in the source region**, *Proc. IEEE* **68**, No. 2, 248-263 (Feb. 1980).

Key words: dyadic Green's functions; electric field; integral equation; source dyadic.

A straightforward approach that does not involve delta-function techniques is used to rigorously derive a generalized electric dyadic Green's function which defines uniquely the electric field inside as well as outside the source region. The electric dyadic Green's function, unlike the magnetic Green's function and the impulse functions of linear circuit theory, requires the specification of two dyadics: the conventional dyadic  $\bar{G}_e$  outside its singularity and a source dyadic  $\bar{L}$  which is determined solely from the geometry of the "principal volume" chosen to exclude the singularity of  $\bar{G}_e$ . The source dyadic  $\bar{L}$  is characterized mathematically, interpreted physically as a generalized depolarizing dyadic, and evaluated for a number of principal volumes (self-cells) which are commonly used in numerical integration or solution schemes. Discrepancies at the source point among electric dyadic Green's functions derived by a number of authors are shown to be explainable and reconcilable merely through the proper choice of the principal volume. Moreover, the ordinary delta-function method, which by itself is shown to be inadequate to extract uniquely the proper electric dyadic Green's function in the source region, can be supplemented by a simple procedure to yield unambiguously the correct Green's function representation and associated fields.

- 19250.** Berger, P. W., **Federal data banks as potential information resources to meet the needs of local communities**, *Spec. Lib.* **71**, No. 2, 77-82 (Feb. 1980).

Key words: Federal data bases; Federal information services; Federal libraries; networks; special libraries; White House conference on library and information services.

Article reports potential impacts of the November, 1979 White House Conference on Library and Information Services deliberations on Federal libraries and Federal information services. Public access to Federal libraries, data bases and information services was a major concern to the Conference Delegates, as were questions of networking and network design.

- 19251.** Berger, H., Birnbaum, G., Free, G., **Recent progress in eddy current testing**, *Proc. Int. Symp. New Methods of Non-Destructive Testing of Materials and their Application Especially in Nuclear Engineering*, Saarbrücken, West Germany, Sept. 17-19, 1979, pp. 99-106 (Deutsche Gesellschaft für Zerstörungsfreie, Berlin, West Germany, Mar. 1980).

Key words: eddy current; finite element analysis; multifrequency; nuclear applications; pattern recognition; reference standards.

The effectiveness of eddy current nondestructive testing is being enhanced by recent advances in theoretical analysis, new measurement methods, and the use of automation and computers for data analysis. Progress has been made in these areas as evidenced by papers presented at a Symposium held September 1979 in USA. This paper presents a survey of the symposium papers related to the nuclear industry dealing with theory and applications of multifrequency techniques, automation methods and data analysis including pattern recognition. Those areas in which increased emphasis in further research appear to be profitable will be indicated.

- 19252.** Bussey, H. E., **Microwave dielectric measurements of lunar soil with a coaxial line resonator method**, *Proc. 10th Lunar and Planetary Science Conf.*, Houston, TX, Mar. 19-23, 1979, pp. 2175-2182 (Pergamon Press, Inc., Elmsford, NY, Dec. 1979).

Key words: coaxial bead resonance; coaxial resonator; dielectric constant; dielectric loss; dielectric temperature dependence; lunar soil.

A method is given for sensitive dielectric measurements at a series of microwave frequencies using a section of coaxial line. The line is used as a 1-port cavity resonator; it resonates when the electrical length of the center conductor (which is open circuited at each end) equals  $1, 2, \dots, N$  half-wave lengths. The dielectric properties of an Apollo 17 dried soil sample were measured in vacuum over a temperature range of 173 to 373 K. Stated as a function of the packing density  $\rho$  in g/ml, the relative permittivity was  $2.1^{\rho}$  and the loss tangent was  $0.0037 \rho$  at 296 K and about 1 GHz frequency. The frequency dependence was very small. The derivative with respect to temperature, per degree, was 0.00045 for the permittivity and 0.00002 for the loss tangent.

- 19253.** Lashmore, D. S., Swartzendruber, L. J., Bennett, L. H., **Mössbauer spectroscopy of polycrystalline steel fibers**, *Appl. Phys. Lett.* **36**, No. 1, 39-40 (Jan. 1, 1980).

Key words: carbon; cementite; hyperfine fields; iron fibers; magnetism; Mössbauer effect; Schladitz whiskers.

Polycrystalline steel fibers, commonly known as "Schladitz whiskers," produced by thermal decomposition of iron pentacarbonyl in the presence of a magnetic field, have been studied by means of the  $^{57}\text{Fe}$  Mössbauer effect. Results show that the fibers are a two-phase alloy of  $\alpha\text{-Fe}$  and  $\text{Fe}_3\text{C}$ . Almost all the carbon present in the fibers is tied up as  $\text{Fe}_3\text{C}$ . The magnetic polariza-



tion (in zero applied field) is random rather than being aligned along the fiber axis.

- 19254.** Klein, R., Siegel, R., Erickson, N. E., **Oxide formation on ruthenium observed by TDS and ESCA**, *J. Vac. Sci. Technol.* **16**, No. 2, 489-491 (Mar./Apr. 1979).

Key words: chemisorption; ESCA; oxygen; ruthenium; ruthenium oxide; surface reactions.

Oxygen adsorbed at room temperature on a Ru(10 $\bar{1}0$ ) surface shows a single peak in its thermal desorption curve, the peak maximum shifting to lower temperature with higher initial concentration in accordance with second order kinetics. Additional peaks in the thermal desorption spectrum of oxygen from Ru(10 $\bar{1}0$ ) were observed after exposure of the ruthenium above 600 K to oxygen. These peaks, desorbing with first order kinetics, are attributed to oxide formation. The change in the size of the peaks with respect to the temperature of the surface during oxygen exposure is correlated with an oxygen sticking coefficient that is constant up to 850 K and decreases thereafter. The ESCA spectrum of a surface with the "oxide" showed an increase in the height of the O(1s) peak but no chemical shift. Sulfur adsorbed on Ru(10 $\bar{1}0$ ) prevents the adsorption of oxygen.

- 19255.** Lynn, J. W., Glinka, C. J., **Magnetic properties of the superconducting alloy system (Ce<sub>1-c</sub>Ho<sub>c</sub>)Ru<sub>2</sub>—A neutron scattering study**, *J. Mag. Magn. Mater.* **14**, 179-180 (1979).

Key words: crystal field; magnetic superconductors; neutron scattering; rare earth; small angle scattering; superconductivity.

Neutron scattering measurements have been carried out on the superconducting alloy system (Ce<sub>1-c</sub>Ho<sub>c</sub>)Ru<sub>2</sub> for  $c = 0.10, 0.32$  and  $0.38$  as a function of temperature and magnetic field. The observed crystal-field transitions for all concentrations are found to be very similar and can be understood on the basis of a cubic crystal field acting on the Ho<sup>3+</sup> ( $J = 8$ ), with  $W = +0.03$  meV and  $x = -0.3$ . The Ho ground state is thus established to be the magnetic  $\Gamma_5$  triplet over the entire composition range of interest. Small-angle scattering data taken on an alloy with 38% Ho, in which a conventional ferromagnetic transition was anticipated, show that indeed ferromagnetic correlations develop at low temperatures. However, no characteristic peak in the intensity vs. temperature was observed; rather the intensity at small wavevectors  $Q$  continues to increase slowly down to the lowest temperatures attained (1.05 K), while little intensity change is observed below  $T \sim 2$  K at larger  $Q$  ( $0.05 \rightarrow 0.15 \text{ \AA}^{-1}$ ).

- 19256.** Rhyne, J. J., Koon, N. C., Das, B. N., **Ground state excitations in HoCo<sub>2</sub>**, *J. Mag. Magn. Mater.* **14**, 273-274 (1979).

Key words: crystal fields; exchange interaction; magnetism; neutron scattering; rare earth compounds; spin excitations.

Spin excitations in a single crystal of the Laves phase compound HoCo<sub>2</sub> have been studied using inelastic neutron scattering. At 4 K three modes are observable: an in-phase spin precision acoustic mode and two out-of-phase optic modes involving the rare earth spins. A self-consistent Green's function RPA theory has been used to analyze the data and obtain exchange and crystal field parameters.

- 19257.** Feldman, A., Waxler, R. M., **Properties of crystalline materials for optics**, (Proc. SPIE Conf. on Recent and Future Developments in Medical Imaging II, San Diego, CA, Aug. 27-29, 1979), *SPIE J.* **204**, 68-76 (1980).

Key words: absorption coefficient; birefringence; crystal optics; dielectric constant; elasto-optic; electro-optic; photoelastic; piezo-optic; refractive index; relative dielectric impermeability.

A tutorial review of refractive index, absorption, birefringence, the electro-optic effect and the photoelastic effect in

crystalline materials is presented. Tensorial relationships are presented and related to the symmetry classes of crystals.

- 19258.** Lynn, J. W., Moncton, D. E., Passell, L., Thomlinson, W., **Magnetic correlations and crystal-field levels in the superconductor (Ce<sub>0.73</sub>Ho<sub>0.27</sub>)Ru<sub>2</sub>**, *Phys. Rev. B* **21**, No. 1, 70-78 (Jan. 1, 1980).

Key words: crystal field effects; ferromagnet; magnetic superconductor; neutron scattering phase transition; rare earth.

Neutron scattering studies have been carried out to investigate the atomic magnetic properties of the "magnetic" superconductor (Ce<sub>0.73</sub>Ho<sub>0.27</sub>)Ru<sub>2</sub>. At low temperatures we observe the appearance of elastic or quasielastic magnetic scattering at small momentum transfers, indicating the development of ferromagnetic correlations. The temperature and wave-vector dependence of this scattering can be described to a good approximation by an Ornstein-Zernike correlation function over the entire range of wave vectors ( $0.035 - 0.20 \text{ \AA}^{-1}$ ) and temperatures ( $0.05 - 4.2$  K) explored. The range of the spatial correlations  $\xi$  ( $= 1/\kappa$ ) increases smoothly with decreasing temperature and suggests the onset of ferromagnetism at  $\sim 0.5$  K. However, below 0.5 K,  $\xi$  ceases to increase, saturating at a value of  $80 \text{ \AA}$  with no detectable change in the scattering below that temperature. Thus there is no transition to conventional long-range ferromagnetic order. There is also no indication in the magnetic scattering of the onset of superconductivity at 1.6 K. Measurements of the inelastic magnetic scattering reveal a number of crystal-field transitions, demonstrating that the crystalline electric field removes the 17-fold degeneracy of the  $J = 8$  Ho<sup>3+</sup> free ion. The nature of the splittings can be understood on the basis of a crystal field with cubic symmetry, and the ground state is found to be the triply degenerate  $\Gamma_5$  state, which possesses a magnetic moment. At low temperatures additional magnetic inelastic scattering is observed at low energies; this suggests that there are substantial exchange effects even though the characteristic magnetic temperature (0.5 K) is very small.

- 19259.** Wallerstein, G., **The behavior of H $\alpha$  in delta Cephei**, *Publ. Astron. Soc. Pac.* **91**, 772-774 (Dec. 1979).

Key words: delta Cephei; H $\alpha$  profiles.

A new radial velocity curve for  $\delta$  Cep is presented based on  $10 \text{ \AA mm}^{-1}$  red spectrograms. The curves for neutral metallic lines, low excitation ions, and high excitation Si II lines follow the curve of Shane (1958) within observational uncertainties. For H $\alpha$  the curve shows an amplitude  $15 \text{ km s}^{-1}$  larger than for the metallic lines. Arguments are presented to show that the H $\alpha$  absorption is formed high in the atmosphere of  $\delta$  Cep.

- 19260.** Rosenberg, L., **Infrared radiation in potential scattering**, *Phys. Rev. A* **21**, No. 1, 157-162 (Jan. 1980).

Key words: electron scattering; free-free transitions; infrared radiation.

Some time ago Bloch and Nordsieck, working in a model in which the spectrum of the radiation field is cut off beyond some low frequency  $\omega_1$ , showed that the transition probability for scattering, summed over final photon states, is approximately that which would be obtained if the interaction of the projectile with the radiation field were neglected entirely. Here, within the context of a nonrelativistic treatment of the scattering process, the sum rule is generalized through the inclusion of corrections of first order in  $\omega_1$ . These corrections can be interpreted in terms of a simple classical picture. In the course of the derivation, a low-frequency approximation for the transition amplitude is obtained which contains as special cases the perturbative result of Low for single-photon bremsstrahlung and the more recently derived approximation for scattering in a low-frequency laser field.



**19261.** Rabinow, J., **National Bureau of Standards and the individual inventor**, (Proc. Conf. Innovation, Entrepreneurship and the University, University of California, Santa Cruz, CA, Nov. 8-10, 1978), *CIED Publ.*, N. S. Kapany, Ed., pp. 83-87 (CIED, University of California, Santa Cruz, CA, Aug. 13, 1979).

Key words: entrepreneurship; innovation; innovation centers; invention; invention evaluation; Santa Cruz.

This talk outlines the program of evaluating inventions submitted to the National Bureau of Standards Office of Energy-Related Inventions. A brief history of the now defunct National Inventors Council is included. The talk states my personal opinions about the procedures to be followed in evaluating inventions, my firm belief that no routine type of examination is proper, and that the evaluation of inventions must be done by highly trained, technically educated people.

**19262.** Schroeder, L. W., Bowen, R. L., Ferris, J. S., **Adhesive bonding of various materials to hard tooth tissues. XX. Calcium-to-calcium distances in hydroxyapatite**, *J. Biomed. Mater. Res.* **14**, 83-90 (1980).

Key words: adhesion; bonding; calcium phosphates; crystal structure; dental; hydroxyapatites; tooth mineral.

Distributions of Ca-to-Ca distances have been obtained from the crystal structure of hydroxyapatite for all biologically significant planes. Most frequently, calcium ions are separated by about 4, 6.3, 7.9, and 9.0 to 9.6 Å. Frequent occurrence of distances at 10.4, 11.8, and 12.6 Å result from a Ca ion in one repeating unit being paired with a Ca in another unit cell.

**19263.** Wacławski, B. J., Boudreaux, D. S., **Ultraviolet photoelectron spectroscopy of Pd-Si glasses**, *Solid State Commun.* **33**, 589-591 (1980).

Key words: alloys; alloy stability; amorphous alloys; electron density of states; palladium-silicon alloys; photoelectron; ultraviolet photoelectron spectroscopy; UPS.

In order to determine systematic changes in the density of states with alloy composition, photoelectron spectra at  $h\nu = 21.2$  eV were measured for several amorphous alloys based on the well-known Pd-Si glass system. Three binary alloys with 15, 20, and 25 at. % Si, two ternaries,  $\text{Pd}_{80}\text{Si}_{17}\text{Cu}_3$  and  $\text{Pd}_{80}\text{Si}_{14}\text{Cu}_6$ , polycrystalline Pd were analyzed. Compared to Pd, both the density of states at the Fermi energy and the d-band width are reduced in the glasses. The d-bands display an overall shift of 0.4 eV over the range of alloy compositions studied. Partial agreement with recent density of states calculations was obtained.

**19264.** Coriell, S. R., Cordes, M. R., Boettinger, W. J., Sekerka, R. F., **Convective and interfacial instabilities during unidirectional solidification of a binary alloy**, *J. Cryst. Growth* **49**, No. 1, 13-28 (May 1980).

Key words: alloy; convection; interface; solidification; solute.

The onset of coupled convective and constitutional interfacial instabilities during the directional solidification of a single phase binary alloy at constant velocity vertically upwards (positive z-direction) is treated by a linear stability analysis. We consider a system for which the temperature gradient alone would cause a negative density gradient and the solute gradient alone would cause a positive density gradient. The temperature and concentration fields are coupled through the hydrodynamic equations. The solidification boundary conditions at the solid-liquid interface couple the hydrodynamic and interfacial stability phenomena. Specific calculations were made for physical properties appropriate to the solidification of lead containing tin. Results indicate that the stability-instability criterion differs substantially

from the criterion of a net neutral density gradient. For a temperature gradient in the liquid of 200 K/cm and for velocities in the range 1-40  $\mu\text{m/s}$ , a convective-like long wavelength instability occurs at a critical concentration that increases with velocity; whereas for  $V > 40 \mu\text{m/s}$ , the concentration at which instability occurs decreases as velocity is increased and the values of concentration and wavelength at the onset of instability correspond to the predictions of previous morphological stability theory in which density changes and convection are neglected. Application of a vertical static magnetic field increases the critical concentration for convective instabilities but a field of a tesla ( $10^4$  gauss) is needed to cause an order of magnitude change.

**19265.** Danos, M., **Quartet effects in masses and in charge exchange reactions**, *Proc. Int. Symp. on Future Directions in Studies of Nuclei Far From Stability*, Nashville, TN, Sept. 10-14, 1979, pp. 195-207 (North Holland Publ., Co., Amsterdam, The Netherlands, 1980).

Key words: charge exchange reactions; exotic nuclei; heavy ion collision; mass formula; quartets; SU4.

A mass formula based on the quartet model is presented; some differences in its predictions with that of other mass formulae are pointed out. The possibility of reaching highly unstable nuclei by charge exchange reactions is discussed. It is shown that surface quartets play a decisive role in multiple charge transfer processes.

**19266.** Eesley, G. L., Levenson, M. D., Nitz, D. E., Smith, A. V., **Narrow-band pulsed dye laser system for precision nonlinear spectroscopy**, *IEEE J. Quant. Electron.* **GE-16**, No. 2, 113-115 (Feb. 1980).

Key words: CW injection; laser; narrow band laser; Nd:YAG pump; pulsed laser; tunable laser.

We report a CW oscillator/pulsed amplifier dye laser system that produces 20 kW of diffraction limited radiation with a linewidth of  $17 \pm 4$  MHz. The key component is a unique long pulse Nd:YAG pump laser.

**19267.** Flynn, J. H., **The effect of heating rate upon the coupling of complex reactions. I. Independent and competitive reactions**, (Proc. 7th North American Thermal Analysis Society Meeting, St. Louis, MO, Sept. 27, 1977), *Thermochim. Acta* **37**, 225-238 (1980).

Key words: activation energy; competitive reactions; complex reactions; heating rate; independent reactions; kinetics; lifetime prediction; nonisothermal kinetics; thermal analysis.

Theoretical curves of the rate of conversion vs. temperature at constant heating rate for first-order reactions with activation energies of 80, 160, 240 and 320  $\text{kJ mole}^{-1}$  are compared over a range of heating rates from  $10^{-9}$  to  $10^5 \text{ K s}^{-1}$  for independent and competitive reactions. Independent reactions with different activation energies may be separated from one another by either increasing or decreasing the rate of heating. The spectrum of derivative peaks for two competing reactions at various heating rates has a dispersion effect in the region of change from low to high activation energy reactions. The practical range of heating rates in thermal analytical experiments and the application of these model cases to the understanding of the kinetics of complex systems at high and low temperatures are discussed.

**19268.** Haisch, B. M., Linsky, J. L., Basri, G. S., **Outer atmospheres of cool stars. IV. A discussion of cool stellar wind models**, *Astrophys. J.* **235**, 519-533 (Jan. 15, 1980).

Key words: late-type stars; stellar chromospheres; stellar coronae; stellar winds.

We investigate possible wind models for late-type stars which appear not to have hot coronae and transition regions. Taking



Arcturus as our prototypical star, we consider wind models with  $T \lesssim 20,000$  K and search for solutions with mass loss rates  $\sim 10^{-9} M_{\odot} \text{ yr}^{-1}$ . Thermally driven models which are spherically symmetric or include widely diverging geometries predict mass loss rates orders of magnitude less than  $10^{-9} M_{\odot} \text{ yr}^{-1}$ . We find that the radiation pressure of  $\text{Ly}\alpha$  resonance scattering can exceed the force of gravity in the chromosphere and initiate a net outflow, but it is insufficient to sustain a wind. If an additional momentum input term, such as Alfvén wave pressure, is also present, then  $\text{Ly}\alpha$  radiation pressure may play a crucial role in turning on strong winds in stars like Arcturus by producing a critical point in the chromosphere and a locally supersonic flow which the additional mechanism can further accelerate. We conclude that  $\text{Ly}\alpha$  radiation-pressure-initiated winds can occur in stars to the right of the Linsky-Haisch dividing line in the H-R diagram between stars with and without transition regions and presumably hot coronae, and that the existence of these winds may explain energetically the absence of hot coronae in these stars.

- 19269.** Haisch, B. M., Linsky, J. L., **Observations of the quiescent corona, transition region, and chromosphere in the dM5e flare star proxima centauri**, *Astrophys. J.* **236**, L33-L37 (Feb. 15, 1980).

Key words: flare stars; stellar chromospheres; stellar coronae; ultraviolet spectra; x-ray sources.

We present x-ray fluxes and ultraviolet spectra (1175-3200 Å) of the dM5e flare star Proxima obtained with the imaging proportional counter on *HEAO 2* and the ultraviolet spectrographs on *IUE*. The quiescent, soft x-ray emission outside of flares is characterized by  $L_x = 1.5 \times 10^{27} \text{ ergs s}^{-1}$ ,  $L_x/L_{\text{bol}} = 2.2 \times 10^{-4}$ , and a coronal temperature of  $\sim 3.5 \times 10^6$  K. The ultraviolet spectra include emission lines of C IV, N V, and Si IV, indicative of a transition region between the chromosphere and corona. These observations are the first concrete evidence for a quiescent corona in an M dwarf outside of flares. We show that our measured coronal properties are consistent with the coronal loop model of Rosner, Tucker, and Vaiana.

- 19270.** Ledbetter, H. M., **Anomalous low-temperature elastic-constant behavior in Fe-13 Cr-19 Mn**, *Metall. Trans.* **11A**, 543-544 (Mar. 1980).

Key words: elastic constants; iron alloy; Néel transition; stainless steel.

Elastic constants determined by sound-velocity measurements in an Fe-13Cr-19Mn steel show anomalous temperature behavior around 274 K, indicating a paramagnetic-antiferromagnetic transition.

- 19271.** Penn, D. R., **Bound hole pairs in Ni: Evidence from photoemission**, *J. Appl. Phys.* **50**, No. 11, 7480-7482 (Nov. 1979).

Key words: d-hole pairs; photoemission; satellite.

I show that the Ni d-band density of states contains a peak due to excitations of bound hole pairs. The density of states is observed directly in photoemission experiments which show a satellite peak below the bottom of the d bands.

- 19272.** Mehlman, G., Ederer, D. L., Saloman, E. B., Cooper, J. W., **The K-edge photoabsorption cross section of lithium vapour**, *J. Phys. B: Atom. Molec. Phys.* **11**, No. 22, L689-L692 (1978).

Key words: K edge; lithium; photoabsorption.

The photoabsorption cross section of lithium vapour has been measured between 200 and 172 Å. The average cross section is about 2 Mb in this region. Preliminary estimates of branching ratios for absorption leaving the ion in each of the  $n = 2$  states

are obtained from the data. The resonance structure in this region, which is compatible with earlier work, is discussed.

- 19273.** Eisenhauer, C., **Model for diffusion of a narrow beam of charged particles**, *Radiat. Res.* **81**, 336-354 (1980).

Key words: charged particle; electron; energy deposition; Monte Carlo; multiple scatter; tracklength.

A simple analytic expression is presented to describe the three-dimensional spatial distribution of flux or energy deposition by a narrow beam of charged particles. In this expression distances are expressed in terms of a scaling parameter that is proportional to the mean square scattering angle in a single collision. Finite ranges are expressed in terms of the continuous-slowing-down-range. Track-length distributions for one-velocity particles and energy deposition for electrons are discussed. Comparisons with rigorous Monte Carlo calculations show that departures from the analytic expression can be expressed as a slowly varying function of order unity. This function can be used as a basis for interpolation over a wide range of source energies and materials.

- 19274.** Pierman, B. C., Lerner, N. D., **Testing symbols for fire situations**, *Fire Command* **47**, No. 3, 12-13 (Mar. 1980).

Key words: fire fighting; fire safety; pictograms; safety; signs; standardization; symbols; visual alerting.

This article describes the testing and development of pictorial signs for fire situations. The use of symbols for visual communication and issues of standardization are discussed. The National Bureau of Standards has cooperated actively with the National Fire Protection Association in studying two sets of symbols, and the testing programs are described. One set of pictograms included *fire safety symbols*, for alerting building occupants to aspects of egress, fire alarm, fire fighting, and fire safety. The other set was *fire fighting symbols*, to aid fire fighters in locating and identifying equipment and utilities. Work on both symbol sets is directed toward eventual standardization by NFPA.

- 19275.** Feldman, A., Waxler, R. M., Malitson, I. H., **Survey of refractive data on materials for high-power ultraviolet laser applications**, (Proc. Conf. on Physical Properties of Optical Materials, San Diego, CA, Aug. 27-29, 1980), *SPIE J.* **204**, 95-101 (1979).

Key words: alkali halides; crystalline materials; glasses; photoelastic constants; refractive index; thermal coefficient of refractive index; ultraviolet.

A literature survey of refractive indices, thermo-optic constants and photoelastic constants has been conducted for materials of potential use in high-power ultraviolet applications. The limiting ultraviolet wavelength for which data exist is given for twenty alkali-halides, sixteen other crystalline solids, and three glasses. The bulk of the materials selected for the survey have band gaps that exceed 7 eV which is twice the photon energy of the XeF laser. There are large gaps in the available data for most of the materials.

- 19276.** Mehlman, G., Ederer, D. L., Saloman, E. B., Cooper, J. W., **Absolute photoabsorption cross section of core excited electrons in lithium vapor**, (Proc. Int. Conf. on X-Ray and XUV Spectroscopy, Sendai, Japan, 1978), *Jpn. J. Appl. Phys.* **17**, Suppl. 17-2, 167-169 (1978).

Key words: absorption cross section; core excitation; electron correlation; heat pipe; lithium vapor; partial photoionization cross section; synchrotron radiation.

The photoabsorption cross section of lithium vapor has been measured between 200 and 172 Å using a heat pipe absorption cell with aluminum windows. An average cross section of  $\sim 2$  Mb was observed in this region. Preliminary estimates indicate that 70% of the ions produced are in the  $1s2s^1S$  states. The



resonance structure in this region, which is compatible with earlier work, is discussed.

- 19277.** Jones, F. E., **Telescopic viewer in syringe calibration**, *Anal. Chem.* **52**, 364 (Feb. 1980).

Key words: Karl Fischer titration; moisture content; syringe calibration; telescopic viewer; volumetric dispensing; water calibration.

A telescopic viewer was used in the calibration of a syringe for volumetric dispensing of methanol-water mixtures and methanol blanks into Karl Fischer titrator reaction vessels for determination of moisture content of materials. Using a "gas-tight" 1-mL ( $\text{cm}^3$ ) syringe filled to the 0.500 graduation with water, the mean volume dispensed for 15 observations was  $0.50142 \text{ cm}^3$  with an estimate of the standard deviation of the mean of  $0.00015 \text{ cm}^3$  and an estimate of the relative standard deviation of the mean of 0.00030.

- 19278.** Wheeler, J. C., Miller, G. E., Scalo, J. M., **Nucleosynthetic yields and the history of the stellar birthrate**, *Astron. Astrophys.* **82**, 152-156 (1980).

Key words: nucleosynthesis; stellar birthrates; supernovae.

The rate of production of metals is recomputed using the constant mass stellar models of Arnett (1978) and the stellar birthrate of Miller and Scalo (1979), which has a higher birthrate for massive stars. Massive stars produce an appropriate amount of metals if the stars lose negligible mass and if the birthrate is constant. With constant mass evolution and a higher past birthrate, metals would be over-produced. Chiosi (1979) has shown that mass loss decreases the yield of massive stars. In this case massive stars can account for the observed metal abundances only if the birthrate were significantly higher in the past in contradiction to independent evidence that it is nearly constant. If massive stars do not contribute significantly to metal production, stars in the mass range  $\sim 5\text{-}15 M_{\odot}$  which produce most of the observed supernova, could account for the bulk of the heavy elements by ejecting an average of  $\sim 1.6 M_{\odot}$  in metals per event. With a constant birthrate, many supernova could be of the carbon-detonation type without producing too much iron.

- 19279.** Vogel, G. L., Brown, W. E., **Microanalytical techniques with inverted solid state ion-selective electrodes. II. Microliter volumes**, *Anal. Chem.* **52**, No. 2, 377-379 (Feb. 1980).

Key words: adapter; analysis; electrodes; fluorides; microvolumes; rapid.

We reported recently how a commercial solid state electrode may be adapted for microvolumes by bringing a glass microreference electrode into contact with hemispherical microdrops of specimen deposited under mineral oil on the surface of the electrode mounted in an inverted position. While this method is fast (20 to 30 specimens per hour), and although specimens of microscopic size can be determined (300 pL and less), it is somewhat elaborate for routine laboratory use with specimens of 1 to 5  $\mu\text{L}$ . In this paper we describe a simple device that will, in a few minutes, adapt most solid state electrodes for the rapid determination of samples in this volume range.

- 19280.** Vogel, G. L., Chow, L. C., Brown, W. E., **Microanalytical techniques with inverted solid state ion-selective electrodes. I. Nanoliter volumes**, *Anal. Chem.* **52**, No. 2, 375-377 (Feb. 1980).

Key words: analysis; biophysics; chloride; fluorides; microelectrodes; microvolume.

A procedure is described for measuring the fluoride concentration in nanoliter sample volumes deposited on the surface of an inverted commercial fluoride electrode, utilizing a reference microelectrode maneuvered into contact with the specimen via a micromanipulator.

This technique permits the fluoride concentration of the microvolume to be measured with an accuracy approaching that of a conventionally used electrode. Since many specimens can be equilibrated simultaneously on the surface of the electrode, this method is rapid (20-30 specimens per hour). Furthermore, the technique may be used with other solid state electrodes.

- 19281.** Ehrich, H., Kelleher, D. E., **Experimental investigation of plasma-broadened hydrogen Balmer lines at low electron densities**, *Phys. Rev. A* **21**, No. 1, 319-334 (Jan. 1980).

Key words: Balmer; diagnostics; hydrogen; line-broadening; plasma; Stark.

The central regions of the plasma-broadened Balmer lines  $H_{\alpha}$ ,  $H_{\beta}$ , and  $H_{\gamma}$  have been measured in a wall-stabilized arc over an electron density range between approximately  $4 \times 10^{14}$  and  $2 \times 10^{16} \text{ cm}^{-3}$ . The experimental profiles exhibit much less structure in the line core than predicted by theories based on the static-ion approximations. These discrepancies increase towards lower electron densities and lower Balmer-series members, e.g., the  $H_{\alpha}$  half-width as well as the central minimum of  $H_{\beta}$  deviate by about a factor of three from current hydrogen-broadening theories at low electron densities ( $10^{15} \text{ cm}^{-3}$ ). Consistent with earlier experiments, the central minimum of  $H_{\beta}$  was found to depend on the reduced mass of the radiator-ion perturber system. Also, the temperature dependence of the experimental data suggests that the central  $H_{\beta}$  minimum depends approximately linearly on the relative mean velocity between radiator and perturber. Extrapolation of the  $H_{\beta}$  results to the static case yields good agreement with the quasistatic calculations. The theoretically predicted "shoulder" in the  $H_{\gamma}$  line shape is nearly absent in the experimental profile. Besides ion dynamics, fine-structure (spin) effects can account for a considerable portion of the observed discrepancies in the case of  $H_{\alpha}$ , and possibly a small part in the case of  $H_{\beta}$  at low electron densities ( $\leq 10^{15} \text{ cm}^{-3}$ ).

- 19282.** Reader, J., Acquista, N., **Spectrum and energy levels of twelve-times ionized niobium (Nb XIII)**, *J. Opt. Soc. Am.* **70**, No. 3, 317-321 (Mar. 1980).

Key words: energy levels; ion; ionization energy; niobium; spectrum; wavelengths.

The spectrum of Nb XIII was observed with a low-inductance spark and a laser-produced plasma in the region from 70-630 Å on the 10.7-m grazing incidence spectrograph at NBS. From the identification of 38 lines, a system of 29 energy levels was determined. The level system (Cu I isoelectronic sequence,  $3d^{19}n\ell$ ) includes the series  $ns(n=4-6)$ ,  $np(n=4-7)$ ,  $nd(n=4-6)$ ,  $nf(n=4-7)$ , and  $ng(n=5-8)$ . The observed energy levels are compared with Hartree-Fock calculations. The ionization energy is determined from the  $nf$  and  $ng$  series to be  $2\,166\,300 \pm 300 \text{ cm}^{-1}$  ( $268.59 \pm 0.04 \text{ eV}$ ).

- 19283.** Greenberg, R. R., **Simultaneous determination of mercury and cadmium in biological materials by radiochemical neutron activation analysis**, *Anal. Chem.* **52**, No. 4, 676-679 (Apr. 1980).

Key words: activation analysis; cadmium; mercury; radiochemical; separation; solvent extraction.

A radiochemical procedure has been developed for the simultaneous determination of Hg and Cd in biological matrices. The procedure is based upon bomb dissolution followed by solvent extraction using Ni and Zn diethyldithiocarbamates. Mercury is separated from Se allowing the use of the  $^{203}\text{Hg}$  isotope as well as the  $^{197}\text{Hg}$  isotope to quantify Hg.

- 19284.** Collé, R., **Accuracy requires precision: A comment on understanding and using statistics in nuclear medicine**, *J. Nucl. Med.* **21**, No. 3, 90-92 (Mar. 1980).

Key words: accuracy; bias; measurement; precision.



This letter to the Editor is in regards to a recent article by Levin (J. Nucl. Med. 20: 550-558, 1979) who reviewed some of the fundamental principles of statistics as they apply to the estimation of measurement uncertainties. Levin unfortunately, has reinforced a common misunderstanding of the meaning of "accuracy." He uses the extremely restrictive definition of accuracy as equivalent to the absence of bias, and contends that accuracy is independent of precision. This letter clarifies the distinction between precision and bias, and their relation to accuracy. It points out that accuracy requires precision, and that an understanding of this furthers the understanding of the measurement process and the requirements for obtaining accurate measurements.

- 19285.** Khan, Z., Duckett, E. J., Early, J., **Determination of content of combustible material in ferrous scrap recovered from refuse**, *Resource Recov. Conserv. Short Commun.* **4**, 301-304 (1979).

Key words: combustibles; ferrous scrap; resource recovery; temperature; test procedure; time.

The results of combustion experiments on ferrous scrap recovered from refuse suggests that the test procedure contained in a proposed ASTM standard provides a generally reliable method of determining the combustibles content of the ferrous scrap.

Although the number of tests conducted was limited, the absence of a significant variation in the results indicates a high degree of reproducibility in the data obtained.

- 19286.** Molinar, G. F., Bean, V., Houck, J., Welch, B., **The mercury melting line up to 1200 MPa**, *Metrol.* **16**, 21-29 (1980).

Key words: melting line; mercury; pressure; pressure fixed points; pressure metrology; pressure scale.

The mercury melting line has been determined for pressures up to 1200 MPa. The change of electrical resistance in the mercury sample was used for detecting the equilibrium between the solid and liquid phases. Pressure measurements were made with highly stable manganin gages calibrated against two controlled clearance piston gages. Temperature measurements were made in the constant temperature bath by means of platinum resistance thermometry. Systematic errors in pressure and temperature were evaluated for all the measurements as well as the scatter due to the resolution of the equilibrium determination between the two phases of mercury. The mercury melting point at 0 °C is  $756.84 \pm 0.16$  MPa which is in close agreement with the value obtained by Daddon and Greig. The experimental results are compared with previous melting lines. There are systematic differences when compared to Bogdanov's equation up to 1200 MPa but there is very close agreement with recent data obtained by Houck and Morris over the pressure range they covered. The experimental data were fitted to a third polynomial; this equation fits the melting line data much more closely than the Simon type heretofore recommended and can be used up to 1200 MPa to increase the accuracy of a practical pressure scale based on the melting line of mercury.

- 19287.** Raj, R. K., Bloch, D., Snyder, J. J., Camy, G., Ducloy, M., **High-frequency optically heterodyned saturation spectroscopy via resonant degenerate four-wave mixing**, *Phys. Rev. Lett.* **44**, No. 19, 1251-1254 (May 12, 1980).

Key words: four-wave mixing; heterodyne spectroscopy; iodine spectroscopy; non-linear spectroscopy; phase conjugate spectroscopy; saturation spectroscopy.

Resonant degenerate four-wave mixing with two close optical frequencies ( $\omega, \omega + \delta$ ) is used to perform high-frequency optically heterodyned saturation spectroscopy. Doppler-free spectra of  $I_2$  ( $\lambda = 514.5$  nm) are obtained in this way for  $20 \text{ kHz} < \delta < 20 \text{ MHz}$ . Lock-in detection for  $\delta < 1 \text{ MHz}$  allows

relaxation studies and line assignments. At higher frequencies, rf-power detection yields Doppler-free doublets split by  $3\delta/2$ .

- 19288.** Snyder, J. J., Raj, R. K., Bloch, D., Ducloy, M., **High-sensitivity nonlinear spectroscopy using a frequency-offset pump**, *Opt. Lett.* **5**, No. 4, 163-165 (Apr. 1980).

Key words: Doppler-free spectroscopy; high-resolution spectroscopy; laser spectroscopy; non-linear spectroscopy; saturated absorption; saturation spectroscopy.

We report the development of a simple method for eliminating coherent background noise and fluctuations from saturation-spectroscopy signals. With this technique, which we believe will also be effective in two-photon and other types of nonlinear spectroscopy, we have routinely observed background-free saturation signals in  $I_2$  at 514.5 nm with signal-to-noise ratios within an order of magnitude of the fundamental quantum limit.

- 19289.** Dunlap, B. I., Connolly, J. W. D., Sabin, J. R., **On first-row diatomic molecules and local density models**, *J. Chem. Phys.* **71**, No. 12, 4993-4999 (Dec. 15, 1979).

Key words:  $B_2$ ;  $CO$ ;  $C_2$ ;  $F_2$ ;  $H_2$ ; local density models;  $N_2$ ;  $O_2$ ;  $X\alpha$ .

The total  $X\alpha$  energy accurate to 0.3 eV is computed for  $H_2$ ,  $B_2$ ,  $C_2$ ,  $N_2$ ,  $O_2$ ,  $CO$ , and  $F_2$ . Relative to experiment, the  $X\alpha$  model ( $\alpha = 0.7$ ) is accurate to within  $\Delta R_e = 0.1$  bohr,  $\Delta D_e = 2$  eV, and  $\Delta \omega_e = 300 \text{ cm}^{-1}$  for these molecules. Except for the lightest first-row diatomic molecules, the  $X\alpha$  and experimental dissociation energies are bracketed by those of the Hartree-Fock model (from below) and the Local Spin Density model (from above).

- 19290.** Domen, S. R., **Absorbed dose water calorimeter**, *Med. Phys.* **7**, No. 2, 157-159 (Mar./Apr. 1980).

Key words: absorbed dose; calorimeter; primary standard; water.

Advantage was taken of the low thermal diffusivity of water and the imperviousness of polyethylene film to water to construct a calorimeter for directly measuring absorbed dose in that medium. An ultrasmall bead thermistor was sandwiched between two thin films stretched on polystyrene rings and immersed in an unregulated water bath. Ten cobalt-60 irradiation runs were made with a precision of 0.5% mean error of the mean at a dose rate of 66 mGy/s. Further development is directed toward a standard instrument that can be used in a medical therapy beam.

- 19291.** Inghram, M. G., Hanson, G. R., Stockbauer, R., **The fragmentation of  $C_2F_6$** , *Int. J. Mass Spectrom. Ion Phys.* **33**, 253-261 (1980).

Key words: coincidence mass spectrometry; field ionization mass spectrometry; ion fragmentation; mass spectrometry; perfluoroethane; photoelectron spectroscopy; quasiequilibrium theory; threshold photoelectron spectroscopy;  $C_2F_6$ .

The fragmentation of  $C_2F_6^+$  has been studied by threshold photoelectron-photoion coincidence mass spectrometry and field-ionization mass spectrometry. Four types of data were obtained with the coincidence apparatus: threshold photoelectron spectra, fragmentation breakdown curves, time-dependent breakdown curves and kinetic energy release on fragmentation. The results indicate that the  $CF_3^+$  and  $C_2F_5^+$  fragments are formed independently, probably from separate electronic states which do not internally convert to the ground electronic state. The field-ionization data show that these fragments are formed in less than  $5 \times 10^{-13}$  s. Quasi-equilibrium calculations could not reproduce the experimental results.



**19292.** Goodman, D. W., Yates, J. T., Jr., Madey, T. E., **Interaction of hydrogen, carbon monoxide, and methanol with Ni(100)**, *Surf. Sci.* **93**, L135-L142 (1980).

Key words: carbon monoxide; hydrogen; methanol; nickel; surface intermediates; thermal programmed desorption.

The interaction of H<sub>2</sub>, CO, and methanol with a clean Ni(100) surface has been studied using temperature programmed desorption methods. Formation of a new surface entity has been shown to occur upon interacting CO with preadsorbed H(ads). This species, designated as the  $\Sigma$ -state, is formed in significant quantities and exhibits new bonding states of CO and H<sub>2</sub> desorbing in the same temperature region near 200 K. Upon adsorption of CH<sub>3</sub>OH at 77 K and subsequent desorption, an adsorbed alcoholic "COH" species is formed and decomposes at 500 K into CO and H<sub>2</sub>.

**19293.** Powell, C. J., **Recent progress in quantification of surface analysis techniques**, *Appl. Surf. Sci.* **4**, 492-509 (1980).

Key words: Auger-electron spectroscopy; ion-scattering spectroscopy; quantitative analysis; secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy.

A short review is presented of recent developments and remaining problems in the quantification of the four techniques in common use for surface analysis (Auger-electron spectroscopy, x-ray photoelectron spectroscopy or ESCA, secondary-ion mass spectroscopy, and ion-scattering spectroscopy). The particular topics discussed include: the homogeneity of the sample; the tradeoffs between spatial resolution, accuracy and precision, sensitivity, and beam damage to the sample; the analytical methods; the measurement of spectral intensities and corrections for interferences; the "response function" of the particular instrument; and the advantages and disadvantages of instrument computerization.

**19294.** Chilton, A. B., Eisenhauer, C. M., Simmons, G. L., **Photon point source buildup factors for air, water, and iron**, *Nucl. Sci. Eng. Tech. Note* **73**, 97-107 (1980).

Key words: air; buildup factors; gamma rays; iron; photons; point sources; water.

Buildup factors for photons in infinite homogeneous samples of air, water, and iron have been calculated by a moments method code. The photons were assumed to be emitted from a point source. Comparisons of these results to values obtained earlier, both by experiment and by calculation, show reasonable agreement except in some instances of deep penetration. The parameters in the Berger empirical formula for buildup factors have been evaluated from the present work. The Berger formula is shown to fit the calculational results for nuclei of low atomic number at energies above 1 MeV and below 0.06 MeV. In mid-energy range, differences of as much as 40% are observed. The formula appears to provide excellent fit to the data for nuclei of medium atomic number.

**19295.** Schoonover, R. M., Davis, R. S., Bower, V. E., **Mass measurement at the National Bureau of Standards: A revision**, *Science* **207**, 1347-1348 (Mar. 21, 1980).

Key words: air buoyancy correction; air density; mass measurement; mass standard.

In 1975, the results of a series of mass measurements undertaken by the National Bureau of Standards were published in *Science*. The inconsistencies reported seemed to depend on barometric pressure. An inference to be drawn from the report is that buoyant forces on objects weighed in air are somehow incorrectly accounted for by the usual appeal to Archimedes' principle in which the density of air,  $\rho$ , is computed from an equation of state. The magnitude of the unexpected effect was

estimated as approaching 1 milligram in 1 kilogram over a pressure range from 0.5 to 2.0 atmospheres for objects having a volume difference of 200 cubic centimeters. In a new experiment at the National Bureau of Standards, in which more elaborate and precise equipment was used, the calculation of air density from the atmospheric variables is confirmed to within 0.05 percent, hence within the uncertainty usually claimed for the air density and buoyancy calculations.

**19296.** Steele, W. A., Birnbaum, G., **Molecular calculations of moments of the induced spectra for N<sub>2</sub>, O<sub>2</sub>, and CO<sub>2</sub>**, *J. Chem. Phys.* **72**, No. 4, 2250-2259 (Feb. 15, 1980).

Key words: anisotropic polarizability; CO<sub>2</sub>; induced absorption spectra; molecular calculations; N<sub>2</sub>; O<sub>2</sub>; spectral moments; three-body contributions; virial coefficients.

Two moments of the induced absorption spectra for gaseous N<sub>2</sub>, O<sub>2</sub>, and CO<sub>2</sub> are calculated and compared with experiment. The theoretical expressions evaluated are those for spectra due to quadrupole-induced dipoles in molecules with anisotropic polarizability. The intermolecular interaction functions used include the effects of nonspherical shape by modelling the potential as a sum of quadrupolar plus atom-atom energies with parameters that are known to give realistic values for a number of other measured properties. Satisfactory agreement between the calculation and experiment was obtained in the binary interaction limit if hexadecapolar contributions are assumed to be present in the case of O<sub>2</sub>. These intermolecular potentials are then used together with an approximate theory for the requisite correlation functions in an evaluation of the spectral moments for liquid N<sub>2</sub> and O<sub>2</sub>. It was found that the agreement between experiment and theory for the liquid improved dramatically when three-body contributions to the spectral moments were included in the calculation.

**19297.** Lucas, L. L., **The standardization of alpha-particle sources**, (Proc. ASTM Conf. on Effluent and Environmental Radiation Surveillance, Johnson, VT, July 9-14, 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* **698**, pp. 342-354 (American Society for Testing and Materials, Philadelphia, PA, 1980).

Key words: alpha-particle activity; alpha-particle sources; calibration; radioactivity; standardization.

The calibration of alpha-particle sources at the National Bureau of Standards (NBS) began about 1950 with the measurement of  $2\pi$  alpha-particle-emission rates using a hemispherical gas-flow proportional counter. Today activities are also determined using defined-geometry counters with scintillation detectors and  $4\pi\alpha\gamma$  coincidence counters. As the measurement techniques have evolved, the overall uncertainty associated with the determination of the activity of an alpha-particle source has decreased by about an order of magnitude, from several percent to several tenths of one percent. The factors contributing to the overall uncertainty fall into two general categories: those associated with the detection system (such as uncertainties in geometry, scintillation efficiency, and deadtime) and those associated with the source (such as uncertainties in self-absorption and scattering). These factors are discussed, along with suggestions for minimizing the overall uncertainty.

**19298.** Noyce, J. R., **Standards for the assay of radionuclides of solid environmental samples**, (Proc. ASTM Conf. Effluent and Environmental Radiation Surveillance, Johnson, VT, July 9-14, 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* **698**, pp. 309-326 (American Society for Testing and Materials, Philadelphia, PA, 1980).

Key words: calibration; environments; homogeneity; natural materials; nondestructive assay; particles; quality assurance; radiation; radioactivity; radiochemical assay; radionuclide; segregation; standard.



This paper discusses radioactivity standards in the form of naturally occurring solid materials for use in the assay of solid environmental samples for radioactivity. Topics include the selection and preparation of materials for these standards, "spiking" with radionuclides (if desired), induced segregation of particles, availability and proper use of these standards, and their application to both radiochemical and nondestructive types of assay. The role these standards have in quality-assurance programs is also considered.

**19299.** Richmond, J. C., **Measurement of thermal radiation properties of materials**, *High Temp.—High Pressures* **11**, 355-381 (1979).

Key words: absorptance; blackbody; ellipsoidal reflectometer; emittance; hemispherical mirror reflectometer; integrating spheres; paraboloidal mirror reflectometer; radiometric measurements; reflectance; transmittance.

The thermal radiation properties, reflectance, absorptance, emittance, and transmittance, are defined, and the equations showing the relationships between these properties are given. The equations relating the amount and the spectral and geometric distribution of the flux emitted by a blackbody or complete radiator to its temperature are given, and it is shown how these equations can be applied to a real material by use of thermal radiation properties of the material. Methods of measuring the thermal radiation properties of the solid materials are briefly described and illustrated and references are given to the original papers describing such measurements.

**19300.** Zalewski, E. F., **Calibrating a spectroradiometer with cw laser lines and a calibrated detector**, *Proc. Electro-Optics/Laser 78 Conf. & Exposition, Sept. 19-21, 1978*, pp. 271-276 (Industrial & Scientific Conference Management, Inc., 222 West Adams Street, Chicago, IL 60606, 1978).

Key words: electrical substitution radiometer; infrared radiation measurements; radiometry; spectral irradiance; spectral radiant power; spectroradiometry; ultraviolet radiation measurements; visible radiation measurements.

Presently the most widely used procedure to calibrate a spectroradiometer is based on using a known source of spectral irradiance as the reference standard. These lamps have continuous, rather than discrete, emission spectra and are usually calibrated at only one level of irradiance. This calibration procedure works well in substitution type measurements where the unknown source also has a continuous emission spectra and a similar level of irradiance. If the unknown source has a considerably different spectral power output and/or emits a highly structured spectrum, then several auxiliary measurements have to be performed to adequately characterize the spectroradiometer's response. The auxiliary measurements of primary importance are: (1) a detailed mapping of the spectrometer bandpass function, (2) calibration of the wavelength settings on the spectrometer, and (3) determination of the spectroradiometer response as a function of the input radiant power level. The accuracy of these auxiliary measurements can be significantly improved through the use of amplitude stabilized cw laser sources and silicon detectors characterized for linearity of response. In addition, the high levels of accuracy now attainable in electrical substitution radiometry can be utilized in conjunction with the stable cw laser sources to measure the absolute response of the spectroradiometer.

**19301.** Collé, R., **Treatment and reporting of uncertainties for environmental radiation measurements**, (Proc. 23d Conf. on Analytical Chemistry in Energy Technology, Gatlinburg, TN, Oct. 9-11, 1979), Paper in *Radioelement Analysis*, W. S. Lyon, Ed., pp. 387-394 (Ann Arbor Science Publ., Inc., 230 Collingwood, P.O. Box 1425, Ann Arbor, MI, 1980).

Key words: data reporting; environmental; measurements; radiation; random uncertainty; systematic uncertainty.

Recommendations for a practical and uniform method for treating and reporting uncertainties in environmental radiation measurements data are presented. The method requires that each reported measurement result include the value, a total propagated random uncertainty expressed as the standard deviation, and a combined overall uncertainty. The uncertainty assessment should be based on as nearly a complete assessment as possible and should include every conceivable or likely source of inaccuracy in the result. Guidelines are given for estimating random and systematic uncertainty components, and for propagating and combining them to form an overall uncertainty.

**19302.** Kessler, E. G., Jr., Deslattes, R. D., Sauder, W. C., Henins, A., **Precise  $\gamma$ -ray energy standards**, (Proc. 3d Int. Symp. on Neutron Capture Gamma-ray Spectroscopy & Related Topics, Upton, NY, Sept. 18-22, 1978), Paper in *Neutron Capture Gamma-ray Spectroscopy*, R. E. Chrien and W. R. Kane, Eds., pp. 427-440 (Plenum Publ. Corp., New York, NY, 1979).

Key words: crystal diffraction; gamma-ray energy standards; x rays.

A number of  $\gamma$ -ray energy standards have recently been re-measured with respect to a visible standard wavelength with an accuracy of about 0.5 ppm. These measurements which were made on a double axis flat crystal spectrometer established the  $\gamma$ -ray energy scale in the 50 keV to 1 MeV region about 40 times more accurately than it was previously known. This report describes the measurement steps involved in the visible to  $\gamma$ -ray comparison. Some results and applications of the results are presented. The extension of the measurement techniques developed for the  $\gamma$ -ray measurements to x-rays, higher energy  $\gamma$ -rays, and dense  $\gamma$ -ray spectra is briefly discussed.

**19303.** Engen, G. F., Hoer, C. A., **"Thru-reflect-line": An improved technique for calibrating the dual six-port automatic network analyzer**, *IEEE Trans. Microwave Theory Tech. MTT-27*, No. 12, 987-993 (Dec. 12, 1979).

Key words: automatic network analyzer; calibration; microwave; microwave measurements; six-port.

In an earlier paper, the use of a "thru-short-delay" (TSD) technique for calibrating the dual six-port automatic network analyzer was described. Another scheme required only a length of precision transmission line and a "calibration circuit." The better features of these two somewhat different approaches have now been combined and the requirement for either a known short, or a "calibration circuit" eliminated. This paper will develop the theory for this new procedure.

**19304.** Armstrong, L., Fielder, W. R., Jr., **Photoionization cross sections using the multiconfiguration Hartree-Fock and its extensions**, *Phys. Scr.* **21**, 457-461 (1980).

Key words: chlorine; Hartree-Fock; K-matrix; photoionization; rare gases.

We discuss the use of the multiconfiguration Hartree-Fock (MCHF) to obtain initial state wave functions for photoionization calculations. An extension of the MCHF, a multiconfiguration  $N^{N-1}LS$ , can be used to obtain final state wave functions such that most intrachannel corrections to these wave functions vanish. Application of these techniques to the rare gases and the Cl are discussed. In the case of Cl, the strong interchannel interactions are included through use of the K-matrix. Excellent agreement between theory and experiment is obtained for the rare gases.

**19305.** Armstrong, L., Jr., O'Neil, S. V., **Resonance lineshape and photoelectron spectrum in power broadened two-photon ionisation**, *J. Phys. B: Atom Molec. Phys.* **13**, 1125-1141 (1980).

Key words: lasers; multiphoton ionization; photoelectrons; resonance.



We study the resonance lineshape in two-photon ionisation of atoms when the power broadening due to the bound-bound transition is by far the dominant broadening mechanism. We consider the effect on the lineshape of turn-on of the laser-atom interaction, spontaneous emission and laser linewidth, and show that several different types of lineshapes can result depending on the conditions involved. We also consider the photoelectron spectrum, and show that it is also sensitive to these same parameters.

- 19306.** Moldover, M. R., Cahn, J. W., **An interface phase transition: Complete to partial wetting**, *Science* **207**, 1073-1075 (Mar. 7, 1980).

Key words: contact angle; critical point; cyclohexane; interface; methanol; phase transition; surface; surface tension; wetting.

When two fluid phases are near a critical point, one of them will be excluded from contact with any third phase that happens to be present by a wetting film of the other critical phase. A simple and quite general strategy that may be used to induce a phase transition from complete wetting of the third phase to incomplete wetting is to add a new component to the fluid phases chosen to drive the two phases away from their critical point. This strategy is illustrated for methanol-cyclohexane mixtures.

- 19307.** Rowe, J. M., Magerl, A., **Neutron diffuse-scattering intensities in niobium**, *Phys. Rev. B*, **21**, No. 4, 1706-1707 (Feb. 15, 1980).

Key words: alloy; defect; diffuse scattering; neutron; niobium; strain.

New neutron diffuse-scattering data on "pure" Nb and on Nb doped with N impurities are presented and compared to the results shown previously by Chang and Colella. The new data show that the effects previously observed in nominally pure Nb can be explained as arising from small concentrations of O or N impurities.

- 19308.** Pierce, D. T., Celotta, R. J., **Recent advances in polarized electron sources**, *Nature* **284**, 308 (Mar. 27, 1980).

Key words: electron scattering; GaAs polarized electron source; polarized electrons; source of polarized electrons.

We extend the discussion of a recent *Nature* article, which discussed atomic physics based sources of polarized electrons and the fact that beams of electrons become polarized as they circulate in a storage ring, to include recent advances in solid state sources of polarized electrons. Field emission from tungsten covered with a ferromagnetic Europium sulfide film provides a very bright source of polarized electrons. Photoemission from negative electron affinity GaAs provides the most intense source and the polarization can be easily modulated. The GaAs polarized electron source is very versatile and has been applied in areas as diverse as high energy physics and surface physics.

- 19309.** Lu, T. M., **Ising models for order-disorder transition in an adsorbed overlayer**, *Surf. Sci.* **93**, L111-L116 (1980).

Key words: adatom-adatom interaction; angular profiles of superlattice beam; Ising model; LEED; order-disorder phase transition; overlayer; spin-spin correlation functions.

Based on a 2D zero field anti-ferromagnetic Ising model, we obtain a relation between the angular distribution of intensity of a LEED superlattice beam from an adsorbed lattice gas with nearest-neighbor repulsive interaction and the spin-spin correlation functions in the Ising model.

- 19310.** Pierce, D. T., Celotta, R. J., Wang, G. C., Unertl, W. N., Galejs, A., Kuyatt, C. E., Mielczarek, S. R., **GaAs spin polar-**

**ized electron source**, *Rev. Sci. Instrum.* **51**, No. 4, 478-499 (Apr. 1980).

Key words: electron optics; electron spin polarization; GaAs; negative electron affinity; photoemission; polarization; source of polarized electrons; spin polarization.

The design, construction, operation, and performance of a spin polarized electron source utilizing photoemission from negative electron affinity (NEA) GaAs are presented in detail. A polarization of  $43 \pm 2\%$  is produced using NEA GaAs (100). The polarization can be easily modulated without affecting other characteristics of the electron beam. The electron beam intensity depends on the intensity of the exciting radiation at 1.6 eV; beam currents of 20  $\mu\text{A}/\text{mW}$  are obtained. The source is electron optically bright; the emittance phase space (energy-area-solid angle product) is 0.043 eV  $\text{mm}^2 \text{sr}$ . The light optics, electron optics, and cathode preparation including the GaAs cleaning and activation to NEA are discussed in depth. The origin of the spin polarization in the photoexcitation process is reviewed and new equations describing the depolarization of photoelectrons in the emission process are derived. Quantum yield and polarization measurements for both NEA and positive electron affinity surfaces are reported. The important considerations for interfacing the polarized electron source to an experiment are illustrated by its application to polarized low energy electron diffraction (PLEED). The advantages of this spin polarization modulated electron gun for PLEED are clearly demonstrated by sample PLEED results for W(100) and ferromagnetic Ni(110). A comparison with other polarized electron sources shows that the GaAs spin polarized electron source offers many advantages for a wide range of applications.

- 19311.** Cezairliyan, A., **Advances in measurements of thermophysical properties by dynamic techniques**, *High Temp.—High Pressures* **11**, 9-27 (1979).

Key words: dynamic techniques; high-speed measurements; high temperatures; thermodynamics; thermophysical properties.

Advances during the last decade in the development and use of dynamic techniques (by resistive self-heating of the specimen) for the measurement of selected thermophysical properties in the temperature range 1000 to 10000 K are presented. The principles of subsecond-duration experimentation and the methods of obtaining the properties are briefly discussed. Millisecond- and microsecond-resolution pulse-heating systems developed in various laboratories are described and a summary of the measurements is given.

- 19312.** Coxon, B., Fatiadi, A. J., Cohen, A., Hertz, H. S., Schaffer, R., **Nitrogen-15 NMR evidence for the structures of N-9H-xanthen-9-yl- and N,N-Di-9H-xanthen-9-yl-ureas**, *Org. Magn. Reson.* **13**, No. 3, 187-192 (1980).

Key words: carbon-13 NMR; chemical shifts; coupling constants; mass spectrometry; nitrogen-15 NMR; proton NMR; xanthen-0-yl derivatives of urea.

A new monoxanthen-9-yl derivative of urea has been synthesized and the structure of this product (*N*-9H-xanthen-9-ylurea) and that of the previously known *N,N'*-di-9H-xanthen-9-ylurea have been proved by  $^{15}\text{N}$  NMR and other spectroscopic techniques. A series of  $^{13}\text{C}$  and  $^{15}\text{N}$  labeled urea derivatives has been prepared and the utility of their  $^{13}\text{C}$  and  $^{15}\text{N}$  chemical shifts and coupling constants in the structural analysis of urea derivatives has been investigated.

- 19313.** Schneider, S. J., Frederikse, H. P. R., Negas, T., **Materials for open cycle MHD generators**, Chapter 3 in *Materials for Open Cycle MHD Generators. Current Topics in Materials Science*, **4**, 89-149 (North-Holland Publ. Co., Amsterdam, The Netherlands, Mar. 1980).



Key words: alloys; candidate materials; coal slag; materials performance.

The purpose of this article is to set forth the current status of MHD generator materials development, the physical and chemical properties of candidate electrode materials and process contaminants (K-salts and coal slag) and finally descriptions of materials performance under real MHD conditions. Emphasis will be placed on ceramic electrode applications particularly those involving  $\text{ZrO}_2$ ,  $\text{CeO}_2$ , perovskites ( $\text{LaCrO}_3$ ), spinels ( $\text{MgAl}_2\text{O}_4$ ), and some metals and alloys.

**19314.** Lindstrom, R. M., **Measuring trace elements in semiconductors: Methods and pitfalls**, (Proc. Photovoltaic Material and Device Measurement Workshop, Focus on Polycrystalline Thin Film Cells, Arlington, VA, June 11-13, 1979), *Sol. Cells* 1, No. 2, 117-122 (1979/80).

Key words: accuracy; analytical methods; microanalysis; semiconductor materials; sensitivity; trace element analysis.

A quantitative understanding of the electrical behavior of semiconductors requires quantitative knowledge of impurities at concentrations as small as one part per billion. Methods available for trace measurements at this level are few in number; for many constituents there are no routine, inexpensive and reliably accurate methods. If the sample of interest is a thin film on a substrate, the mass of sample is small and the difficulties of microanalysis are added to those of trace analysis.

Nearly all methods available for approaching this problem rely on physical rather than chemical reactions. The sample is probed with an external stimulus and the response to this stimulus is then detected. The probe and also the response may be photons (from microwaves to  $\gamma$ -rays), electrons, neutrons or other nuclear particles, or ions. Desirable properties of a method are high sensitivity to the signal from the component sought, insensitivity to the presence of uninteresting factors such as the matrix, and a response related to the stimulus by a known factor of proportionality.

Although semiquantitative or relative information is sufficient to answer many questions, the analyst's goal is to produce measurements of high and known accuracy. The history of blind inter-laboratory comparisons of trace element measurements shows that agreement is seldom as good as expected *a priori*. The resolution of discrepancies is most efficiently done if one or more common lots of material is available for repeated analyses.

**19315.** Ayres, T. R., Linsky, J. L., **Outer atmospheres of cool stars. III. IUE spectra and transition region models for alpha Centauri A and B**, *Astrophys. J.* 235, No. 1, 76-84 (Jan. 1, 1980).

Key words: late-type stars; stellar chromospheres; stellar coronae; ultraviolet spectra.

We describe *IUE* ultraviolet spectra of two nearby dwarf stars,  $\alpha$  Centauri A (G2 V) and B (K1 V). These data include high-resolution profiles of the Mg II *h* and *k* features and lower-resolution integrated fluxes of lines from the following species: H I, C I-IV, N V, O I, Al II, Si II-IV, and Fe II. We find that surface fluxes in chromospheric and transition-region lines of  $\alpha$  Cen A and B are nearly identical to those of the quiet Sun. In addition, the measured stellar line fluxes are in good agreement with predictions of a transition-region scaling law based on conductive heating and pressures estimated from chromospheric models of  $\alpha$  Cen A and B. While this agreement does not verify the conductive heating hypothesis, it does suggest that the basic physical processes that control the structure and energy balance in the chromospheres and transition regions of  $\alpha$  Cen A and B and the Sun are, on a gross scale, very likely the same.

**19316.** Hummer, D. G., Kunasz, P. B., **Energy loss by resonance line photons in an absorbing medium**, *Astrophys. J.* 236, No. 2, 609-618 (Mar. 1, 1980).

Key words: quasars; radiative transfer.

The mean path length of photons undergoing repeated scatterings in media of large optical thickness is calculated from accurate numerical solutions of the transfer equation including the effect of frequency redistribution characteristic of combined Doppler and natural broadening. Energy loss by continuous absorption processes, such as ionization or dust absorption, is discussed, and asymptotic scaling laws for the energy loss, the mean path length, and the mean number of scatterings are inferred from the numerical data.

**19317.** Stettler, J. D., Bowden, C. M., Witriol, N. M., Eberly, J. H., **Population trapping during laser induced molecular excitation and dissociation**, *Phys. Lett.* 73A, No. 3, 171-173 (Sept. 17, 1979).

Key words: laser induced excitation; population trapping; vibrational-rotational states.

A four-level model is solved analytically and used to show that laser induced excitation can result in population trapping in excited states under quasi-steady state conditions, even when chemical reactivity and/or dissociation occurs from higher states.

**19318.** Phelps, A. V., **Applications and needs**, Chapter 3 in *Electron-Molecule Scattering*, S. C. Brown, Ed., pp. 81-106 (John Wiley & Sons, Inc., New York, NY, 1979).

Key words: air; electron; energy-generation; lasers; molecules.

This is a review of the state of knowledge of the electron-molecule scattering with particular attention to the applications of that knowledge to technology. We also consider the needs for further knowledge of electron-molecule scattering in order to meet current and foreseeable technology. For convenience, the review is divided into three main parts. The first is a discussion of applications and the state of knowledge involving air and its constituent gases. Note that we do not discuss the earth's atmosphere or ionosphere, etc., since these are thoroughly covered in Professor Biondi's paper. The second part is concerned with the role of electron-molecule scattering in the area of energy generation, e.g., MHD generators and isotope separation. Finally, we discuss some of the applications and needs in the area of gaseous lasers utilizing electron excitation of molecules.

**19319.** Peek, J. M., Katriel, J., **Hydrogen molecular ion in a high magnetic field**, *Phys. Rev. A* 21, No. 2, 413-417 (Feb. 1980).

Key words: excited states; high magnetic fields; molecular structure.

The ground and several excited states of the hydrogen molecular ion in a homogeneous magnetic field aligned along the molecular axis are studied. A pair of self-consistent equations is derived in prolate spheroidal coordinates and solved numerically. The results are exact at the limit of vanishing magnetic field and more accurate than previous results up to about  $10^9$  G. The equilibrium internuclear separation and binding energy for a number of electronic states are reported as functions of the magnetic field strength. The dissociation energy is deduced from the study of the hydrogen atom in the same coordinate system.

**19320.** Pierman, B. C., **The application of fault trees to the evaluation of risk**, *Proc. Fourth Int. System Safety Conf., San Francisco, CA, July 9-13, 1979*, pp. 167-170 (System Safety Society, P.O. Box A, Newport Beach, CA, 1979).

Key words: accidents; fault trees; loss prevention; risk; safety.

Advances in the state of technology result in benefits that are often accompanied by increased risks which require critical



evaluation. Many parameters contribute to the general acceptability of societal risk. A preliminary framework is developed to classify and display parameters in a systematic manner. Called SART—Situational Analysis and Risk Tree, the framework utilized a fault tree approach and results in a density display of risk parameters that are overrepresented in a given situation. A Standard Test Question for each tree element reflects that an issue occurs "more than average" in a situation. Completed SART trees for different risk situations can result in comparisons of the number of parameters affecting risk acceptability for those situations. The version presented requires detailed development, but serves to illustrate the concept.

**19321.** 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 programs; history; interlaboratory testing program; laboratory evaluation; National Bureau of Standards; paper; paperboard; TAPPI; test methods; Youden graphical analysis

A brief history of the first ten years of the NBS-TAPPI collaborative reference program for paper, including a description of the program both past and present. This voluntary program provides participating laboratories with a means for checking the level and uniformity of tests for more than 20 paper and board properties.

**19322.** Krause, R. F., Jr., Gann, R., **Rate of heat release measurements using oxygen consumption, J. Fire Flammability 12, 117-130 (Apr. 1980).**

Key words: combustion; fire; heat release; oxygen consumption; polymers.

The novel method of oxygen consumption calorimetry was tested against a conventional temperature rise method as an alternative for rate of heat release measurements. An existing apparatus was modified to include an oxygen analysis of the exhaust gas, and a variety of gaseous and polymeric fuels were burned. The new method gives fairly accurate values and is not confounded by heat transfer considerations that are inherent in thermal techniques.

**19323.** Zimmermann, J. E., Radebaugh, R., Siegwarth, J. D., **Refrigeration for small superconductive devices, (Proc. Int. Inst. of Refrigeration Commission A 1-2 und Deutscher Kaelte- und Klimatechnischer-Verein Commission I Joint Meeting, Munich, Germany, Oct. 1976), Paper in Developments in Cryogenic Techniques in the 1-20K Range, pp. 53-60 (International Institute of Refrigeration, Paris, France, 1976).**

Key words: cryogenics; instrumentation; refrigeration; superconducting devices.

The present state of the art is such that the greatest cost in using small superconducting devices, in many applications, is the expense and inconvenience of the associated cryogenic system. The practicality of such devices would be greatly enhanced, therefore, if a practical and economical self-contained, closed-cycle cryocooler could be made compatible with such devices. We have built an experimental cryocooler whose unique features (non-magnetic materials and very low input power) may represent a partial solution to the problem.

**19324.** McKinney, J. E., Davis, G. T., Broadhurst, M. G., **Plasma poling of poly(vinylidene fluoride): Piezo- and pyroelectric response, J. Appl. Phys. 51, No. 3, 1676-1681 (Mar. 1980).**

Key words: charge; compressibility; piezoelectricity; plasma; polarization; poly(vinylidene fluoride); pyroelectricity; thermal expansion.

A plasma poling technique and its use with polyvinylidene fluoride (PVDF) films is described. Specimens of biaxially

drawn (blow extruded) PVDF containing both Form I ( $\beta$ ) and Form II ( $\alpha$ ) crystals were poled under various conditions in a plasma field while the charging current was monitored to determine the polarization. Subsequently, both piezoelectric and pyroelectric activity were measured in order to evaluate their magnitudes with respect to the remnant polarization (that is, the polarization remaining after returning the applied field to zero). The results are shown to be in reasonable quantitative agreement with the predictions of a model of PVDF consisting of a mixture of preferentially aligned crystals in randomized amorphous material.

**19325.** Jenkins, J. P., **A comparison of test results for flat-plate water-heating solar collectors using the BSE and ASHRAE procedures, (Proc. Int. Congress Int. Solar Energy Society, Atlanta, GA, May 28-June 1, 1979), Paper in SUN II, K. W. Boer and B. H. Glenn, Eds., 1, 365-369 (Pergamon Press, New York, NY, 1979).**

Key words: collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance.

The German Bundesverband Solarenergie (BSE) Working Group recently adopted and published a procedure for testing solar collectors based on thermal performance. Research facilities for testing flat-plate water-heating collectors have been built at NBS in accordance with the BSE procedure and the existing ASHRAE Standard 93-77. The purpose of this paper is to describe the BSE test procedure and compare experimental test results with those obtained using the existing ASHRAE Standard 93-77. Included is a description of the collector test facilities at NBS and the results obtained from testing five commercially available flat-plate water-heating collectors using both procedures.

**19326.** Levine, H., McLaughlin, W. L., Miller, A., **Temperature and humidity effects on the gamma-ray response and stability of plastic and dyed plastic dosimeters, (Trans. 2d Int. Meeting on Radiation Processing, Radiation Physics and Chemistry, Miami, FL, Nov. 16-19, 1978), Radiat. Phys. Chem. 14, 551-574 (1980).**

Key words: absorption spectroscopy; blue cellophane; cellulose triacetate; dosimetry; dye dosimetry; dyed plastics; film dosimeters; gamma-ray dosimetry; humidity effects; megard dosimetry; nylon polycarbonate; polyethylene terephthalate; polymethyl methacrylate; polyvinyl chloride; polyvinyl fluoride; polyvinyl pyrrolidone radiochromic dyes; temperature dependence.

Several plastics and dyed plastics are widely used for routine dosimetry in radiation processing with gamma radiation. A study was made of the effects of different temperatures and relative humidities during and after irradiation on the dose interpretation of these dosimeters, which are normally calibrated under controlled laboratory conditions. Samples of dosimeter materials investigated were cellulose triacetate, polycarbonate, polyethylene terephthalate, polyvinyl fluoride, dyed polymethyl methacrylate ("red Perspex"), undyed polymethyl methacrylate (UVT Lucite), dyed Nylon, dyed polyvinyl pyrrolidone, dyed and undyed polyvinylchloride, dyed polyvinyl butyral, and dyed Cellophane or Ultraphan. The results show that most of these dosimeters when used under extreme conditions of relative humidity and temperature may give erroneous readings unless suitable corrections are made. There is also indication that the environmental effects on dosimeter response are apt to differ somewhat from one supply of a given material to another.



**19327.** Coyne, J. J., Fishbane, P. M., Meshkov, S., **Glueballs: Their spectra, production and decay**, *Phys. Lett.* **91B**, No. 2, 259-264 (Apr. 7, 1980).

Key words: configuration mixing; gauge theory; glueball; hyperball; quark; spectroscopy.

A systematic enumeration of the glueball spectrum of QCD and other  $SU(n)$  gauge theories yields  $J^{PC} = \text{odd}^{--}, \text{even}^{+-}$ , and  $0^{--}$  states in addition to the usual quark model states. Production and decay mechanisms for these new states are discussed. We obtain a significant radiative decay width of the  $\psi/J$  into a  $0^{--}$  glueball via mixing with the  $\eta_c$ .

**19328.** Dunlap, B. I., Connolly, J. W. D., Sabin, J. R., **On some approximations in applications of  $X\alpha$  theory**, *J. Chem. Phys.* **71**, No. 8, 3396-3402 (Oct. 15, 1979).

Key words: diatomic nitrogen; LCAO  $X\alpha$ ; molecular charge density.

An approximate  $X\alpha$  functional is proposed from which the charge density fitting equations follow variationally. LCAO  $X\alpha$  calculations on atomic nickel and diatomic hydrogen show the method independent of the fitting (auxiliary) bases to within 0.02 eV. Variational properties associated with both orbital and auxiliary basis set incompleteness are used to approach within 0.2 eV the  $X\alpha$  total energy limit for the nitrogen molecule.

**19329.** Bowen, R. L., **Adhesive bonding of various materials to hard tooth tissues. XXII. The effects of a cleanser, mordant, and polySAC on adhesion between a composite resin and dentin**, *J. Dent. Res.* **59**, No. 5, 809-814 (May 1980).

Key words: acid etch; adhesion; coupling agents; dentin; mordants; smear layer.

Preliminary evaluations on the effects of a cleanser, mordant, and polyfunctional surface-active comonomer on adhesion between a composite resin and dentin evinced that the ferric chloride mordant significantly improved bonding. The effects of the cleanser and coupling agent were also favorable, as were all of their interactions.

**19330.** Giessen, B. C., Grant, N. J., Parker, D. P., Manuszewski, R. C., Waterstrat, R. M., **The niobium (columbium)-palladium constitution diagram**, *Metall. Trans. A* **11A**, 709-713 (May 1980).

Key words: constitution diagrams; crystal chemistry; inter-metallic compounds; niobium alloys; palladium alloys; phase diagrams.

The Nb-Pd system was investigated over the entire composition range by metallography and x-ray diffraction analysis. The solubility limits of terminal and intermediate phases and solidus temperatures were determined.  $\alpha$ -Nb dissolves  $\sim 36$  at.pct Pd at 1520 °C and  $\sim 20$  at.pct Pd at 800 °C;  $\alpha$ -Pd dissolves  $\sim 31$  at.pct Nb at 1610 °C and  $\sim 18$  at.pct Nb at temperatures below 1500 °C. The presence of three intermediate phases  $\text{NbPd}_2$  (MoPt<sub>2</sub>-type),  $\alpha$ -NbPd<sub>3</sub> (TiAl<sub>3</sub>-type), and  $\beta$ -NbPd<sub>3</sub> ( $\beta$ -NbPd<sub>3</sub>-type) was confirmed; NbPd<sub>2</sub> melts at 1610 °C and one of the NbPd<sub>3</sub> phases transforms at the same temperature into  $\alpha$ -Pd solid solution which melts at 1625 °C. In addition, an approximately equiatomic high-temperature phase  $\alpha$ -NbPd with a homogeneity range of  $\sim 11$  at.pct was found which melts at 1520 to 1565 °C and probably is an extension of and isomorphous with the  $\alpha$ -Pd solid solution. Five three-phase reactions are described, and crystal chemical relationships are discussed.

**19331.** Goodman, L. J., Coyne, J. J.,  **$W_n$  and neutron kerma for methane-based tissue-equivalent gas**, *Radiat. Res.* **82**, 13-26 (1980).

Key words: dosimetry; energy per ion pair; kerma; neutrons; secondary charged particles; tissue-equivalent gas.

Homogenous tissue-equivalent ionization chambers containing a methane-based gas mixture are widely used to determine the absorbed dose of neutrons employed in radiobiology and radiotherapy. Conversion of the measured ionization charge to the absorbed dose requires knowledge of  $W_n$ , the mean energy expended to form an ion pair in the gas by the initial spectra of secondary charged particles produced by the neutrons. This report discusses the computed charged particle spectra in the gas and the relative kermas contributed by the various types of charged particles. These spectra are combined with an evaluation of the available experimental data on  $W$  for the secondary particles to compute  $W_n$  as a function of neutron energy. Over the energy range of 0.1 to 20 MeV,  $W_n$  was found to vary from 32.8 to 31.0 eV, respectively, including sharp changes in  $W_n$  due to large resonances in the energy transferred to carbon and oxygen. It is recommended that the data presented be used to evaluate  $W_n$  for each neutron spectrum for which accurate dosimetry is required. A single value of  $31.9 \pm 0.9$  eV is recommended for less demanding applications or when neutron spectra are poorly known.

**19332.** Liggett, W., **Assessing errors related to characteristics of the items measured**, *J. Inst. Nucl. Manage.* **IX**, No. 1, 78-82 (1980).

Key words: item-dependent error; measurement error; nuclear material accounting; referee measurement methods; robust statistical methods; systematic error, robust statistical methods.

Errors that are related to some intrinsic property of the items measured are often encountered in nuclear material accounting. An example is the error in nondestructive assay (NDA) measurements caused by uncorrected matrix effects. Such errors cannot be assessed by remeasurement of the items, and they cannot be fully assessed by measuring standards, although standards that span the range of the item characteristics might give upper and lower bounds. Nuclear material accounting requires for each material type one measurement method for which bounds on these errors can be determined. If such a method is available, a second method might be used to reduce costs or to improve precision. If the second method is less expensive than the first, then cost might be reduced by substituting the second method for the first in the measurement of some items. If the measurement error for the first method is longer-tailed than Gaussian, then precision might be improved by measuring all items by both methods.

**19333.** Miller, A., McLaughlin, W. L., Pedersen, W. B., Pejtersen, K., **Absorbed dose distributions in small copper wire insulation due to multiple-sided irradiations by 0.4 MeV electrons**, *Radiat. Phys. Chem.* **13**, 181-186 (1979).

Key words: copper wire; cross linking; dose distribution; dosimetry; electron beams; isodose curves; polyethylene; polyvinyl butyral; radiation curing; radiation processing; radiochromic dye film; wire and cable.

When scanned electron beams are used to crosslink polymeric insulation of wire and cable, an important goal is to achieve optimum uniformity of absorbed dose distributions. Accurate measurements of dose distributions in a plastic dosimeter simulating a typical insulating material (polyethylene) surrounding a copper wire core show that equal irradiations from as few as four sides give approximately isotropy and satisfactorily uniform energy depositions around the wire circumference. Electron beams of 0.4 MeV maximum energy were used to irradiate wires having a copper core of 1.0 mm dia. and insulation thicknesses between 0.4 and 0.8 mm. The plastic dosimeter simulating polyethylene insulations was a thin radiochromic polyvinyl butyral film wrapped several times around the copper wire, such that when unwrapped and analyzed optically on a scanning microspectrophotometer, high-resolution radial and depth-dose profiles could be determined.



**19334.** Shuker, R., Gallagher, A., Phelps, A. V., **Models of high-power discharges for metal-Xe excimer lasers**, *J. Appl. Phys.* **51**, No. 3, 1306-1320 (Mar. 1980).

Key words: discharges; excimer laser; metal atoms.

High-power ( $\sim 10^8$  W/l) discharges in metal-doped Xe are modeled for typical metal atom densities of  $10^{15}$ – $10^{17}$  cm $^{-3}$  and Xe densities of  $\sim 10^{20}$  cm $^{-3}$ , and electron densities of  $10^{14}$ – $10^{17}$  cm $^{-3}$  as appropriate for proposed excimer lasers. Na is used as a prototype species, while its properties are varied to indicate some of the changes that could result from the use of different metals. The model includes sixteen excited levels of Na, three ionic species, the excimer levels of NaXe, and Na $_2$ . The degree of ionization is determined by collisional multistep excitation and ionization of excited atoms versus dissociative recombination of electrons with Na $_2^+$ . Steady-state conditions in the positive column are calculated for typical gas temperatures of  $\sim 0.06$  eV and electron temperatures  $T_e$  of 0.3–0.5 eV. The Na population distribution is largely Boltzmann at the electron temperature and the electron density is close to the Saha equilibrium value except at low electron temperatures and very high extracted laser powers. Useful gain and extracted powers of  $\sim 10$  MW/cm $^2$  are predicted for the higher  $T_e$  and Na densities, with the pulse width limited to  $\sim 10^{-7}$  sec by gas heating. The model indicates that a metal which produces a deeply bound product state via dissociative recombination could yield a very efficient high-power laser or gain cell.

**19335.** Weidner, V. R., Hsia, J. J., **NBS specular reflectometer-spectrophotometer**, *Appl. Opt.* **19**, No. 8, 1268-1273 (Apr. 15, 1980).

Key words: mirrors; reflectance; spectrophotometry; specular; standards.

A specular reflectometer has been constructed and tested for calibrating the reflectance of mirror standards over the 250–2500-nm spectral range. This instrument is a measurement accessory to a reference spectrophotometer, which is also used for diffuse hemispherical spectral reflectance and 45°/0° spectral reflectance. The specular reflectometer is designed to measure mirror reflectances at angles of incidence between 5 and 80° using both vertically and horizontally polarized radiation. Absolute reflectance measurements are obtained by an optical system, which provides for direct measurement of the incident beam and for the sample mirror reflectance using the same beam. This is accomplished by means of a beam tracking system through which the beam is directed into a signal averaging sphere. The sphere rotates with the beam tracking optics, and the stationary detector views the interior of the sphere. Control of the beam tracking optical system is accomplished by a computer-controlled stepping-motor-driven precision turntable. Uncertainties of the reflectance measurements obtained with this system are estimated to be  $\pm 0.2\%$  of the measured value.

**19336.** Baughcum, S. L., Hofmann, H., Leone, S. R., Nesbitt, D. J., **Photofragmentation dynamics and reactive collisions of laser-excited electronic states**, (Proc. Faraday Symp. 67, Birmingham, England, Apr. 4-11, 1979), *Faraday Discuss. Chem. Soc.* **67**, No. 1, 306-315 (1979).

Key words: electronic excitation; laser; photodissociation; quantum yield; quenching; reactive collisions; vibrational excitation.

Tunable laser excitation followed by observation of infrared fluorescence provides a means of readily studying electronically excited photoproducts and their reactions. A number of specific examples involving the production of I\*( $5^2P_{1/2}$ ) and Br\*( $4^2P_{1/2}$ ) upon molecular photodissociation are considered. The quantum yield of I\* production from HgI $_2$  is obtained as a function of wavelength. An inconclusive search was made for unobserved states in IBr which lead to I\* product atoms and for states of

BrCl which lead to Br\*. Photodissociation of CH $_2$ I $_2$  in an intense laser field is observed to undergo multiphoton dissociation. Quenching and reactive collisions of Br\* and I\* with halogens, I $_2$ , Br $_2$  and Cl $_2$ , and interhalogens, IBr, ICl and BrCl, are investigated. Electronically adiabatic reactive channels are detected for the collisions I\* + Br $_2$   $\rightarrow$  IBr + Br\* and I\* + IBr  $\rightarrow$  I $_2$  + Br\*. Vibrationally excited HBr product molecules are observed in 10% of the quenching collisions of Br\* with H $_2$ S.

**19337.** MacDonald, R. A., Mountain, R. D., **High temperature crystals: Limitations on the phonon description**, (Proc. 3d Int. Conf. on Phonon Scattering in Condensed Matter, Brown University, Providence, RI, Aug. 28-31, 1979), Paper in *Phonon Scattering in Condensed Matter*, H. J. Maris, Ed., pp. 137-140 (Plenum Publ. Corp., New York, NY, 1980).

Key words: atom migration; high temperature; lattice structure; Monte Carlo calculations; rubidium; specific heat.

The Monte Carlo method has been used to calculate the energy, pressure, and specific heat at constant volume,  $C_v$ , for a model of rubidium. This calculation, for a fully anharmonic perfect crystal, is a necessary step in understanding the anomalous behavior of the specific heat at high temperatures ( $3\theta_D$  or greater). In this regime, lowest order anharmonic lattice dynamics is inadequate and vacancies are present in insufficient numbers to account for the observed increase in specific heat. Our results show that the fully anharmonic calculation does indeed yield some increase in  $C_v$  over the second order perturbation theory calculation. However, it is of particular interest that in cases where a significant amount of atomic migration occurred without disrupting the lattice structure, there was a further increase in  $C_v$ . Such large scale atomic motion cannot be handled by conventional lattice dynamics, and, if this is, indeed, typical behavior of the high temperature solid, these results point to an explanation for the breakdown of the phonon description.

**19338.** McLaughlin, W. L., Humphreys, J. C., Radak, B. B., Miller, A., Olejnik, T. A., **The response of plastic dosimeters to gamma rays and electrons at high absorbed dose rates**, (Trans. 2d Int. Meeting on Radiation Processing, Radiation Physics and Chemistry, Miami, FL, Nov. 16-19, 1978), *Radiat. Phys. Chem.* **14**, 535-550 (1979).

Key words: blue cellophane; cellulose triacetate; clear Perspex; dose rate dependence; dosimetry; dyed plastic dosimeters; electron beams; gamma rays; plastic dosimeters; polyvinylchloride; radiation processing; radiochromic dye films.

Several clear plastics and dyed plastics are commercially available for dosimetry in intense radiation fields, particularly for radiation processing applications using gamma rays from intense cobalt-60 sources and electron beams from accelerators running at potentials from 0.1 to 10 MeV. Some of these widely used dosimeters are: colorless cellulose triacetate, polymethylmethacrylate, or polyvinylchloride, showing induced absorption bands in the ultraviolet spectrum; radiochromic dyed plastics, such as nylon, polychlorostyrene, polyvinylbutyral, polyvinylpyrrolidone, showing induced absorption bands in the visible spectrum; blue cellophane, showing a bleaching in the visible absorption spectrum. A major source of error in making dose interpretations by spectrophotometric analysis of these dosimeters comes from dose-rate dependence of response. The present work shows measurements at high dose rates (e.g., 100 and 1050 rad·s $^{-1}$  with gamma radiation,  $10^6$  rad·s $^{-1}$  with a scanned beam of 2-MeV electrons,  $10^{10}$  rad·s $^{-1}$  with a pulsed beam of 10-MeV electrons and  $10^{11}$  to  $10^{14}$  rad·s $^{-1}$  with single pulses of 2-MeV electrons). For calibrations with gamma rays, only those plastics containing the radiochromic triphenylmethane cyanides or methoxides, i.e., nylon, polychlorostyrene, polyvinylbutyral, or polyvinylpyrrolidone, can correctly interpret



dose determinations from electron beam irradiation. The other systems show a marked rate dependence of response. Of radiochromic dye systems, only polyvinylpyrrolidone as host matrix can be read with precision immediately after electron irradiation, since a slow build-up of the absorption band during the first hours after irradiation occurs in the other radiochromic plastic systems.

- 19339.** McLaughlin, W. L., **The measurement of absorbed dose and dose gradients**, (Proc. Seminar on Radiation Sterilization of Plastic Medical Devices, University of Lowell, MA, Mar. 28-29, 1979), *Radiat. Phys. Chem.* **15**, 9-38 (1980).

Key words: dose distributions; dose mapping; dosimetry; dye dosimetry; electron beams; gamma radiation; leucocyanides; radiation processing; radiation sterilization; radiochromic dyes; red Perspex.

The more reliable systems and procedures of dosimetry for radiation sterilization applications are described, along with sources of uncertainty and ways to achieve optimum accuracy and reproducibility. Dosimetry practice in production must be accompanied by correct methods of dosimeter calibration to achieve measurement assurance and quality control. For routine use and for determination of dose distributions, certain thin-film dosimeters satisfying cavity-theory requirements are most suitable.

- 19340.** Miller, A., McLaughlin, W. L., **Absorbed dose distributions in irradiated plastic tubing and wire insulation**, (Trans. 2d Int. Meeting on Radiation Processing, Radiation Physics and Chemistry, Miami, FL, Nov. 16-19, 1978), *Radiat. Phys. Chem.* **14**, 525-533 (1979).

Key words: dose distribution; dosimetry; dye dosimeters; electric wires; electron beams; isodose curves; radiation curing; radiation processing; radiochromic dye films.

Plastic tubing and wire insulation were simulated by radiochromic dye dosimeter films having electron absorbing properties similar to the materials of interest (polyethylene and PVC). A 400-keV electron accelerator was used to irradiate from 1, 2, 3 and 4 sides simulating possible industrial irradiation situations. The results indicate that in most cases it is necessary but also sufficient to irradiate from two opposite sides.

- 19341.** Pierce, D. T., Celotta, R. J., Wang, G. C., Felcher, G. P., Bader, S. D., Miyano, K., **A polarized LEED study of surface magnetism**, (Proc. Int. Conf. on Magnetism, Munich, Germany, Sept. 3-7, 1979), *J. Magn. Magn. Mater.* **15**, No. 18, 1583-1584 (1980).

Key words: magnetism; Ni; nickel; PLEED; polarized electrons; polarized LEED; surface magnetism; surface magnetization.

The surface magnetization of ferromagnetic Ni(110) has been observed via the use of a spin polarized electron beam. The spin dependence of the scattered electron intensity was measured as a function of external magnetic field strength and temperature.

- 19342.** Pierce, D. T., Kuyatt, C. E., Celotta, R. J., **Spin and energy analyzed photoemission: A feasibility analysis**, *Rev. Sci. Instrum.* **50**, No. 11, 1467-1473 (Nov. 1979).

Key words: electron optics; photoelectron emission; spin and energy analysis; spin polarized electron.

New scientific opportunities, particularly for investigation of surface magnetism, will be provided by spin and energy analyzed photoemission. Electron-optical conservation laws and phase space concepts are summarized and applied to determine the feasibility of an experiment consisting of a photoemitter in a magnetic field, a photoelectron energy analyzer and an electron spin analyzer. For the example of photoemission from a Ni crystal using He I resonance radiation and typical parameters

for the energy and spin analyzers, a final signal count rate of approximately 220 counts/s is calculated. Ways to increase the count rate by orders of magnitude are described. In particular, a new experimental configuration is suggested which may avoid the large reduction in count rate caused by the magnetic field.

- 19343.** Radak, B. B., Markovic, V. M., McLaughlin, W. L., **Dosimetry for the commissioning of a versatile irradiation plant**, (Trans. 2d Int. Meeting on Radiation Processing, Radiation Physics and Chemistry, Miami, FL, Nov. 16-19, 1978), *Radiat. Phys. Chem.* **14**, 449-456 (1979).

Key words: absorbed dose; ceric sulfate dosimeter; cobalt-60 source; commissioning dosimetry; dosimetry; ferrous sulfate dosimeter; gamma radiation; process control; quality control; radiation sterilization; radiochromic dye dosimeter; red Perspex dosimeter.

The chief objective of dosimetry for commissioning of a radiation plant is the comparison of the real, i.e., measured absorbed doses, with the ones expected from the calculations of the designer or producer of the plant. This mainly comprises the values of minimum and maximum absorbed dose in a typical box of products to be treated in the plant. With a little more effort, however, the complete set of relevant parameters for a suitable running of the plant can be obtained from the commissioning measurements. In the present work the results of such measurements obtained with the Irradiation Plant for Industrial Sterilization of Disposable Medical Supplies at the Boris Kidric Institute-Vinca are presented.

- 19344.** Schooley, J. F., **State-of-the-art of instrumentation for high temperature thermometry**, *Proc. 1977 Symp. on Instrumentation and Process Control for Fossil Demonstration Plants, Argonne, National Laboratory, Argonne, IL, Aug. 13-15, 1977*, pp. 323-347 (ERDA Fossil Energy Division Argonne National Laboratory, Instrument Society of America, Chicago, IL, 1977).

Key words: coal conversion; high temperatures; Johnson noise; process instrumentation; thermocouples; thermometry.

Current pilot-plant coal conversion operations have exposed several deficiencies in the present practice of industrial temperature measurement. Among these are the limited high-temperature performance (both ultimate temperature limit and rate of failure or of decalibration) of thermocouples which are presently in common use, response time of thermowell-protected temperature sensors, and measurement errors associated with radiation pyrometry. Some of these problems will be discussed in other talks, particularly that of N. Pitcher.

Recent innovations in high-temperature thermometry may help to improve both the quality and efficiency of coal conversion processes.

In this talk, I will discuss the use of specially-prepared tungsten-rhenium alloy thermocouples and platinum-rhodium alloy thermocouples for extended-term temperature measurements above 1200 °C, and the use of a new nickel-based (Nicrosil-Nisil) thermocouple for similar measurements below 1200 °C. I will also discuss both the use of velocity-of-sound thermometry, and temperature measurement employing the detection of Johnson noise in resistors. Finally, I will present some general remarks on radiation pyrometry as a preface to the discussion by R. F. Leftwich.

- 19345.** Stockbauer, R., **Observation of the OH<sup>+</sup> fragment threshold in the threshold photoelectron spectra of water**, *J. Chem. Phys.* **72**, No. 9, 5277-5279 (May 1, 1980).

Key words: appearance energy; coincident ion mass spectrometry; deuterated water; deuterium oxide; photoelectron spectroscopy; threshold photoelectron spectroscopy; water.



A step in the threshold photoelectron spectra of  $\text{H}_2\text{O}$  and  $\text{D}_2\text{O}$  is observed at the onset for the  $\text{OH}^+$  and  $\text{OD}^+$  fragmentations. The coincident ion mass spectrum shows that the step is associated with the fragmentation process. This is explained in terms of a change in the competition between formation of charged and neutral products brought about by the opening of the fragmentation channel.

**19346.** Younger, S. M., **Atomic many-body perturbation theory using radially restricted basis functions**, *Phys. Rev. A* **21**, No. 5, 1364-1375 (May 1980).

Key words: atomic correlation energy; atomic structure theory; atomic transition probabilities; electron correlation; many-body perturbation theory.

The construction of a potential barrier around an atom such that a chosen zeroth-order reference state is left unaffected results in a square-integrable virtual basis set with rapid convergence properties for use in atomic many-body perturbation theory. Encouraging results have been obtained using this technique for calculations of the correlation energies and transition probabilities of small atoms and ions. In the case of  $\text{H}^-$  it is shown that the conventional formulation of many-body perturbation theory involving continuum functions produces classes of energy diagrams which diverge with order, although the total summation remains finite. No such divergence is present in a properly constructed contracted basis set.

**19347.** Younger, S. M., Wiese, W. L., Knystautas, E. J., **Theoretical simulation of the decay of the  $4s4p\ ^1P_1^\circ$  level in Kr VII following beam-foil excitation**, *Phys. Rev. A* **21**, No. 5, 1556-1560 (May 1980).

Key words: atomic transition probabilities; beam-foil method; cascading; core-excited states; yrast states.

The decay of the  $4s4p\ ^1P_1^\circ$  level in Kr VII following beam-foil excitation has been simulated using theoretical initial-state populations and calculated transition probabilities. It was found that the decay curve was substantially influenced by cascading from higher levels and that such cascades dominate the decay in the region beyond three times the lifetime of the  $4s4p\ ^1P_1^\circ$  level. The simulation is in good agreement with an experimental decay curve at short decay times, but is unable to reproduce the long-time behavior of the experimental data. However, recent spectroscopic evidence indicates that line blending is responsible for this aspect. Complications due to core-excited states and other complex cascade mechanisms are discussed.

**19348.** Sleater, G. A., **Preliminary performance criteria for stone preservatives**, *Proc. RILEM/ASTM/CIB Symp. Evaluation Performance External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1978*, **11**, 309-321 (1977).

Key words: accelerated decay; performance criteria; preservative testing; stone decay; stone preservatives.

As part of a program to develop performance criteria for the selection of stone preservatives, laboratory methods of accelerated stone decay have been used to obtain data on stone preservatives and to suggest criteria for their selection. Causes of stone decay were simulated in two types of testing: (1) a number of causes were combined in one testing operation, using a special test chamber; (2) the effects of single causes of stone decay were studied individually. Methods for measuring the effects of the test exposures are given, as are the preliminary performance criteria for selecting stone preservatives. No one stone preservative studied in the program met all criteria.

**19349.** Cezairliyan, A., Müller, A. P., Righini, F., Rosso, A., **Radiance temperature of vanadium at its melting point**, *High Temp. Sci.* **11**, 223-232 (1979).

Key words: emittance; high-speed measurements; high temperature; melting; radiance temperature; vanadium.

The radiance temperature (at two wavelengths, 653 and 993 nm) of vanadium 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 the melting point of vanadium is 1992 K at 653 nm and 1875 K at 993 nm, with a standard deviation of 1.2 K at 653 nm and 0.3 K at 993 nm. The total inaccuracy in radiance temperature is estimated to be not more than  $\pm 7$  K.

**19350.** Ruegg, R. T., **Economic feasibility of solar applications to office buildings and retail stores**, *Proc. Solar Energy Market Analysis and Evaluation Contractor's Review Meeting, Washington, DC, Apr. 8-10, 1980*, pp. 1-7 (U.S. Department of Energy, Washington, DC).

Key words: active solar energy; break-even analysis; building economics; commercial buildings; economic feasibility; economic optimization; solar energy systems.

Comprehensive economic optimization models and a computer program for evaluating the economic feasibility of active solar energy for commercial buildings are developed by this study. Data and assumptions for use in the models are compiled. The models are applied to assess the economic feasibility of active solar hot water and combined space heating and hot water systems for a new and an existing office building and retail store in 13 U.S. cities.

Net savings (or losses) of the solar energy systems are estimated in present value dollars over a 20 year life cycle, based on a set of representative data and assumptions. Break-even values of system costs, energy prices, and future energy price escalation rates are also calculated to determine the minimum conditions under which the solar energy systems become cost effective for the selected office buildings and retail stores. Sensitivity analysis is conducted for other key variables. The relationship between net savings (losses) and the solar fraction is tested for selected cities.

The approach, models, computer program, and data bases are of interest to analysts; the results, to the policy, research, and building communities.

**19351.** Kautz, R. L., **On a proposed Josephson-effect voltage standard at zero current bias**, *Appl. Phys. Lett.* **36**, No. 5, 386-388 (Mar. 1, 1980).

Key words: Josephson effect; phase locking; superconductivity; voltage standard.

A voltage standard has been proposed which uses a series array of Josephson junctions locked to rf-induced constant-voltage steps at zero current bias. The feasibility of this proposal is examined in theory and experiment by determining the conditions under which rf-induced steps cross the zero current axis and the stability of phase lock under the zero bias condition.

**19352.** McLaughlin, W. L., Lucas, A. C., Kapsar, B. M., Miller, A., **Electron and gamma-ray dosimetry using radiation-induced color centers in LiF**, (Trans. 2d Int. Meeting on Radiation Processing, Radiation Physics and Chemistry, Miami, FL, Nov. 16-19, 1978), *Radiat. Phys. Chem.* **14**, 467-480 (1979).

Key words: absorption spectroscopy; alkali halides; color centers; darkening of crystals; dosimetry; electron dosimetry; F-centers; gamma-ray dosimetry; lithium fluoride; M-centers; megared dosimetry; N-centers; radiation darkening; radiation processing; R-centers.

Ionizing radiation produces relatively stable color centers in lithium fluoride. The values of the optical absorbance at the maxima of the resulting absorption bands are measured at the following wavelengths:  $\lambda = 247$  nm (F-centers); 443 nm (M-centers); 315 nm ( $\text{R}_1$ -centers); 374 nm ( $\text{R}_2$ -centers); 517 nm ( $\text{N}_1$ -



centers); 547 nm ( $N_2$ -centers). We show that the response expressed in terms of optical absorbance as a function of absorbed dose in LiF is approximately the same for electron beams at very high absorbed dose rates ( $<10^{12}$  rad·s $^{-1}$ ) and for gamma radiation at intermediate dose rates ( $\sim 10^2$  rad·s $^{-1}$ ). A change in ambient temperature over the range from  $-78^\circ\text{C}$  to  $+100^\circ\text{C}$  during irradiation has only a small influence on response. The production of each type of color center is initially proportional to absorbed dose and then gradually tends toward saturation. By utilizing absorption bands corresponding to different types of color centers, an absorbed-dose range from  $10^1$  to  $10^9$  rad can be covered, with response regions overlapping at the doses of change-over from one to the other center. Commercially available cleaved LiF crystals, 6 mm  $\times$  6 mm  $\times$  2 mm in size and containing only very low amounts of impurities, proved to have satisfactory optical properties for high-level dosimetry applications. Commercially available LiF discs, 25 mm in diameter and 1.5 mm in thickness, supplied as vacuum-ultraviolet-transmitting window material, are also useful for dosimetry. Both types are of optical quality and may be reused by thermally bleaching the radiation-induced color centers.

- 19353.** Younger, S. M., Electron impact excitation of the resonance transitions of highly ionized atoms of the Be-, Mg-, and Zn-isoelectronic sequences, *J. Quant. Spectrosc. Radiat. Transfer* **23**, 489-498 (1980).

Key words: beryllium sequence; collision strength; effective Gaunt-factor; electron impact excitation; magnesium sequence; zinc sequence.

Electron impact excitation collision strengths for the  $ns^2\ ^1S$ - $nsnp\ ^1P$  resonance transitions of highly ionized Be, Mg, and Zn-like ions have been computed in the distorted wave approximation, including the effects of exchange and target state correlation. Good agreement is observed between these data and collision strengths computed in the Coulomb-Born and Born approximations at high incident energies. Analytic fits to the distorted wave data are presented.

- 19354.** Zalewski, E. F., Geist, J., Silicon photodiode absolute spectral response self-calibration, *Appl. Opt.* **19**, No. 8, 1214-1216 (Apr. 15, 1980).

Key words: absolute spectral response; laser power measurement; photodetector; radiant power measurement; radiometry; silicon photodiode; spectroradiometry.

A new technique is demonstrated for the determination of the absolute spectral response of a uv enhanced silicon photodiode. This technique is completely independent of the traditional approaches to absolute radiometry based on the thermal physics of blackbodies or electrically calibrated radiometers and surpasses them in accuracy and simplicity. For the photodiodes used in this study the radiant power in a 1 mW laser beam at 0.63299  $\mu\text{m}$  was measured to within an uncertainty of  $\pm 0.04\%$ .

- 19355.** Akcasu, A. Z., Summerfield, G. C., Jahshan, S. N., Han, C. C., Kim, C. Y., Yu, H., Measurement of single chain neutron scattering in concentrated polymer solutions, *J. Polym. Sci.: Polym. Phys. Ed.* **18**, 863-869 (1980).

Key words: concentrated solution; interchain interference; polyisoprene; radius of gyration; single chain scattering form factor; small angle neutron scattering.

For some time there have been measurements of single-chain form factors for small-angle neutron scattering (SANS) in bulk polymers and in concentrated solutions. These were done by mixing a fraction of completely deuterated polymer with the normal polymer. Until recently, it was believed that these experiments had to be performed using a small fraction of deuterated polymer to avoid interchain interference effects. However, the work of Williams et al. has shown that these experiments are better if one uses large fractions of marked polymer and

determines both the single chain and interference contributions to the SANS cross section. We generalize the technique of Williams et al. somewhat and apply it to the measurement of the radius of gyration of polyisoprene in the bulk.

- 19356.** Kunc, J., Averaged ionization cross sections and rate coefficients in a partially ionized gas for small and high electron energy, *Phys. Lett.* **70A**, No. 1, 12-16 (Feb. 5, 1979).

Key words: cross sections; high electron energy; Maxwell's velocity distribution; rate coefficients.

Averaged (with Maxwell's and Druyvesteyn's electron velocity distribution functions) electron collisional ionization cross sections and rate coefficients are given for the atoms in the ground state in the form of analytical formulas. These formulas work well either for small or for high values of mean electron energy in the partially ionized gas.

- 19357.** Simon, T., Kelch, W. L., Linsky, J. L., Outer atmospheres of cool stars. VI. Models for  $\epsilon$  Eridani based on IUE spectra of C II, Mg II, Si II, and Si III, *Astrophys. J.* **273**, No. 1, 72-81 (Apr. 1, 1980).

Key words: late-type stars; stellar atmospheres; stellar chromospheres; ultraviolet spectra.

Observations of the ultraviolet line spectrum of the active chromosphere star,  $\epsilon$  Eridani, obtained with the IUE satellite have been analyzed. We have solved the coupled statistical equilibrium and radiative transfer equations for the prominent transitions of C II, Mg II, Si II, and Si III. A satisfactory fit to all of the line strengths can be achieved with a model similar to that recently proposed to explain bright points on the quiet Sun. We derive a surface pressure at the base of the transition region of 0.5 dynes cm $^{-2}$ , which is a factor of 3 higher than the quiet-Sun value, but a factor of 3 smaller than predicted by scaling laws, assuming a conductively heated stellar transition region. We find that the surface fluxes of the C II  $\lambda\lambda 1334$ , 1335 and Si III  $\lambda 1892$  emission lines are good diagnostics of pressure at the base of the transition region, but line ratio techniques using the  $\lambda 1892$  line for estimating electron densities may be invalid.

- 19358.** Kunc, J. A., Electron ionisation cross sections of excited atoms and ions, *J. Phys B: Atom. Molec. Phys.* **13**, 587-602 (1980).

Key words: cross sections; electron impact; electron ionisation; energy distribution functions; excited atoms.

A general approach for calculating cross sections for electron impact ionisation of atoms and ions with a single valence electron in either the ground or an excited state is presented. The differential energy exchange cross sections are based on the semiclassical treatments of Burgess and Vriens. The model takes into account direct as well as electron exchange collisions, and also includes interference effects. The motion of an atomic electron in the  $nl$  state is represented by the semiclassical energy distribution function. The criterion of validity of the method is given, from this it follows that the theory is applicable to the calculation of the electron impact ionisation cross sections for H I, He II, Li III, C IV, N V, O VI, Ne VII and Ne X. The present results are compared both with experimental data and with other theoretical calculations.

- 19359.** Sullivan, D. B., Zimmerman, J. E., Very low-power Stirling cryocoolers using plastic and composite materials, (Proc. 15th Int. Congress of Refrigeration, Venice, Italy, Sept. 1979), *Int. J. Refrig.* **2**, No. 6, 211-213 (Nov. 1979).

Key words: cryocoolers; helium liquefaction; refrigerator; regenerator materials; Stirling cycle.

An experimental investigation of several concepts for very-low-power cryocoolers for operating highly-sensitive superconducting devices has been undertaken. The devices to be cooled



are those using Josephson junctions, such as SQUID magnetometers, voltage standards and A/D converters. The common basic feature of the concepts is that very low levels of magnetic, electric, and mechanical interference are potentially realizable.

- 19360.** Simiu, E., **Hazards: High winds**, *J. Architect. Educ.* **33**, No. 4, 23-27 (1980).

Key words: buildings; climatology; hurricanes; structural engineering; tornadoes; winds.

The paper provides information, believed to be useful to architectural students and faculty, on damage caused by windstorms, extreme wind climatology, wind effects on buildings, tornado effects on buildings, effects of winds on users of buildings and outdoor spaces, sources of data on wind effects, and possible research topics on architectural implications of windstorms.

- 19361.** Berger, P. W., **Integration of an information system: Chaos or control? How to select a system**, *Proc. 4th Natl. Information Conf. and Exposition, Washington, DC, May 29, 1980*, 40 pages (Information Industry Assoc., Washington, DC, 1980).

Key words: automation; information systems; integrated systems; library automation.

With the bewildering array of options available to information managers, selection of an information system is critical. Failing to appreciate the impact automated information services will have on the library and information center may indeed cause "chaos".

- 19362.** Zwier, T. S., Maricq, M. M., Simpson, C. J., Bierbaum, V. M., Ellison, G. B., Leone, S. R., **Direct detection of the product vibrational-state distribution in the associative detachment reaction  $\text{Cl}^- + \text{H} \rightarrow \text{HCl}(\nu) + e$** , *Phys. Rev. Lett.* **44**, No. 16, 1050-1053 (Apr. 21, 1980).

Key words: associative detachment; flowing afterglow; infrared chemiluminescence; ion molecule reactions; vibrational excitation.

The initial product vibrational-state distribution is obtained for the thermal associative-detachment reaction,  $\text{Cl}^- + \text{H} \rightarrow \text{HCl}(\nu = 0, 1, 2) + e$ , produced by infrared chemiluminescence in a flowing afterglow. The ratio of  $\text{HCl}(\nu = 2)$  to  $\text{HCl}(\nu = 1)$  population formed in the reaction is  $N_{\nu=2}/N_{\nu=1} = 0.60 \pm 0.03$ . Comparison of the total emission intensity to that from a reaction of similar exothermicity suggests that  $\text{HCl}(\nu = 0)$  formation may be small.

- 19363.** Ditmars, D. A., **Measurement of the relative enthalpy of tungsten between 273.15 and 1173.15 K; derived electron heat-capacity coefficient**, *High Temp.—High Pressures* **11**, 615-624 (1979).

Key words: drop calorimetry; electronic heat capacity; enthalpy; heat capacity; high-temperature; standard reference material; thermodynamic functions; tungsten.

The enthalpy relative to the enthalpy at 273 K of two tungsten samples, one single-crystal (> 99.99% pure) and one polycrystalline sintered (> 99.9% pure), has been measured between 273 and 1173 K in a precision Bunsen ice calorimeter. The enthalpy values are believed to have an overall inaccuracy  $\leq 0.3\%$ . The enthalpy of the single-crystal sample is uniformly 0.3% above that of the sintered sample. The heat capacity is found to be in good agreement with literature data for tungsten. The value of  $1.9 \text{ mJ mol}^{-1} \text{ K}^{-2}$  for the electronic heat-capacity coefficient of tungsten derived from the measured data is about twice as large as currently accepted values for this coefficient derived from heat-capacity data below 20 K.

- 19364.** Waksman, D., Streed, E., Dawson, A., **The influence of environmental exposure on solar collectors and their materials**, *Proc. American Section/International Solar Energy Society 1980 Annual Meeting, Phoenix, AZ, June 2-6, 1980*, pp. 415-419 (AS/ISES, Inc., McDowell Hall, University of Delaware, Newark, DE, 1980).

Key words: absorber materials; absorptive coatings; accelerated aging; cover plates; durability; environmental exposure; materials; polymeric materials; solar collectors.

Efforts in the development of reliability/durability tests for solar collectors and their materials have been hampered by the lack of data on the real time and accelerated degradation of these materials. The focus of this paper is upon research related to the development of standards for evaluating the reliability and durability of cover plate and absorber materials used in flat plate solar collectors. In this research, several different types of collectors, cover plates and absorbers are being studied in laboratory and field tests. Optical property measurements are being performed in conjunction with aging tests intended to induce degradation in the materials. The aging tests include accelerated laboratory exposure of material specimens and outdoor exposure of these materials in simulated solar collectors. Full-size solar collectors in which several of these materials are used are being concurrently subjected to outdoor and solar simulator exposure. Changes in thermal performance at the collector level are being compared with changes in optical properties at the materials level. The results obtained in the first year of this study are presented.

- 19365.** Suenram, R. D., Lovas, F. J., **Millimeter wave spectrum of glycine**, *J. Mol. Spectrosc.* **72**, 372-382 (1978).

Key words: amino acid; centrifugal distortion; glycine; microwave spectrum; rotational constants; structure.

The millimeter wave spectrum of glycine ( $\text{NH}_2\text{CH}_2\text{COOH}$ ), the simplest amino acid, is reported. The observed  $a$ -type transitions have been fit to a centrifugal distortion model for both the ground and first excited vibrational state. Based on qualitative arguments, a lower limit of  $\sim 3$  Debye has been determined for the  $\mu_a$  component of the molecular electric dipole moment. The spectral data are consistent with the compact conformation as the source of the observed spectrum. This conformer involves a hydrogen bond between the lone pair of electrons of the amino group and the hydrogen atom of the hydroxyl group.

- 19366.** Streed, E., Waksman, D., Dawson, A., Lunde, A., **Comparison of solar simulator and outdoor ASHRAE Standard 93 thermal performance tests**, *Proc. American Section/International Solar Energy Society 1980 Annual Meeting, Phoenix, AZ, June 2-6, 1980*, pp. 405-409 (AS/ISES, Inc., McDowell Hall, University of Delaware, Newark, DE, 1980).

Key words: ASHRAE Standard 93; collector rating; environmental influence; outdoor testing; solar collectors; solar simulators; thermal testing.

Standard test methods for determination of solar collector thermal performance permit the use of solar simulators. A comparison of efficiency measurements for seven collectors of varying construction and materials is used to illustrate the high bias in results when using two types of solar simulators as compared to outdoor measurements. Spectral distribution, sky temperature and collector tilt angle are shown to be parameters that must be considered in addition to the normal environmental test conditions of wind, irradiance, diffuse fraction and ambient temperature when comparing indoor and outdoor tests results.

- 19367.** Nahman, N. S., Andrews, J. R., Gans, W. L., Guillaume, M. E., Lawton, R. A., Ondrejka, A. R., Young, M., **Applications of time-domain methods to microwave measurements**, *IEEE Proc. Microwaves, Optics and Antennas* **127**, Pt. H, No. 2, 99-105 (Apr. 1980).



Key words: microwave systems; transmission-line theory; signal processing; waves.

Microwave applications of a computer-controlled time-domain measurement system are presented. Examples of actual measurements are given showing the acquired time-domain waveforms and their corresponding Fourier transforms. Measurement results are presented for (a) impulse-generator spectrum-amplitude calibration, (b) transmission-line impulse response, (c) picosecond-domain photoconductor response, and (d) pulsed electromagnetic fields.

- 19368.** Maki, A. G., Olson, W. B., Sams, R. L., **High-resolution infrared spectrum of the 859- and 1711-cm<sup>-1</sup> bands of carbonyl sulfide (OCS)**, *J. Mol. Spectrosc.* **81**, 122-138 (1980).

Key words: absorption; calibration; carbonyl sulfide; infrared; laser calibration; molecular spectra; spectra; spectroscopy.

The  $\nu_1$  and  $2\nu_1$  bands of OCS have been measured using grating spectrometers and a tunable diode laser spectrometer. Preliminary wavenumbers for OCS absorption lines useful for calibrating tunable laser systems are given for the wavenumber intervals 825 to 885 cm<sup>-1</sup> and 1665 to 1737 cm<sup>-1</sup>. Measurements and an analysis are given for the bands 10<sup>0</sup>0-00<sup>0</sup>0, 11<sup>0</sup>0-01<sup>0</sup>0, 20<sup>0</sup>0-00<sup>0</sup>0, 21<sup>0</sup>0-01<sup>0</sup>0, and 30<sup>0</sup>0-10<sup>0</sup>0 of the <sup>16</sup>O<sup>12</sup>C<sup>32</sup>S isotopic species and for the 20<sup>0</sup>0-00<sup>0</sup>0 band of the <sup>16</sup>O<sup>13</sup>C<sup>32</sup>S and <sup>16</sup>O<sup>12</sup>C<sup>34</sup>S species. Effective band constants are given for these bands.

- 19369.** Mies, F. H., **Perturbed Rydberg series: Relationship between quantum-defect and configuration-interaction theory**, *Phys. Rev. A* **20**, No. 5, 1773-1783 (Nov. 1979).

Key words: atomic spectroscopy; Cd; configuration interaction theory; perturbations; quantum defect theory; Rydberg states; spectra.

In this paper the theory of a single Rydberg series perturbed by an interloping state is examined. General analytic expressions are presented which apply both to the bound-state regions and to the autoionizing regions above the Rydberg ionization limit. The parameters are expressed in terms of configuration-interaction matrix elements, which can be calculated *a priori*. There is no restriction to weak-perturbation theory, and the wave function and all its associated properties, such as transition moments, can be extracted. Explicit calculations are presented for the Cd(5s nd)<sup>1</sup>D<sub>2</sub> series perturbed by the Cd(5p<sup>2</sup>)<sup>1</sup>D<sub>2</sub> valence state, and excellent results are obtained.

- 19370.** Lovas, F. J., Snyder, L. E., Johnson, D. R., **Recommended rest frequencies for observed interstellar molecular transitions**, *Astrophys. J. Suppl. Ser.* **41**, 451-480 (Nov. 1979).

Key words: astronomy; hyperfine structure; interstellar molecules; microwave spectra; rotational transitions; spectroscopy.

The most accurate values presently available for the rest frequencies of all known interstellar molecular transitions are presented and recommended for reference in future astronomical observations in the radio and microwave regions. The recommended values have been carefully selected after critical evaluation of the spectroscopic literature. Probable error limits along with the proper molecular and quantum mechanical labels are presented for each observed transition. Representative line antenna temperatures are also presented for a typical source as a convenience to users. References are cited to both the astronomical and the laboratory literature.

- 19371.** King, D. S., Schenck, P. K., Stephenson, J. C., **Spectroscopy and photophysics of the CF<sub>2</sub>A <sup>1</sup>B<sub>1</sub>-X <sup>1</sup>A<sub>1</sub> system**, *J. Mol. Spectrosc.* **78**, 1-15 (1979).

Key words: CF<sub>2</sub>; difluorocarbene; fluorescence excitation spectroscopy; Franck-Condon factors; laser excited fluorescence; radiative lifetime; single vibronic level spectroscopy.

Laser excited single vibronic level (SVL) fluorescence and SVL fluorescence excitation spectra of the low pressure vapor phase CF<sub>2</sub>  $\bar{A}$ - $\bar{X}$  transition are reported. The spectral origin is at 268.74 nm (37 197 cm<sup>-1</sup>); extensive progressions in the bending mode  $\nu_2'' = 666 \pm 5$  cm<sup>-1</sup> dominate the spectra; weaker combination bands involving the symmetric stretch  $\nu_1'' = 1186 \pm 15$  cm<sup>-1</sup> are observed. Fluorescence bands appear that may be assigned as originating either from the 1<sup>2</sup><sub>g</sub> or the 2<sup>3</sup><sub>1</sub> vibronic levels, giving  $\nu_1' = 976 \pm 24$  cm<sup>-1</sup> or  $\nu_3' = 900 \pm 20$  cm<sup>-1</sup>, respectively. Measured vibronic band intensities  $\langle \nu' | \nu'' \rangle^2$  are given for all transitions from the upper states 2<sup>n</sup> for  $0 \leq n_2' \leq 6$ . The collision-free  $A$  (0,0,0) state radiative lifetime is  $61 \pm 3$  nsec. This same lifetime is observed even for vibronic states containing 8000 cm<sup>-1</sup> excess vibrational energy (i.e., the  $n_2' = 16$  level). SVL fluorescence spectra and radiative lifetimes were used to calculate the transition dipole moment  $\bar{R}_e = 1.22$  D for this system, and a low resolution absorption cross section  $\sigma(2\theta_0, 300 \text{ K}) = 6.7 \times 10^{-19}$  cm<sup>2</sup> for the  $\bar{A}$ - $\bar{X}$  origin at band maximum (268.74 nm).

- 19372.** Dunlap, B. J., Gadzuk, J. W., **Surface plasmon relaxation energies for CO adsorbed on jellium**, *Surf. Sci.* **94**, 89-104 (1980).

Key words: chemisorption; dielectric response theory; photoemission; relaxation energy; surface spectroscopy.

Substrate induced screening or extra-atomic relaxation energies are calculated for molecular orbital (MO) hole states of CO adsorbed on jellium surfaces, within a previously elucidated linear response model. For realistic adsorbate-substrate spacings, screening energies of  $\sim 2$  eV and differential shifts amongst the MO's of  $\sim$  a few tenths eV are obtained. The classical expression for the screening energy  $E = e^2/4(s + \kappa^{-1})$  gives a reasonable estimate when  $s$  is taken as the distance between the image plane and the MO charge centroid and  $\kappa^{-1}$  is the Fermi-Thomas screening length.

- 19373.** Bowman, C. D., **Efficient neutron production using low-energy electron beams**, *Nucl. Sci. Eng.* **75**, 12-15 (1980).

Key words: bremsstrahlung; electron beams; linear accelerator; neutron physics; neutron radiography; neutrons.

A comparison of ( $\gamma, n$ ) and atomic cross sections shows that neutron production with an electron beam can be as energy efficient with 10-MeV electrons as with the conventionally used 30- to 100-MeV electrons. Neutron production from tungsten using 100-MeV electrons is compared with a thin tungsten converter followed by a deuterium-containing target using electrons near 10 MeV.

- 19374.** Cardman, L. S., Lightbody, J. W., Jr., Penner, S., Fivovinsky, S. P., Maruyama, X. K., Trower, W. P., Williamson, S. E., **The charge distribution of <sup>13</sup>C**, *Phys. Lett.* **91B**, No. 2, 203-206 (Apr. 7, 1980).

Key words: carbon; combined analysis; electron scattering; high accuracy; low and high momentum transfer; rms radius.

We report the results of a precision absolute elastic electron scattering experiment on carbon from which we determine the shape of the ground-state charge distribution and the rms charge radius to an accuracy significantly better than heretofore achieved.

- 19375.** Fanne, A. H., Liu, S. T., **Test results on hot water systems show effects of system design**, (Proc. Symp. on Solar Hot Water Systems, Los Angeles, CA, Feb. 3-7, 1980), *Solar Eng.*, pp. 25-29 (May 1980).



Key words: computer; energy; heat transfer; hot water; measurement; modeling; solar; testing.

Currently three computer programs, TRNSYS, f-CHART, and SOLCOST, are being extensively used for the design and evaluation of solar space heating and domestic hot water systems. Although widely used, the accuracy of their predictions needs to be verified with experimental data. In order to provide data required for the validation of these computer programs for solar domestic hot water systems, the staff of the National Bureau of Standards fabricated and instrumented six typical systems at its Gaithersburg, Maryland site. The systems have been operating since June, 1978. This paper describes the testing done, the experimental results, and compares the experimental results with the computer predictions for the first twelve months of operation.

**19376.** Bur, A. J., **Porous polymer tape screening program, EL-1259**, 47 pages (Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA, 1979).

Key words: buoyant force; dielectric insulation; dielectric oil; impregnation; porosity; porous polymers.

A screening program has been developed for porous polymer tapes which are considered to be candidates for a tape-oil insulation system in a high-voltage transmission cable. The program consists of 21 tests for measuring mechanical, electrical and physical properties. Descriptions of most of these tests have been published in ASTM test schedules or in other literature sources. Two of the tests had to be developed in our laboratories. They are the degree-of-void-filling test and the solubility test.

For the degree-of-void-filling test, a buoyancy measurement is utilized to calculate the void volume which is not filled by the permeating oil. Two buoyancy measurements are made: first, the specimen is immersed in a calibration fluid which is assumed to permeate all voids in the specimen. A true specimen density is calculated and then compared to an apparent density which is obtained from the specimen immersed in oil. The difference in the two densities is proportional to the reciprocal of the unfilled void volume.

Four materials and two oils have been used for these experiments. The materials are a polypropylene synthetic paper (PPSP), a porous polypropylene (PP), a polyethylene synthetic paper (PE) and a paper-polypropylene-paper laminate (PPP). The oils are an alkyl benzene oil and a polybutene oil. The results show a range of void filling from very little for PPSP to complete filling for PP.

**19377.** Waksman, D., Dikkers, R. D., **Solar heating standards activities in the United States, Proc. Technical Meeting on Solar Energy Codes of Practice and Test Procedures, London, England, Apr. 25, 1980**, pp. 89-98 (UK-ISES, 19 Albemarle St., London, England, 1980).

Key words: codes; performance criteria; solar heating system; standards.

With the impending widespread use of solar technology, standards are urgently needed to ensure acceptable levels of technical performance. Such standards need to address not only thermal performance but also health, safety and reliability/durability. These standards will also be used as the basis for model state and local building code provisions as well as for Federal specifications. In addition, they are needed for purposes of consumer acceptance, mortgage insurance, tax credit or incentive programs, and industry commercialization. Mechanisms for the implementation of these standards, e.g. laboratory accreditation and certification procedures, are also needed.

This paper provides an overview of efforts that are currently underway in the United States to develop and implement standards for solar heating applications. A summary of standards

development and building regulatory systems used in the United States is also provided.

**19378.** Zwier, T. S., Bierbaum, V. M., Ellison, G. B., Leone, S. R., **Vibrational product state distributions of ion-molecule reactions by infrared chemiluminescence:  $\text{Cl}^- + \text{HBr}$ ,  $\text{HI} \rightarrow \text{HCl}(v) + \text{Br}^-$ ,  $1^-$** , *J. Chem. Phys.* **72**, No. 10, 5426-5436 (May 15, 1980).

Key words: associative detachment; flowing afterglow; infrared chemiluminescence; ion molecule reactions; vibrational excitation.

The initial vibrational product state distribution is obtained for the thermal associative detachment reaction,  $\text{Cl}^- + \text{H} \rightarrow \text{HCl}(v=0,1,2) + e$ , utilizing infrared chemiluminescence in a flowing afterglow. The ratio of  $\text{HCl}(v=2)$  to  $\text{HCl}(v=1)$  population formed in the reaction is  $N_{v=2}/N_{v=1} = 0.60 \pm 0.03$ . Comparison of the total emission intensity to that from a reaction of similar exothermicity suggests that  $\text{HCl}(v=0)$  formation may be small.

**19379.** Olver, F. W. J., **Asymptotic approximations and error bounds, SIAM Rev.** **22**, No. 2, 188-203 (Apr. 1980).

Key words: Bessel functions; generalized asymptotic expansions; irregular singularities; Liouville-Green approximation; multiple asymptotic expansions; Stokes Phenomenon; WKBJ approximation.

The purpose of this paper is to demonstrate that well-constructed error bounds for asymptotic approximations can provide useful analytical insight into the nature and reliability of the approximations, enable somewhat unsatisfactory concepts such as multiple asymptotic expansions and generalized asymptotic expansions to be avoided, and lead to significant extensions of asymptotic results.

Also included are numerical values of error terms in the asymptotic expansion of Macdonald's modified Bessel function  $K_\nu(z)$ , and some new results pertaining to the Stokes phenomenon for this expansion.

**19380.** Clenshaw, C. W., Olver, F. W. J., **An unrestricted algorithm for the exponential function, SIAM J. Numer. Anal.** **17**, No. 2, 310-331 (Apr. 1980).

Key words: error analysis; exponential function; multiprecision calculations; relative precision; unrestricted arguments; unrestricted ranges.

An algorithm is presented for the computation of the exponential function of real argument. There are no restrictions on the range of the argument or on the precision that may be demanded in the results.

**19381.** Haber, S., **An elementary inequality, Internat. J. Math. & Math. Sci.** **2**, No. 3, 531-535 (1979).

Key words: arithmetic-geometric mean inequality; compound interest; inequalities; rearrangements inequality.

A number of closely related inequalities are presented and proven. The basic inequality is  $\{(a^n + a^{n-1}b + a^{n-2}b^2 + \dots + b^n)/(n+1)\} \geq \{(a+b)/(2)\}^n$ , for  $a, b, n \geq 0$ ,  $n$  an integer. A typical related inequality is  $(1+a)^b \geq 1 + ab(1+a/2)^{b-1}$  for  $a, b \geq 0$  — with the inequality reversed when  $1 \leq b \leq 2$ .

**19382.** Bardsley, J. N., Norcross, D. W., **Oscillator strengths for thallium calculated using a semiempirical relativistic one-electron central-field model potential, J. Quant. Spectrosc. Radiat. Transfer** **23**, 575-583 (1980).

Key words: lifetimes; model potentials; oscillator strengths; relativistic atomic structure; thallium.

The results of calculations for oscillator strengths, radiative transition probabilities and excited state lifetimes are presented



and compared with those of other calculations and measurements. The agreement with measured oscillator strengths is generally quite good. The importance of core polarization effects for the diffuse series is demonstrated. The significance of the results for measurements of parity-nonconserving effects due to weak neutral currents is discussed.

19383. Behrens, J. W., Johnson, R. G., Bowman, C. D., **Pinhole camera imaging of neutrons using a position-sensitive proportional counter**, *Trans. Am. Nucl. Soc.* **34**, 663-664 (1980).

Key words: eV neutron energy; neutron imaging techniques; pinhole camera; position-sensitive proportional counter.

We describe in this paper progress at NBS in imaging eV neutrons produced by a spatially extended source using a position-sensitive proportional counter in a pinhole camera configuration. This work is being conducted (1) for a better understanding of the eV neutron source characterization from the neutron-producing target at the NBS linac, (2) for the development of resonance neutron radiography, and (3) for possible use in imaging high energy neutron sources.

19384. Wheeler, J. C., Mazurek, T. J., Sivaramakrishnan, A., **Supernovae in molecular clouds**, *Astrophys. J.* **237**, No. 3, Pt. 1, 781-792 (May 1, 1980).

Key words: dust grains; molecular clouds; star formation; supernovae; supernova remnants; x rays.

The evolution of a supernova buried in a molecular cloud is studied analytically and compared with preliminary numerical dynamical results. Such a supernova can disrupt a cloud of mass  $M < 10^4 M_\odot$  but will be assimilated by larger clouds. The rate of evolution of a buried supernova is considerably enhanced by the large ambient density  $n \geq 10^3 \text{ cm}^{-3}$ . For constant density  $n \geq 10^5 \text{ cm}^{-3}$  and ejected mass  $\sim 10 M_\odot$  the system cannot relax into a true self-similar adiabatic solution because the radiative losses are already appreciable by the time a mass exceeding that of the supernova ejecta is swept up. With a density gradient the shock is accelerated while the emissivity decreases. This serves to prolong the adiabatic phase which may last until the remnant reaches the edge of the cloud. For a constant density  $n = 10^4 \text{ cm}^{-3}$  the luminosity rises during the adiabatic phase to a peak greater than  $10^6 L_\odot$  lasting  $\sim 100$  years. It plummets rapidly thereafter in the radiative phase but may still be  $\sim 10^4 L_\odot$  after several thousand years when the radius is  $\sim 1 \text{ pc}$ . The spectrum will be characterized by a self-absorbed radio free-free tail and a large peak in the IR due to absorption and reradiation by dust grains of optical, UV, and soft x-ray photons. This peak is determined basically by flux balance and thus will qualitatively resemble the IR spectrum of a buried O star of the same luminosity. There will also be a characteristic x-ray signature in the free-free emission with conspicuous absorption edges in the range 1/2-1 keV.

19385. Tersoff, J., Falicov, L. M., Penn, D. R., **Core-level satellite structure in photoemission spectra of transition metals**, *Solid State Commun.* **32**, 1045-1047 (1979).

Key words: core level; photoemission; transition metal.

A theory of the satellite structure of the core-level photoemission spectrum of transition metals is presented. It is applied to the  $2p_{3/2}$  level of metallic nickel. The calculation is carried out for both the paramagnetic and ferromagnetic states and is based on two scattering parameters, one intraband and one interband. Agreement with experiment is very good.

19386. Takagi, S., Mathew, M., Brown, W. E., **Phosphate ion with three 'symmetric' hydrogen bonds: The structure of  $\text{Ca}_2(\text{NH}_4)\text{H}_7(\text{PO}_4)_4 \cdot 2\text{H}_2\text{O}$** , *Acta Cryst.* **B36**, 766-771 (1980).

Key words: calcium ammonium phosphate; calcium phosphate; crystal structure; sheet type structure; symmetric hydrogen bonds.

$\text{Ca}_2(\text{NH}_4)\text{H}_7(\text{PO}_4)_4 \cdot 2\text{H}_2\text{O}$  crystallizes in the triclinic space group  $\bar{P}1$  with  $a = 5.693(2)$ ,  $b = 12.299(4)$ ,  $c = 6.297(2)$  Å,  $\alpha = 103.98(2)^\circ$ ,  $\beta = 115.10(2)^\circ$ ,  $\gamma = 84.22(2)^\circ$  [ $\lambda(\text{MoK}\alpha_1) = .70932$  Å] at room temperature with  $Z = 1$ . The structure was refined by the method of least squares to  $R(F) = 0.048$ ;  $R_w(F) = 0.050$  for 904 reflections with  $F_0 > 2\sigma(F_0)$ . The structure contains  $[\text{CaH}_2\text{PO}_4]^+$  chains held together by  $\text{Ca}\cdots\text{O}$  bonds to form corrugated  $\text{Ca}-\text{P}(2)\text{O}_4$  sheets analogous to those found in  $\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O}$  and several other calcium phosphates. Between these sheets are  $[\text{H}_3(\text{PO}_4)_2]^{3-}$  ions, water molecules and  $[\text{NH}_4]^+$  ions. Three of the O atoms of the  $\text{P}(1)\text{O}_4$  group between the corrugated sheets are hydrogen bonded across three crystallographic centers of symmetry  $[\text{O}(11)\cdots\text{H}\cdots\text{O}(11)$ ;  $\text{O}(13)\cdots\text{H}\cdots\text{O}(13)$ ;  $\text{O}(14)\cdots\text{H}\cdots\text{O}(14)]$  forming an infinite  $[\text{H}_3(\text{PO}_4)_2]_n^{3-}$  sheet structure. The water molecule is bonded to a  $[\text{CaH}_2\text{PO}_4]^+$  sheet and to a  $[\text{H}_3(\text{PO}_4)_2]_n^{3-}$  sheet by multiple hydrogen bonds. The  $[\text{NH}_4]^+$  ion is disordered across a center of symmetry. The Ca atom is coordinated to eight O atoms with  $\text{Ca}\cdots\text{O}$  distances in the range 2.319 to 2.687 Å.

19387. Phelps, A. V., **The determination of electron collision cross sections from swarm data**, *Proc. Int. Seminar on the Swarm Experiments in Atomic Collision Research*, Tikkyo Univ., Tokyo, Japan, Sept. 6-7, 1979, pp. 23-32 (Department of Physics, Rikkyo University, Tokyo, Japan, 1980).

Key words: cross sections; electrons; nitrogen; oxygen; rare gases; rate coefficients; transport.

Electron collision cross sections have been determined from swarm data, such as mobility and diffusion coefficients, since the early studies of Townsend and co-workers. Work through the 1940's provided a) still useful measurements of electron transport coefficients and approximate momentum transfer cross sections in a wide variety of gases; b) the recognition of the unique ability of swarm measurements to provide cross sections for very low energy processes such as rotational excitation; and c) rigorously formulated, lowest order solutions to the Boltzmann equation for electrons in gases in a uniform electric field. The application of high speed computers and the development of techniques for precision measurement of electron transport coefficients in the 1960's made possible the serious determination of electron collision cross sections from swarm data. With the recognition of the usefulness and accuracy of this approach has come more precise formulations of the relationship between the experiments and the Boltzmann equation used to calculate the measured quantities from electron collision cross sections. The determination of cross sections at energies for which inelastic collisions are important requires that the analysis include comparisons with rate coefficients for electron attachment, ionization and excitation. Swarm experiment data have been used for the determination of electron collision cross sections for rare gases, some metal vapors and several molecular gases. We review the methods of data analysis and summarize results obtained for atomic and molecular gases.

19388. Leuchs, G., Smith, S. J., Khawaja, E., **Quantum beats observed in photoionization**, *Opt. Commun.* **31**, No. 3, 313-316 (Dec. 1979).

Key words: angular distribution; atomic; hyperfine structure; multiphoton; photoionization quantum beats; sodium.

Quantum beats of the hyperfine levels of the  $3^2\text{P}_{3/2}$  state of sodium have been observed in photoionization. The atoms are ionized stepwise with two pulsed lasers. The photoelectron angular distribution, measured as a function of the delay between the two laser pulses, exhibits a periodic variation due to the quantum beat effect. The hyperfine splitting of the intermediate



state estimated from these measurements is in good agreement with literature values.

- 19389.** Kayser, R. F., Jr., **Logarithmic terms in the softness expansion of dilute gas transport properties**, *J. Chem. Phys.* **72**, No. 10, 5458-5468 (May 15, 1980).

Key words: dilute gas transport properties; inverse power potential; logarithmic terms; perturbation theory; softness expansion.

We consider the dilute gas coefficients of viscosity and thermal conductivity for the inverse power potential,  $\phi(x, r) = \phi_0(\sigma/r)^{-\epsilon}$ , and prove that as  $x \rightarrow +0$  they have the form  $a_0 + a_1x + a_2x^2 \ln x + a_3x^2 + a_4x^3 \ln^2 x + O(x^3 \ln x)$ . We determine the coefficients  $a_0 - a_4$  in closed form and the analysis may be easily adapted to other properties such as the self-diffusion coefficient. We also show that the logarithmic terms are due to binary collisions for which the distance of closest approach of the particles is greater than the diameter  $\sigma$  and discuss the implications of this for developing a general perturbation theory for transport properties.

- 19390.** Hamilton, J. C., Swanson, N., Wacławski, B. J., Celotta, R. J., **Bond directions in adsorbed molecules determined using high resolution electron energy loss spectroscopy (EELS): Acetylene and ethylene on tungsten (100)**, *Proc. Physical Electronics Conf., Ithaca, NY, June 16-18, 1980*, p. E7 (Cornell Materials Science Center, Cornell University, Ithaca, NY, 1980).

Key words: acetylene; chemisorption; electron energy loss spectroscopy; ethylene; physisorption; surface; tungsten.

We have used high resolution electron energy loss spectroscopy in both specular and non-specular directions to identify the vibrational modes of acetylene and ethylene on the tungsten (100) surface. At low coverages several of the vibrational modes were detectable only in the non-specular direction. Analysis of relative intensities of the specular and non-specular losses allows determination of the orientation of molecular dipole moments and thus of bond directions in the adsorbed species. For both acetylene and ethylene initial adsorption was found to be dissociative.

- 19391.** Eisenhauer, C., **Scaling parameter for backscattering of electrons at perpendicular incidence**, *Trans. Am. Nucl. Soc.* **34**, 654-656 (June 1980).

Key words: albedo; backscatter; electrons; range; reflection; scaling parameter; transport mean free path.

A scaling parameter  $\gamma_0$  is suggested for understanding backscattering of electrons from material. This parameter is the product of  $r_0$  the continuous-slowing-down range and  $\gamma$ , the reciprocal of the transport mean free path. Experimental data for backscattering of electrons of varying energies perpendicularly incident on various materials are plotted as a function of  $\gamma_0$ . The results cluster along a single curve for backscatter coefficients ranging from 0.003 to 0.5, for electron source energies between 30 keV and 20 MeV, and for materials with atomic numbers between 6 and 82.

- 19392.** Berger, P. W., **Managing revolutions—Coping with evolving information technologies**, *Proc. 71st Annual Conf. of the Special Libraries Association, Washington, DC, June 10, 1980*, 26 pages (Special Libraries Association, 235 Park Avenue South, New York, NY, 1980).

Key words: bibliographic utilities; information revolution; information technology; library automation; library networks; reprography; special libraries; telecommunications.

An overview of the impacts—past, present and future—of the newer information technologies on special libraries.

- 19393.** Jacox, M. E., **The reaction of F atoms with CO in an argon matrix. Vibrational and electronic spectra of FCO**, *J. Mol. Spectrosc.* **80**, 257-271 (1980).

Key words: CO; discharge sampling; F-atom reactions; FCO;  $F_2CO$ ; infrared spectrum; matrix isolation;  $NF_3$ ; normal coordinate analysis; photodissociation; ultraviolet spectrum.

Upon codeposition at 14 K of an Ar:CO sample with an Ar: $NF_3$  sample that had been passed through a low-power microwave discharge in an  $Al_2O_3$  tube, very prominent infrared absorptions of FCO and  $F_2CO$  were observed. Overtone bands of FCO were identified at 2032 and  $3690\text{ cm}^{-1}$ , and their assignment was confirmed by both carbon-13 and oxygen-18 isotopic substitution. Further data were also obtained on the vibrational fundamentals of isotopically substituted  $F_2CO$ . A six-constant valence force potential has been derived for FCO using a least-squares force constant adjustment to the isotopic data and assuming a recently calculated structure. The photodissociation of FCO into  $F + CO$  was observed with a threshold near 2800 Å. The assignment of two overlapping electronic transitions of FCO between 3400 and 2300 Å is discussed.

- 19394.** Eckerle, K. L., Hsia, J. J., Weidner, V. R., Venable, W. H., Jr., **NBS reference retroreflectometer**, *Appl. Opt.* **19**, No. 8, 1253-1259 (Apr. 15, 1980).

Key words: coefficient of luminous intensity; coefficient of retroreflection; projector; receiver; retroreflectometer; retroreflector; sample carrier.

A long-range retroreflectance instrument has been built in the photometric range of the Radiometric Physics Division of the NBS. It is designed to measure photometric properties of retroreflectors for different geometries. It satisfies many needs of the measurement community, and it is planned to use this instrument as the basis for a Measurement Assurance Program (MAP) and for Standard Reference Materials (SRM). This paper describes the design and testing of the instrument. Some estimated uncertainties for typical samples are given.

- 19395.** Franklin, A. D., Epp, J., **Preparation of Pt-Fe alloy foils by electrodeposition of Fe**, *J. Electrochem. Soc.* **126**, No. 12, p. 2162 (1979).

Key words: alloys; electrodeposition; electro preparation; foils; iron platinum.

A technique is described in which Pt-rich Fe-Pt foils are prepared by electrodeposition of Fe onto Pt foils from a 50:50 molar mixture of  $KCl:FeCl_2$  at 500 °C under reducing conditions. Subsequent annealing at 1600 °C in a 5:95  $H_2:He$  atmosphere produced well-annealed homogeneous alloy foils of controlled composition. X-ray diffraction of annealed specimens containing up to 10 atom percent Fe revealed disordered fcc structures for which the lattice parameter accurately obeyed Vegard's law and agreed with literature data.

- 19396.** Paffenbarger, G. C., **Important accomplishments in dentistry, 1930-1980: A personal appraisal**, *NY J. Dent.* **50**, No. 5, 190-191 (May 1980).

Key words: dental accomplishments; dental diseases; dental history; dental treatment; prevention of dental diseases.

The effect of fluoride in the reduction of dental caries was the single most important accomplishment in dental health service in the period between 1930-1980. Caries was found to be caused by microorganisms and is a transmissible disease. The reduction in irradiation of patients in diagnostic procedures, the curtailment of periodontal disease by oral hygiene, the reduction of sugar in the diet, the use of new drugs, the improvement in anesthetics and in dental materials such as the invention of new cements, elastic impression materials, the turbine contraangle



handpiece, the composite restorative materials, and enamel etching techniques all contributed to the improvement of dental health service.

- 19397.** Peterson, R. L., **Space applications of superconductivity: Instrumentation for gravitational and related studies**, *Cryogenics* 20, No. 6, 299-306 (June 1980).

Key words: accelerometers; gravimeters; gravitation; gyro-scope; levitation; navigation.

This is the sixth of a seven part series on the potential applications of superconductivity in space. Superconductivity already appears to have a role in measurements related to gravitational effects (superconducting gyroscope, accelerometers, and levitation), and offers many potential advantages in other, related, studies of relevance to the space programme. Superconducting devices of promise include magnetometers, cavity oscillators, gravimeters, and bearings. In addition to fundamental studies involving many types of tests of gravitational theories, deep space navigation and elucidation of the properties of planetary interiors are areas for potential applications.

- 19398.** Parks, E. J., Brinckman, F. E., Blair, W. R., **Application of a graphite furnace atomic absorption detector automatically coupled to a high-performance liquid chromatograph for speciation of metal-containing macromolecules**, *J. Chromatogr.* 185, 563-572 (1979).

Key words: fractionation; graphite furnace atomic absorption; high pressure liquid chromatography; organometallic polymers; organotin silicate; refractive index; reverse bonded phase chromatography; silicon analysis; size exclusion chromatography; tin analysis.

High-pressure liquid chromatography (HPLC) coupled with graphite furnace atomic absorption (GFAA) is capable of sensitive, nearly non-destructive, element-specific separation and detection of a wide range of molecular species containing metals or metalloids. Applications of HPLC-GFAA techniques are discussed, including size exclusion chromatography for the analysis of experimental organometallic polymers containing chemically bonded biocidal organotin moieties, and reversed bonded phase chromatography for analysis of novel organotin silicates. In conjunction with variably sensitive optical refractive index/ultra violet absorption detection, GFAA demonstrates separation of the polymers into at least two tin-containing fractions of widely different molecular weight (MW). The relative proportions of high- and low-MW fractions have important implications with respect to performance specifications for these and similar controlled release materials. Tin-specific and silicon-specific analysis of an organotin silicate demonstrates coelution of species containing each element. Future off/on-line  $^{29}\text{Si}$  and  $^{119}\text{Sn}$  Fourier transform nuclear magnetic resonance spectroscopy will demonstrate whether each element is bonded to the same molecular species.

- 19399.** Nesbitt, D. J., Leone, S. R., **Laser-induced gas phase chain chemistry**, *Proc. Electro-Optics/Laser 79 Conf., Anaheim, CA, Oct. 23-25, 1979*, pp. 218-289 (Industrial and Scientific Conference Management, Inc., Chicago, IL, 1979).

Key words: chain reaction; laser; laser chemistry; radical.

A detailed kinetic and experimental analysis is presented for chemical chain reaction processes initiated by well-controlled, low power laser pulses. Realtime evolution of the chain reaction is followed by direct detection of infrared chemiluminescence from vibrationally excited HCl product molecules produced by one of the propagation reactions in the chain. By appropriate choice of conditions, the chain reactions may be analyzed separately for pseudo first-order, radical-reagent processes as well as for second-order, radical-radical events. The pulsed laser initiation technique is applied to the  $\text{Cl}_2/\text{H}_2\text{S}$  system; detailed rate constant data are obtained for the fundamental chain propaga-

tion steps, and appropriate chain termination steps are assigned from the observations. The result is a powerful, new, and general technique for the quantitative study of chemical chain reactions and related combustion processes.

- 19400.** Paretzke, H. G., Berger, M. J., **Stopping power and energy degradation for electrons in water vapor**, *Proc. Sixth Symp. on Microdosimetry, Brussels, Belgium, May 22-26, 1978*, pp. 749-758 (Harwood Academic Publishers, Ltd., London, England, 1978).

Key words: electrons; energy degradation spectra; fano factor; ionization yields; stopping power; W-values.

This paper is concerned with electron energy loss and degradation phenomena in water vapor at energies below a few keV where the Bethe theory is no longer applicable. There is practically no experimental information on low-energy stopping power and on degradation spectra in gases, so that these quantities must be obtained by calculation. The required cross sections for the ionization and excitation of water molecules are not well known, and various assumptions and extrapolations have to be made in order to obtain input data which include all the important processes and all energies of interest. Three such data sets for water vapor are available which are based on somewhat different assumptions and approximations. One set has been published by Olivero, Stagat and Green and the other two sets are from more recent analysis made by us. We compare in this paper various quantities derived from these data sets, in order to obtain an indication how sensitively the stopping-power and energy degradation calculations depend on the cross section input.

- 19401.** Yin, L. I., Trombka, J. I., Seltzer, S. M., **A low-energy gamma-ray imaging detector**, *Space Sci. Instrum.* 4, 321-328 (1979).

Key words: CsI scintillator; energy resolution; low-energy gamma rays; microchannel plates; position-sensitive detector; x-ray telescope.

We describe a hard-x-ray/soft-gamma-ray imaging detector, incorporating a microchannel-plate (MCP) electron multiplier, for possible use in future telescopes. In contrast to previous attempts using MCP's, this approach promises to achieve high quantum detection efficiencies in addition to high spatial and temporal resolution. Preliminary results indicate not only the capability of simultaneous imaging and single-photon counting, but also coarse energy resolution.

- 19402.** Yin, L. I., Trombka, J. I., Seltzer, S. M., **A portable x-ray imaging system for small-format applications**, *Nucl. Instrum. Methods* 158, 175-180 (1979).

Key words: microchannel plate; portable; rare-earth scintillator; small-format; x-ray imaging system;  $^{125}\text{I}$  x-ray source.

A prototype low-intensity x-ray imaging system with the acronym LIXIScope was built to demonstrate the feasibility of a modular approach toward x-ray imaging in small-format applications. The prototype, including its own x-ray source, is shown to be fully portable, rugged and pocket-sized. Preliminary results and performance characteristics obtained with the prototype Lixiscope are presented.

- 19403.** Yin, L. I., Trombka, J. I., Seltzer, S. M., **A small rugged imaging x-ray spectrometer: A Lixiscope with good energy resolution**, *Nucl. Instrum. Methods* 172, 471-477 (1980).

Key words: energy resolution; hard x-ray; imaging; Lixiscope; soft gamma-ray; spectrometer.

A new prototype Lixiscope (Low Intensity X-ray Imaging Scope) is described for operation in the 20-200 keV region. In addition to good spatial resolution, the new prototype is capable of providing simultaneous gamma-ray or x-ray single-photon



counting, imaging, and energy resolution. The observed energy resolution determined from gamma-ray pulse-height spectra is only a factor of two poorer than that of a NaI(Tl)-PMT (photomultiplier tube) system. Taking into account the good spatial resolution, such a Lixiscope is thus equivalent to operating thousands of NaI(Tl)-PMT systems in parallel with minimal degradation in overall energy resolution. These characteristics make the new prototype Lixiscope a compact and rugged device eminently suited for possible low-flux imaging applications.

- 19404.** Yin, L. I., Trombka, J. I., Seltzer, S. M., **New position-sensitive hard x-ray spectrometer**, *Rev. Sci. Instrum.* **51**, No. 6, 844-845 (June 1980).

Key words: energy resolution; hard x-ray; imaging; Lixiscope; soft gamma-ray; spectrometer.

A new prototype Lixiscope (Low intensity x-ray imaging scope) is described. In addition to good spatial and temporal resolution in the 20 keV to 200 keV region, it is capable of single-photon counting, imaging, as well as good energy resolution. The new device is well-suited for future low-flux applications in astronomy, medicine, and industry.

- 19405.** Harris, R. E., **Space applications of superconductivity: Digital electronics**, *Cryogenics* **20**, No. 4, 171-182 (Apr. 1980).

Key words: aerospace; computers; digital electronics; Josephson effect; quantum interference; superconductivity.

This is the fourth of a seven part series on the potential applications of superconductivity in space. Superconducting electronics offers a variety of remarkable properties including exceptionally high speed and low dissipation. The technology can be applied to both high speed computing and measurement. Its attributes may make it attractive for both ground-based and space applications.

- 19406.** Hamilton, C. A., **Space applications of superconductivity: Microwave and infrared detectors**, *Cryogenics* **20**, No. 5, 235-243 (May 1980).

Key words: aerospace; infrared detectors; Josephson effect; microwave detectors; parametric amplifiers; superconductivity.

This is the fifth of a seven part series on the potential applications of superconductivity in space. The potential of superconducting microwave and infrared detectors for space applications is reviewed. The devices considered include bolometers, super-Schottky diodes and Josephson junctions operating as oscillators, mixers, and parametric amplifiers. In each case the description includes the physical mechanism, theoretical limits and the current state-of-the-art for the superconducting device as well as its nonsuperconducting competitors.

- 19407.** Mann, W. B., **Nuclear-decay data: The statement of uncertainties**, *Int. J. Appl. Radiat. Isot., Lett. to Ed.* **31**, No. 6, p. 387 (June 1980); *J. Radioanal. Chem.* **59**, No. 1, 253-254 (1980); *Radiochem. Radioanal. Lett.* **44**, No. 1, 1-4 (1980); *Z. Phys. A, Atoms and Nuclei* **296**, p. 1 (1980).

Key words: data evaluation; nuclear-decay data; radioactivity; random error; systematic error; weighting factors.

This letter emphasizes the need to state the nature of uncertainties associated with the publication of nuclear-decay data.

- 19408.** Costrell, L., Persyk, D. E., Sanderson, C., Walford, G., Walter, F. J., **Germanium semiconductor detector efficiency determination using a Standard Marinelli (Reentrant) Beaker Geometry**, *Health Phys.* **38**, 229-232 (Feb. 1980).

Key words: detector efficiency; gamma-ray efficiency; Marinelli beaker; Reentrant beaker; semiconductor detector efficiency; standards.

A standard technique, utilizing Marinelli (reentrant) beakers, has been defined for the determination of gamma-ray efficiency specification of detectors used in the measurement of large-volume, low-activity samples.

- 19409.** Peterlin, A., **The transient of the intrinsic birefringence and light scattering of a suspension of rigid spheroids in the linear laminar jet flow**, *J. Phys. Chem.* **84**, No. 12, 1650-1657 (1980).

Key words: birefringence; jet flow; light scattering; longitudinal gradient; orientational distribution; rigid spheroid; transient.

For the laminar jet flow with a constant longitudinal gradient  $\gamma$  one has calculated the time dependence of the averages of the second and fourth power of the cosine of the angle  $\theta$  between the symmetry axis of the spheroid and the flow direction. These averages are needed for the intrinsic birefringence and light scattering of a dilute suspension of rigid spheroids subjected to such a flow. The effects depend on the parameter  $\sigma = 3\gamma b/4D$  where the coefficient  $b$  is a function of the particle shape and the rotational diffusion coefficient  $D$  of the symmetry axis of the spheroid is a function of the particle size and shape. The time dependence of both optical effects is the sum of exponential functions of  $-\lambda_{2p}Dt$  with  $\lambda_{2p}$  the eigenvalues of the subsequent terms of the infinite series the distribution function of the orientation of the symmetry axis of the particle is expanded in. It turns out that the transient of the averages contributing to the optical effects mainly depend on the lowest eigenvalue  $\lambda_2$  as long as the parameter  $\sigma$  is not extremely high.

- 19410.** Jacox, M. E., **Infrared spectroscopic study of the reaction of H atoms with CF<sub>2</sub> in argon and nitrogen matrices**, *J. Mol. Spectrosc.* **81**, 349-355 (1980).

Key words: CF<sub>2</sub> reaction; CF<sub>2</sub>I; CF<sub>2</sub>S; H atom reaction; HCF<sub>2</sub>; I atom reaction; infrared spectrum; matrix isolation; S atom reaction.

The concurrent generation of CF<sub>2</sub> and of H atoms upon exposure of samples containing CF<sub>2</sub>N<sub>2</sub> and either HI or H<sub>2</sub>S isolated in an argon or a nitrogen matrix at 14 K to 2537-Å mercury-arc radiation leads to the appearance of prominent infrared absorptions of HCF<sub>2</sub>, demonstrating that this species is the primary product of the H + CF<sub>2</sub> reaction. Infrared absorptions assigned to HCF<sub>2</sub>, DCF<sub>2</sub>, CF<sub>2</sub>I, and CF<sub>2</sub>S in previous studies on other reaction systems are confirmed in the experimental studies here reported.

- 19411.** Barkley, J. F., Ruegg, F. C., **Automating analytical instrumentation**, *Proc. of the NBS-IEEE Microcomputer Based Instrumentation Conf., Gaithersburg, MD, June 12-13, 1978*, pp. 83-86 (Institute of Electrical and Electronics Engineers, Silver Spring, MD, 1978).

Key words: analytical chemistry; automation; instrumentation; microcomputer; minicomputer.

The Analytical Chemistry Division at the National Bureau of Standards has the following requirements for the majority of its instrumentation systems; user programmable, data rates less than 50 per second, simple real-time computation, and temporary and archival data storage.

Microcomputer systems with communication facilities to a large mainframe is one approach being used to meet these requirements. The current rapid pace in microcomputer technology implies premature obsolescence of microcomputer systems. The ability to make use of the latest microcomputer technology for new applications while maintaining existing systems is an important consideration.

Two configurations of microcomputers may be used to automate an instrument, a data acquisition machine and a data processing machine. The data acquisition machine runs the experiment and serves as a buffer for the data and provides for



minimum computation and display of results. The data processing machine performs the necessary realtime data reduction and temporary storage. A large mainframe provides major data reduction and archival storage.

- 19412.** Hougen, J. T., Perturbations in the vibration-rotation-torsion energy levels of an ethane molecule exhibiting internal rotation splittings, *J. Mol. Spectrosc.* **82**, 92-116 (1980).

Key words: ethane; group theory; internal rotation; perturbations; torsion; vibration-rotation.

Various examples of perturbations in the vibration-rotation-torsion energy levels of an ethane molecule exhibiting internal rotation splittings are discussed, both from the point of view of the point group  $D_{3d}$ , appropriate when internal rotation tunneling effects cannot be observed, and from the point of view of the group  $G_{36}^{\dagger}$ , appropriate when internal rotation tunneling in ethane leads to observable splittings in the spectrum. It is found, for perturbations allowed in both  $D_{3d}$  and  $G_{36}^{\dagger}$ , that each of the two torsional components of the perturbed  $D_{3d}$  vibration-rotation level can in principle interact with a "corresponding" torsional component in the perturbing vibration-rotation level. It is found for perturbations forbidden in  $D_{3d}$  but allowed in  $G_{36}^{\dagger}$ , which all occur between  $D_{3d}$  vibrational levels of different  $g$ ,  $u$  parity, that *only one* of the two torsional components of the perturbed  $D_{3d}$  vibration-rotation level can interact with a corresponding torsional component in the perturbing vibration-rotation level. Some of the perturbations examined give intensity to otherwise forbidden transitions in such a way that perturbation-induced transitions can be used in conjunction with normally allowed transitions to determine the sum of the internal rotation splittings for two rotational levels differing in  $K$  by three units.

- 19413.** Birnbaum, G., Determination of molecular constants from collision-induced far-infra-red spectra and related methods, Paper in *Intermolecular Spectroscopy and Dynamical Properties of Dense Systems*, pp. 111-145 (Società Italiana di Fisica, Bologna, Italy, 1980).

Key words: coefficient induced dipoles; collision-induced spectra; dielectric virial; intermolecular transactions; molecular constance; 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.

- 19414.** Birnbaum, G., Collision-induced vibrational spectroscopy in liquids, Paper in *Vibrational Spectroscopy of Molecular Liquids and Solids*, S. Bratos and R. M. Pick, Eds., pp. 147-165 (Plenum Publ. Corp., New York, NY, 1980).

Key words: anisotropic polarizability; collision-induced; induced dipoles; infrared absorption; Raman spectrum; spectra; transient dipoles.

Pressure or collision-induced absorption arises from transient dipoles produced by distortion of the electronic distribution of molecules in binary, ternary and higher order interactions. The induced dipole is modulated by the vibration and rotation of the colliding molecules and, because of its strong dependence on the intermolecular separation, by their relative translational motion. Thus a variety of pressure-induced spectra are known ranging from pure translation and rotation in the microwave and far infrared regions to fundamental and overtone rotation-vibration spectra in the infrared region. Such spectra have been observed in pure substances and in mixtures in the gaseous, liquid and solid phases. Collisions also induce anisotropic polarizability in atoms and spherical molecules producing depolarized Rayleigh spectra. More recently, vibrational Raman bands have been studied which are forbidden by symmetry in the isolated mole-

cule but are produced by intermolecular fields. The aim here is to discuss collision-induced vibrational spectra in liquids observed in infrared absorption and Raman scattering.

- 19415.** Larrabee, R. D., Interpretation of Hall measurements, *J. Electrochem. Soc.* **127**, No. 7, 1640-1643 (July 1980).

Key words: electrical measurements; Hall measurements; semiconductors; silicon.

The temperature dependence of the Hall coefficient is the usual parameter measured to determine dopant energy levels and densities in semiconductors. However, this interpretation of Hall measurements is not necessarily unique. An example of current interest is indium-doped silicon, where a new acceptor level has been reported. It was found that the Hall data for an indium-doped silicon sample could be interpreted in two ways: one including, and the other without, the new level. A donor addition experiment was performed that clearly distinguished between these alternative explanations by supporting the new level interpretation and denying the alternative. It is suggested that donor addition is one example of a variety of techniques that can be used to supplement Hall measurements in order to resolve ambiguities of interpretation.

- 19416.** Kaplan, S. B., Simple-heating-induced Josephson effects in quasiparticle-injected superconducting weak links, *J. Appl. Phys.* **51**, No. 3, 1682-1685 (Mar. 1980).

Key words: controllable weak link; cryoelectronic; Josephson effect; nonequilibrium superconductivity; quasiparticle injection; superconducting tunnel junction; superconducting weak link.

The characteristics of quasiparticle-injected superconducting weak links containing films with short electron mean-free paths have been studied. The behavior of these devices at  $T = 4$  K is shown to be consistent with a spatially localized nonequilibrium state in which the electrons and the crystal lattice are at an elevated temperature  $T^* > T$ .

- 19417.** Larrabee, R. D., Thurber, W. R., Theory and application of a two-layer Hall technique, *IEEE Trans. Electron. Dev.* **ED-27**, No. 1, 32-36 (Jan. 1980).

Key words: epitaxial growth; Hall measurements; indium-doped silicon; p-n junction isolation; two-layer structures.

The electrical characterization of epitaxial layers on substrates of the opposite conductivity type presents serious problems if the p-n junction at the interface has significant leakage current such that it cannot be used to effectively electrically isolate the two regions. In order to meet the need for nondestructively characterizing such structures, a modification of the conventional Hall technique was developed in which the Hall measurements are made simultaneously on both the epitaxial layer and its substrate, the interface impedance is measured, and the interaction between the two regions is modeled and taken into account. This can be used to verify those cases in which the perturbing effects of a high-resistivity substrate are negligible, thus justifying conventional measurements on the epitaxial layer. In principle, it can be used to measure the resistivity and Hall coefficient of each layer separately if the assumptions of the model are realized in practice. The use of this technique is discussed and applied to the case of a thin n-type silicon epitaxial layer on: (1) a conducting substrate of indium-doped silicon that had a significant amount of leakage at the interface p-n junction and (2) a high-resistivity silicon substrate that had negligible influence on the measurement of the Hall coefficient of the epitaxial layer.

- 19418.** Albers, J., Novotny, D. B., Intensity dependence of photochemical reaction rates for photoresists, *J. Electrochem. Soc.* **127**, No. 6, 1400-1403 (June 1980).



Key words: chemical kinetics; exposure; exposure reciprocity; kinetic equations; photochemistry; photon intensity; photoresist exposure; rate constants; saturation effect.

The intensity dependence of photochemical reaction rates, and thus the exposure reciprocity, is investigated in terms of a kinetic model. This model assumes a two-step photochemical reaction and reactions that are first order in the concentrations of each of the various species. The model is applicable to both positive and negative photoresists and is specifically applied to the photoactive species of a typical negative photoresist with the efficiency of the polymer cross-linking assumed constant. The model predicts that there is a saturation effect at high intensities which serves as a rate-limiting step, thus limiting the applicability of exposure reciprocity. Calculations using this model indicate that exposure reciprocity should be obeyed for exposure times of 10  $\mu$ sec or greater.

**19419.** Alvarez, R., Rains, T. C., National Bureau of Standards standard reference materials for quality control of nutrient element determinations in food, *Proc. Nutrient Analysis Symp. 93d Annual Meeting, Washington, DC, Oct. 15-18, 1979*, pp. 86-93 (Association of Official Analytical Chemists, 1111 N. 19th St., Suite 210, Arlington, VA 22209, 1980).

Key words: analytical methods; atomic absorption spectrometry; foods; nutrient elements; quality control; standard reference materials.

Accurate data on the chemical composition of foods are needed to determine the effects of changes in crop culture, animal feeds, and food processing on the nutrient content. In these studies, the data may be acquired over a long-term period by a single investigator or by a number of investigators in different laboratories using various methods and types of instruments. Unless each laboratory uses acceptable quality control procedures, faulty values leading to erroneous conclusions will result. Acceptable procedures require the use of reliable methods and food reference materials with certified concentration values for the nutrients of interest. Standard Reference Materials (SRMs) of food are issued by NBS as part of its SRM program. Examples of these SRMs are: Oyster Tissue (SRM 1566), Wheat Flour (SRM 1567), Rice Flour (SRM 1568), Brewer's Yeast (SRM 1569), Spinach (SRM 1570), and Bovine Liver (SRM 1577). SRMs are used to develop reliable methods and to ensure satisfactory quality control of the data provided by the methods by analyzing the SRMs together with the unknown samples. Agreement of the concentrations obtained for the SRMs with the certified values indicates satisfactory quality control.

**19420.** Alvarez, R., Wolf, W., Mertz, W., Biological reference materials certified for chromium content, (Proc. Symp. on Chromium in Nutrition and Metabolism, Sherbrooke, Canada, July 13-15, 1979), Paper in *Chromium in Nutrition and Metabolism*, D. Shapcott and J. Hubert, Eds., pp. 85-93 (Elsevier/North-Holland Biomedical Press, Amsterdam, The Netherlands, 1979).

Key words: biological matrix; bovine liver; certified reference materials; chromium; foods; interlaboratory study; standard reference materials; yeast.

A biological Standard Reference Material, SRM 1569 Brewer's Yeast, has been certified for chromium content at  $2.12 \pm 0.05 \mu\text{g/g}$  by the National Bureau of Standards. Fourteen laboratories participated in an interlaboratory comparison of analytical results on samples of SRM 1569 using a variety of methods. This study led to several conclusions. In general, the analytical results were either close to the certified value or too low with atomic absorption results showing more variation than those by activation analysis. The main analytical problem appeared to be either losses, or incomplete recovery during sample preparation. During certification of this material, a significant fraction of the  $^{51}\text{Cr}$  content of irradiated samples was volatilized

and trapped during a digestion procedure. A second collaborative study with a different sample of brewers yeast, using various SRMs as a comparator was conducted. The results of this study show much better interlaboratory agreement.

The level of chromium in SRM 1569 is somewhat higher than that found in most foods. The recent certification of chromium level of  $0.088 \pm 0.012 \mu\text{g/g}$  for the previously issued Bovine Liver (SRM 1577) gives a reference material with lower content. The use of these two materials in reporting of analytical data for chromium in biological materials will allow valid comparisons of data between laboratories.

**19421.** Haber, S., Shisha, O., On the location of the intermediate point in Taylor's theorem, (Proc. Second Int. Conf. on General Inequalities, Mathematical Research Institut, Oberwolfach, Black Forest, Germany, July 30-Aug. 5, 1978), Paper in *General Inequalities*, E. F. Beckenbach, Ed., 2, 143-144 (Birkhauser Verlag, Stuttgart, Germany, 1980).

Key words: convexity; derivatives; inequalities; intermediate point; mean-value theorem; Taylor's theorem.

It is here shown that, under suitable conditions, the intermediate point in Taylor's theorem must lie in the left half of the interval considered.

**19422.** Ehrstein, J. R., Spreading resistance calibration for gallium- or aluminum-doped silicon, *J. Electrochem. Soc.* 127, No. 6, 1403-1404 (June 1980).

Key words: aluminum-doped silicon; boron-doped silicon; gallium-doped silicon; p-type silicon; resistivity; silicon; spreading resistance; thyristor.

The spreading resistance technique is a powerful method for measuring local changes of resistivity in silicon starting material and devices. However, to obtain values of absolute resistivity the response of the spreading resistance probes must be calibrated on specimens of known resistivity. The calibration response is known to depend on silicon crystallographic orientation, specimen conductivity type, and surface preparation. It has generally been assumed that there is no additional dependence upon the dopant atom species for either conductivity type, but the validity of the assumption has not previously been demonstrated. This paper reports a test of the assumption for the p-type dopants gallium, aluminum, and boron in the concentration range typical of their use in silicon thyristors. It is concluded that in this concentration range, no additional effect exists due to dopant atom species. Hence, calibration done only on boron-doped silicon should be valid for analyzing measurements on aluminum- or gallium-doped silicon layers.

**19423.** Alvarez, R., NBS plant tissue standard reference materials, (Proc. Symp. on Standardizing Methods for Soil Testing and Plant Analysis, 92d Annual Meeting of the AOAC, Washington, DC, Oct. 16-19, 1978), *J. Assoc. Official Anal. Chem.* 63, No. 4, 806-808 (July 1980).

Key words: agriculture; environmental analysis; foliar analysis; food analysis; nutrition; plant tissue analysis; standard reference material; trace analysis.

NBS issues 6 Standard Reference Materials for use in determining nutrient and contaminant elements in plant tissues and agricultural food products. They are SRM 1571, Orchard Leaves; SRM 1573, Tomato Leaves; SRM 1575, Pine Needles; SRM 1570, Spinach; SRM 1567, Wheat Flour; and SRM 1568, Rice Flour. These SRMs are used to calibrate instrumentation, to determine accuracy of existing analytical methods, and to develop more accurate methods. The Certificate of Analysis for each SRM details the homogeneity of the powdered material, the minimum sample size to be used, the certified values for the elements with their uncertainties, and the noncertified values. A certified value is based either on concordant results by 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.

- 19424.** Martinez, R. I., Herron, J. T., **Excited-neutral-metastable  $\text{SO}_2$  formation in the  $\text{O}_3\text{-CH}_2\text{CH}_2\text{S}$ ,  $\text{O}_3\text{-olefin-}\text{SO}_2$ , and active nitrogen- $\text{SO}_2$  systems**, *Chem. Phys. Lett.* **72**, No. 1, 77-82 (May 15, 1980).

Key words: active nitrogen; metastable; olefin; ozone;  $\text{SO}_2$ ; thiirane.

Long-lived ( $\tau > 10^{-3}$  s), electronically-excited ( $E^* > 4$  eV) neutral metastables, whose formation was attributed to the presence of  $\text{SO}_2$ , were observed in the three titled systems. Their possible identity as collisionally-accessed metastable states of the normal ( $\text{O}^{\text{S}}\text{O}$ ), cyclic ( $\text{O}^{\text{S}}\text{O}$ ), or superoxide ( $\text{S}^{\text{O}}\text{O}$ ) isomers of  $\text{SO}_2$  is discussed.

- 19425.** Buehler, M. G., **The d-c MOSFET dopant profile method**, *J. Electrochem. Soc.* **127**, No. 3, 701-704 (Mar. 1980).

Key words: d-c MOSFET dopant profile method; dopant profile method; MOSFET, d-c.

Dopant profiles can be determined from d-c measurements on a four-terminal surface-channel MOSFET. The region from about three Debye lengths from the oxide-silicon interface to a maximum depth, limited by the avalanche breakdown in silicon, can be profiled by this method. Within three Debye lengths of the surface, the depletion approximation fails, and in this region the profile has a characteristic dip which is easily recognized. Other limitations include effects due to the field dependence of the channel mobility, short channel effects, and the lack of parallelism of the depletion edge with the interface. The method is illustrated by dopant profiles of bulk wafers, implanted layers, and a diffused layer. The dopant densities covered by these profiles vary from  $6 \times 10^{14} \text{ cm}^{-3}$  to  $2 \times 10^{18} \text{ cm}^{-3}$ .

- 19426.** McCrackin, F. L., Wagner, H. L., **Measurement of polydispersity of narrow fractions and column spreading parameters by recycle liquid size exclusion chromatography**, *Macromol.* **13**, No. 3, 685-690 (May-June 1980).

Key words: anionic polystyrenes; column spreading; GPC; liquid size exclusion chromatography; narrow fractions; polydispersity; recycle GPC; recycle liquid size chromatography.

A method has been developed, employing recycle size exclusion chromatography (GPC), to separate instrumental spreading from spreading due to the molecular weight distribution of the polymer. This is particularly important for polymers with small  $M_w/M_n$  values, such as the anionic polystyrenes, where instrumental spreading accounts for a large fraction of the total spreading. Because of interferences with the base line from impurities, a novel technique for treating the data was employed to minimize the effect of base line irregularities. The analysis separated the components of instrumental spreading into spreading due to the sample injection,  $\sigma_i$ , to the columns,  $\sigma_c$ , and to the pump and additional tubing needed for recycling,  $\sigma_p$ . A total of six anionic polystyrenes, including two Standard Reference Materials, SRM 705 and 1478, ranging in molecular weight from 9000 to 390 000 were analyzed in toluene and four in THF to give  $M_w/M_n$  values of 1.003-1.05. The value of  $\sigma_c$  increases with increasing molecular weight. In previous treatments of recycling,  $\sigma_i$  and  $\sigma_p$  were neglected, leading to less accurate values of  $M_w/M_n$  and  $\sigma_c$ .

- 19427.** Martinez, R. I., Herron, J. T., **Stopped-flow study of the gas-phase reactions of ozone with organic sulfides: Thiirane**, *Chem. Phys. Lett.* **72**, No. 1, 74-76 (May 15, 1980).

Key words: gas; kinetics; ozone; stopped-flow; sulfur dioxide; thiirane.

The autocatalytic reaction of ozone with thiirane has been studied at 296 K and 1.1 kPa (8 Torr). The specific rate of primary attack of ozone on thiirane is immeasurably slow ( $k < 10^4 \text{ cm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ ). The major products observed are  $\text{C}_2\text{H}_4$ ,  $\text{SO}_2$ ,  $\text{H}_2\text{CO}$  and  $\text{CO}_2$ . A free-radical chain mechanism is suggested to account for these observations.

- 19428.** Myers, D. R., Wilson, R. G., **Alignment effects on implantation profiles in silicon**, *Rad. Effects* **47**, 91-94 (1980).

Key words: capacitance-voltage profiling; controlled doping profile; critical channeling angle; crystallographic orientation effects; ion channeling; random equivalent implants.

Ion implantation is commonly used for the fabrication of fine geometry semiconductor devices. The need for shallower active layers in these devices requires that the extent of ion channeling be minimized to reduce the formation of deeply penetrating tails in the dopant distribution. In this paper, ion channeling in silicon is experimentally examined for a range of ion atomic numbers and implant energies characteristic of semiconductor device fabrication. Implantation profiles were obtained by 1 MHz differential capacitance-voltage (C-V) profiling for silicon substrates implanted at angles from accurately channeled alignment to "random equivalent" orientation. The critical angle for channeling, as calculated from an existing computer fit to the Moliere continuum potential, was used to scale the angular dependence of the implantation profiles. The results of this study indicate that to minimize the extent of unintentional channeling, alignment of the ion beam to the nearest low-index crystallographic direction must be at angles exceeding twice the critical angle.

- 19429.** Myers, D. R., Koyama, R. Y., Phillips, W. E., **An implantation predeposition technique for the introduction of deep-level chemical impurities**, *Rad. Effects* **48**, 145-150 (1980).

Key words: chemical impurities; deep level studies; ion implantation; predeposition technique; sulfur impurities in silicon; thermally-stimulated measurements.

The characterization of deep-level chemical impurity centers in semiconductors requires the controlled introduction of known impurities. A technique is described which employs ion implantation as a predeposition step for the introduction of deep-level chemical impurities into silicon, yet prevents implantation-related damage from interfering with the measured deep-level response of the implanted species. The utility and versatility of this method are demonstrated by its application to the characterization of sulfur defect centers in silicon.

- 19430.** Wineland, D. J., **Limitations on long-term stability and accuracy in atomic clocks**, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ.* **2129**, pp. 81-110 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

Key words: atomic clocks; atomic frequency standards; frequency metrology; frequency standards; high resolution spectroscopy; time metrology; time standards.

The limits to accuracy and long-term stability in present atomic clocks are examined. In order to achieve a significant increase in performance, it appears that the limitations must be attacked on a fundamental level. For instance, the problem of residual first-order and second-order Doppler shifts has for many years been approached by asking how we can better measure these shifts. A more fundamental approach might be to ask how we can significantly lower the velocity of the atoms.

An attempt will be made to put recent proposals for new frequency standards into perspective. The advantages and disadvantages of frequency standards based on such ideas as laser



transitions, single atoms, and atom cooling are examined. In addition, the applicability of some of these new techniques to existing standards is discussed.

- 19431.** Thurber, W. R., **A comparison of measurement techniques for determining phosphorus densities in semiconductor silicon**, *J. Electron. Mater.* 9, No. 3, 551-560 (Mar. 1980).

**Key words:** Hall effect; junction C-V measurements; neutron activation analysis; phosphorus density; photometric technique; silicon.

Phosphorus densities in semiconductor silicon slices cut from 14 single crystal ingots have been determined by two electrical and two analytical techniques. Hall effect measurements were made on specimens from all ingots, and junction capacitance-voltage measurements were made on specimens with densities up to about  $5 \times 10^{17} \text{ cm}^{-3}$ . Neutron activation analysis was used to measure phosphorus densities from  $5 \times 10^{15}$  to  $5 \times 10^{19} \text{ cm}^{-3}$ , and a photometric technique was used for densities greater than  $10^{17} \text{ cm}^{-3}$ . A systematic discrepancy of about 15% between the photometric and neutron activation data is indicative of the interlaboratory agreement that might be realized in practice with these techniques.

- 19432.** Walls, F. L., **Prospects for advances in microwave atomic frequency standards**, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ. 2129*, pp. 619-640 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

**Key words:** cesium atomic resonator; frequency retrace accuracy; frequency stability; passive/active hydrogen atomic resonator; rubidium atomic resonator; stored ions.

This paper will focus on conceptual and component developments which could have a major impact on the performance of microwave atomic frequency standards. Traditional microwave standards based on rubidium, cesium and hydrogen have been greatly refined over the past decade, such that the frequency stability of the current generation of devices is generally limited by the basic concepts on which they are based, as well as the performance of various key subsystems. Future advances in ultimate frequency stability and environmental performance will primarily come from new conceptual developments, and only secondarily from improved components. These new advances will be explored in some detail and projections for possible performance improvements made for microwave frequency standards based on rubidium, cesium and hydrogen. Brief mention of a new class of standards based on stored ions will be made.

- 19433.** Hardgrave, W. T., **Ambiguity in processing Boolean queries on TDMS tree structures: A study of four different philosophies**, *IEEE Trans. Software Eng.* SE-6, No. 4, 357-372 (July 1980).

**Key words:** ambiguity; Boolean; database; hierarchical; information; query; query language; semantics; TDMS; tree; tree structures.

This paper defines and demonstrates four philosophies for processing queries on tree structures; shows that the data semantics of queries should be described by designating sets of nodes from which values for attributes may be returned to the data consumer; shows that the data semantics of database processing can be specified totally independent of any machine, file structure, or implementation; shows that set theory is a natural and effective vehicle for analyzing the semantics of queries on tree structures; and finally, shows that Bolts is an adequate formalism for conveying the semantics of tree structure processing.

- 19434.** Newbury, D. E., Myklebust, R. L., Heinrich, K. F. J., Fiori, C. E., **Specialist workshop on energy dispersive x-ray spectrometry National Bureau of Standards—Apr. 23-25, 1979**, *Scanning* 3, No. 1, 43-45 (1980).

**Key words:** electron probe microanalysis; energy dispersive x-ray spectrometry; solid state x-ray detectors; x-ray fluorescence; x-ray microanalysis; x-ray spectrometry.

A specialist workshop to discuss the state-of-the-art of energy dispersive x-ray spectrometry was held at the National Bureau of Standards, April 23-25, 1979, topics considered included advances in 1) measuring the properties of solid state energy dispersive x-ray detectors, 2) windowless x-ray detectors, 3) electronics for energy dispersive spectrometers, 4) spectral processing techniques, 5) quantitative x-ray microanalysis, 6) artifacts in electron-excited energy dispersive spectra, and 7) applications to x-ray fluorescence.

- 19435.** Sawyer, D. E., Kessler, H. K., **Laser scanning of solar cells for the display of cell operating characteristics and detection of cell defects**, *IEEE Trans. Electron. Dev.* ED-27, No. 4, 864-872 (Apr. 1980).

**Key words:** cell cracks; device measurements; laser scanning; light biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cells.

A new optical scanning technique was developed to map solar-cell operation over the cell area and reveal several types of cell defects. The technique, which makes use of the distributed nature of the cell, an intrinsic property shared by all cells, allows one to detect potentially harmful cracks with a sensitivity greater than any other optical technique reported previously, and it permits one, for the first time, to locate regions of poor metallization. It has also been used to determine efficacy of cell design and to study cell degradation processes. The new scanning technique employs forward biasing of the cell during scanning. Biasing may be achieved through the use of a steady-state light source, or for cells made using conventional semiconductor materials, e.g., silicon and gallium arsenide, the use of an external current source. The scanning technique is nondamaging; it requires no electrical contacts to the cell other than those already present, and it can be used on encapsulated or unencapsulated cells in almost any laboratory or test environment.

- 19436.** Yee, K. W., Stokesberry, D. P., **A method for predicting product life**, *Appliance* 37, No. 8, 45-48 (Aug. 1980).

**Key words:** life distribution; life testing; product life; product use; useful life.

A method is proposed for predicting product life in actual use based upon a laboratory operating life test result and a use distribution determined from field survey. The predicted life is based on a mathematical combination of the measured laboratory life distribution and the field use distribution. The technique is particularly applicable to products which exhibit wear out failures which are dependent on the amount of use and the use is intermittent.

The results from a demonstration of the method are presented. A small motorized product was used in a laboratory life test and a field survey to determine use. Significant differences were found in predicted life for several models of the same product. Values of estimated life, defined as the time for a selected percentage of failures in the field, may be very different if based on the joint distributions rather than on average laboratory life and average use.

- 19437.** Rakowsky, G., Hughey, L. R., **SURF's up at NBS: A progress report**, *IEEE Trans. Nucl. Sci.* NS-26, No. 3, 3845-3847 (June 1979).

**Key words:** beam instabilities; beam lifetime; bunch shape oscillations; electron storage ring; particle accelerator; synchrotron light source.



The NBS Synchrotron UV Radiation Facility (SURF-II) is a 250 MeV single-magnet, weak-focusing electron storage ring, with 10 MeV microtron injector. Circulating beams of up to 35 mA at energies up to 250 MeV have been achieved. Beam lifetime, limited by Touschek effect, is extended to several hours by resonant vertical rf excitation. At low energies bunch shape oscillations occur, involving coherent synchrotron oscillations, negative-mass-type blowup and loss of beam. Effective avoidance and suppression techniques are discussed. A new set of high current gradient correction coils and power supplies, plus additional pancakes for the main field coils are being obtained. These are expected to extend SURF operation to 280 MeV and provide useful light output to 0.4 keV photon energies.

**19438.** Wollin, H. F., **Training in legal metrology**, (Proc. 1979 Annual Conf. Education and Training Workshop, Boulder, CO, Oct. 15-17, 1979), *NCSL Newslett.* **20**, No. 1, 23-25 (Mar. 1980).

Key words: inspectors; laboratory; metrology; seminars; State/local; training.

NBS provides technical training to State and local regulatory officials and laboratory metrologists in the field of legal metrology. Such training is offered on a regular basis to develop and improve the professional skills of those who request the service.

The training program is structured to be sensitive to the differing educational background of officials, their levels of experience and specialization of activities. Instruction is offered on the classroom, laboratory, and field and includes seminars for inspectors, metrologists, supervisors, and administrators.

**19439.** Stein, S. R., **Impact of improved clocks and oscillators on communications and navigation systems**, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ.* **2129**, pp. 31-36 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

Key words: atomic clocks; communications; navigation; precise time; precision oscillators.

This paper discusses the results of a Workshop which addressed the role of clocks and oscillators in large scale systems, particularly communications and navigation. The ultimate purpose of this Workshop was to do two things: first, to provide research and development people in government, at universities and in companies with adequate information to appropriately direct their research activities towards the real needs for clock and oscillator improvements; second, to determine whether or not there are any ways in which existing oscillators and clocks could serve systems better than they are doing now. For military systems in particular and in many cases for civilian systems, there are reasons to obtain timing information using precise clocks or oscillators. Low error rate in digital communications, anti-jam characteristics and fast signal acquisition all require very precise timing information. Survivability and independence depend upon *a priori* knowledge that comes from having precision clocks in the system and that is not available to unauthorized persons. Independent operation of system elements protects the system from human error and various disasters. Two basic mechanisms have been suggested for achieving improved systems; better clocks and system redesign could lead to improved performance or different operational procedures and system redesign could lead to relaxed clock dependence. The conclusion reached as a result of the Workshop is that the real deficiency from which we suffer today is a lack of effective and efficient utilization of existing resources.

**19440.** Wineland, D. J., Bergquist, J. C., Itano, W. M., Drullinger, R. E., **Double-resonance and optical-pumping experiments on electromagnetically confined, laser-cooled ions**, *Opt. Lett.* **5**, No. 6, 245-247 (June 1980).

Key words: atomic spectroscopy; double resonance; high-resolution spectroscopy; laser cooling; laser spectroscopy; microwave spectroscopy; optical pumping; stored ions.

Experiments illustrating advantages and unique features of double-resonance and optical pumping on electromagnetically confined, laser-cooled ions are discussed. In certain cases, scattered light from the cooling transition can be used as a monitor in double-resonance experiments to give nearly 100% detection efficiency. Nonradiative relaxation rates are extremely small for stored ions, permitting nearly complete optical pumping, even in extremely weak pumping schemes.

**19441.** Smith, R. K., Danos, M., **An intranuclear cascade description of relativistic heavy-ion collisions**, *Proc. Topical Conf. on Heavy Ion Collisions, Fall Creek Falls State Park, Pikeville, TN, June 13-17, 1977*, *CONF-770602*, pp. 363-380 (Oak Ridge National Laboratory, Oak Ridge, TN, Oct. 1977).

Key words: cascade calculations; heavy ion collision; Monte Carlo method; nuclear compressibility; nuclear shock waves; relativistic field theory.

The principles of the description of heavy ion collisions on the basis of relativistic quantum field theory are given. The results on single particle cross sections are present; also the detailed histories of the collision process are discussed.

**19442.** Simmons, J. H., Franklin, A. D., Young, K. F., Linzer, M., **Internal friction and sodium transport in beta alumina**, *J. Am. Ceram. Soc.* **63**, No. 1-2, 78-83 (Jan.-Feb. 1980).

Key words: sodium beta alumina; internal friction; ionic transport mechanism; sodium ion; single crystal; interstitials.

Internal friction peaks near 100 K were observed for melt-grown single-crystal sodium  $\beta$ -alumina with a  $< 110 >$  stress at 12 and 16 kHz. These data, combined with those of Barmatz and Farrow, produced limiting values for the activation energy and preexponential factor for the relaxation time, viz. 20 kJ/mol and  $5.6 \times 10^{-16}$  s and 23 kJ/mol and  $7.4 \times 10^{-18}$  s. Split-interstitial  $\text{Na}^+$  ions on mid-oxygen sites could produce these peaks, but not simple interstitials on anti-Beevers-Ross sites. A relaxation mode calculation is given for the relaxation frequency in the internal friction experiment and for the electrical conductivity in the conducting plane for the split interstitial model.

**19443.** Bujarrabal, V., Guibert, J., Rieu, N. Q., Omont, A., **OH pumping by IR line overlap. Application to circumstellar masers**, *Astron. Astrophys.* **84**, 311-316 (1980).

Key words: line overlap; Mira variables; OH maser.

We analyse the pumping of 18 cm OH masers by the overlap of far infrared lines in an expanding or collapsing medium, with a particular reference to circumstellar envelopes. The IR intensity absorbed in one far IR line is strongly perturbed by Doppler shifted absorption or emission of another IR line at other points in the envelope. Strong 18 cm inversions can result. We present a detailed model taking into account the great number of relevant overlaps. Main line intensities of circumstellar masers are easily accounted for, and the emission of the 1612 MHz line is also enhanced by the overlap effects. The pumping by far IR line overlap due to a large scale velocity field is probably more effective by an order of magnitude than all the other pumping mechanisms so far suggested for circumstellar main line masers.

**19444.** Chiang, C. K., Dragoo, A. L., Franklin, A. D., **Slow transient phenomenon in Y-doped  $\text{CeO}_2$** , *Proc. Int. Conf. on Fast Ion Transport in Solids, Electrodes and Electrolytes, Lake Geneva, WI, May 21-25, 1979*, pp. 661-663 (Elsevier North Holland, Inc., Amsterdam, The Netherlands, 1979).

Key words:  $\text{CeO}_2$ ; conducting ceramic; conductivity; diffusion; oxygen conductor; slow transient effect; transport; Y-doped  $\text{CeO}_2$ .



Four-probe dc conductivity measurements on some ceramic Y-doped  $\text{CeO}_2$  specimens exhibit a slow transient voltage under constant current conditions. This transient has the characteristics of a diffusion-controlled process, with diffusion coefficients typical of solid state transport. The most probable mechanism appears to involve some form of diffusion of neutral oxygen atoms.

**19445.** Burch, D. M., Luna, D. E., **A mathematical model for predicting attic ventilation rates required for preventing condensation on roof sheathing**, (Proc. ASHRAE Semiannual Meeting, Los Angeles, CA, Feb. 1980), *ASHRAE Trans.* **86**, Pt. 1, 201-220 (1980).

**Key words:** attic condensation; attic ventilation; moisture control in attics.

A mathematical model for predicting the heat transfer and moisture-transfer processes in residential attic spaces is presented. This model is utilized to predict attic ventilation rates required for preventing condensation or frost accumulation on the underside of roof sheathing. Attic ventilation charts are developed converting a wide range of outdoor temperatures, ceiling thermal resistances, and ceiling air penetration rates. The effectiveness of a ceiling vapor barrier is investigated. The effect of indoor humidification on the required attic ventilation rate is examined. Using measured data of Hinrichs, attic ventilation rates predicted by the mathematical model are converted into net free ventilation areas for soffit venting. These values are subsequently compared with the attic ventilation requirements of ASHRAE and the HUD Minimum Property Standards.

**19446.** Clark, F. O., Lovas, F. J., Johnson, D. R., **Dimethyl ether in Orion**, *Astrophys. J.* **229**, 553-559 (Apr. 15, 1979).

**Key words:** astrophysics; dimethyl ether; interstellar microwave spectra; Orion Nebula.

Seven new dimethyl ether transitions have been observed in emission from the direction of the Orion Nebula. Dimethyl ether has also been detected in Sgr B2 in weak emission from two rotational transitions. The observed high-resolution spectra from several of the Orion transitions exhibit well-resolved splittings due to internal motions in the molecule. All of the Orion signals are quite narrow ( $\langle \Delta V \rangle \approx 2.3 \text{ km s}^{-1}$ ) and centered near  $\langle V_{\text{LSR}} \rangle = 6.6 \text{ km s}^{-1}$ . Laboratory measurements of the rest frequencies of these same transitions are presented, along with the calculated relative intensities of the internal rotor split components.

**19447.** Lovas, F. J., Suenram, R. D., Johnson, D. R., Clark, F. O., Tiemann, E., **Pyrolysis of ethylamine. II. Synthesis and microwave spectrum of ethylidenimine ( $\text{CH}_3\text{CH}=\text{NH}$ )**, *J. Chem. Phys.* **72**, No. 9, 4964-4972 (May 1, 1980).

**Key words:** ethylidenimine; hyperfine and internal rotations; microwave spectra; pyrolysis of ethylamine; Stark effects; synthesis and microwave spectrum of.

Microwave rotational spectra assignable to gas phase *cis*- and *trans*-ethylidenimine ( $\text{CH}_3\text{CH}=\text{NH}$ ) have been detected in the pyrolysis decomposition products from several alkylamines and from the ring trimer,  $(\text{CH}_3\text{CHNH})_3$ . Stark effects, hyperfine and internal rotation splittings have aided the assignment of the observed spectra and allowed the determination of rotational distortion constants,  $^{14}\text{N}$  nuclear electric quadrupole coupling constants, internal rotation barriers, and electric dipole moments. Limited structural information was also obtained.

**19448.** Fong, J. T., **Fatigue research**, *Stand. News* **8**, No. 2, 11-14 (Feb. 1980).

**Key words:** composite materials; corrosion fatigue; durability; fatigue; fatigue mechanism; fatigue research; fracture mechanics; mathematical modeling; metals fatigue; plastics

fatigue; quantitative microscopy; statistical aspects of fatigue.

As a forum for exchanging facts and opinions on the fatigue properties of structural components and systems, subcommittee E9:01 is unique among its peers in ASTM for three specific reasons: (1) The subcommittee is charged not to draft any standards for fatigue testing, but rather to provide an active program of *research support* to other E9 subcommittees which do write standards. (2) The subcommittee is required to provide *research leadership* in the subject of fatigue which is multi-disciplinary. (3) The subcommittee actively seeks an *international constituency* through the sponsorship of conferences, newsletters, and technical visits. Following an introduction of the goals and the organization of the subcommittee, a detailed description of the recent international symposium on fatigue mechanisms (Kansas City, May 1978) is given to illustrate the characteristics and the strength of the subcommittee. A summary of three special activities and some future plans of the subcommittee involving not only members of E9 but also those of other ASTM committees is presented.

**19449.** Kanda, M., **Analytical and numerical techniques for analyzing an electrically short dipole with a nonlinear load**, *IEEE Trans. Antennas Propag.* **AP-28**, No. 1, 71-78 (Jan. 1980).

**Key words:** Auger function; electrically-short dipole; iteration method; nonlinear differential equation; nonlinear load; time-stepping finite difference equation technique.

An electrically short dipole with a nonlinear dipole load is analyzed theoretically using both analytical and numerical techniques. The analytical solution is given in terms of the Auger function of imaginary order and imaginary argument and is derived from the nonlinear differential equation for the Thévenin's equivalent circuit of a dipole with a diode. The numerical technique is to solve the nodal equation using a time-stepping finite difference equation method. The nonlinear resistance of the diode is treated using the Newton-Raphson iteration technique. A comparison between the analytical and numerical solutions is given.

**19450.** Wheeler, J. C., **Stars with anomalous mass: Is there funny business in the main sequence?**, *Comments on Astrophys.* **8**, No. 5, 133-148 (1979).

**Key words:** blue stragglers; stars; stellar evolution; supernovae.

Throughout the subject of stellar astronomy there are examples of stars whose masses are anomalously high and hence their implied main-sequence lifetimes anomalously short compared to other measures of lifetime. The other factors determining times scales are varied: cluster turnoffs, extragalactic stellar populations, galactic kinematics and metal abundance. Several explanations are frequently proposed to account for these anomalies: delayed star formation, binary mass transfer and post-main-sequence evolutionary contortions. The purpose of this Comment is to review the examples of anomalous-mass stars (AMS) in order to remind the reader that they are a ubiquitous phenomenon. In addition, the possible explanations of the various classes of anomalous stars will be explored to see if a common phenomenon might be at work.

**19451.** Streed, E. R., Waksman, D., **NBS solar collector durability/reliability program**, (Proc. 1st Int. Conf. on Durability of Building Materials and Components, Ottawa, Canada, Aug. 21-23, 1978), Paper in *Durability of Building Materials and Components*, P. J. Sereda and G. G. Litvan, Eds., pp. 219-242 (American Society for Testing and Materials, Philadelphia, PA, 1978).

**Key words:** durability/reliability; environmental degradation; materials degradation; solar collector.



There is evidence that significant deterioration in solar collectors used for residential and commercial building applications can occur as a result of exposure to environmental conditions. This problem indicates the need for validated testing and evaluation procedures that can be used to assess the deterioration of solar collectors and their associated materials. A program is being undertaken at the National Bureau of Standards (funded by the Department of Energy) to develop meaningful collector durability/reliability tests. Both laboratory and outdoor field exposure tests will be performed on collectors and collector materials. These tests will take into account the deterioration that can occur at the collector level as a result of exposure to stagnation conditions, thermal shock, moisture, wind, and snow loads, etc. Materials tests in the laboratory or field include ultraviolet (UV) degradation, thermal degradation, and moisture resistance. Correlations will be made between actual and simulated degradation for both collectors and their materials.

- 19452.** Petersen, F. R., Scalabrin, A., Evenson, K. M., **Frequencies of cw FIR laser lines from optically pumped  $\text{CH}_2\text{F}_2$** , *Int. J. Infrar. Millimeter Waves* **1**, No. 1, 111-115 (1980).

Key words:  $\text{CH}_2\text{F}_2$ ; difluoromethane; FIR frequency synthesis; laser frequency measurement; optically pumped FIR laser; stabilized  $\text{CO}_2$  lasers.

The frequencies of 48 optically pumped cw FIR  $\text{CH}_2\text{F}_2$  laser lines have been measured relative to stabilized  $\text{CO}_2$  lasers. Uncertainties are estimated to be about 5 parts in  $10^7$ .

- 19453.** Schumann, L., Wildman, D., Gallagher, A., **Emission of Mg-Xe discharge and the MgXe excimer band**, *J. Chem. Phys.* **72**, No. 11, 6081-6084 (June 1, 1980).

Key words: discharge; excimer; magnesium.

The emission intensities and excited-state densities of a Mg-doped high-pressure Xe discharge are reported. The normalized emission of the MgXe excimer band associated with the  $\text{Mg } 3^1P_1\text{-}3^1S_0$  resonance transition is obtained from the data, as well as a 320-380 nm band attributed to  $\text{XeMg}^+$ . The  $\text{Mg}_2$  A-X band is not seen in emission under any discharge conditions in Mg doped Xe or Ne. This Mg-Xe mixture does not appear to be a reasonable candidate for a discharge-excited excimer laser due to the large excitation energies associated with the Mg and  $\text{Mg}^+$  resonance transitions.

- 19454.** Wallerstein, G., Fawley, W. M., **Additional radial velocities of maser stars and related M supergiants**, *Publ. Astron. Soc. Pac.* **92**, No. 546, 183-187 (Apr. 1980).

Key words: late supergiants; maser stars; radial velocities.

New radial-velocity data for late supergiants with maser emission, long-period variable maser stars, and similar nonmaser stars are presented. For VY CMa, we make use of 20 years of data to show that a correlation exists between the measured radial velocity and the spectral resolution. The correlation may be explained by reflection of starlight from moving dust in agreement with the line-profile calculations of van Blerkom and van Blerkom (1978). For the long-period variables, radial velocities of the K1 resonance lines on  $4 \text{ Å mm}^{-1}$  spectrograms strengthen the correlation between the circumstellar absorption lines and the violet edge of the thermal microwave emission.

- 19455.** Hudson, R. P., **Measurement of temperature**, *Rev. Sci. Instrum.* **51**, No. 7, 871-881 (July 1980).

Key words: temperature; thermometry.

A general review of thermometry is presented. Topics covered include the concept of temperature and temperature scales; the International Practical Temperature Scale (IPTS); the roles played by the Advisory Committee on Thermometry and its parent International Committee on Weights and Measures; anticipated improvements in an extension of the IPTS; recent

advances in primary thermometry; and current developments of practice (including fixed points and interpolation devices, and practical temperature measurements at the secondary level).

- 19456.** Snow, T. P., Jr., Linsky, J. L., **Ultraviolet spectroscopy of the outer layers of stars**, *Astrophys. Space Sci.* **67**, No. 2, 285-307 (1980).

Key words: space astrophysics; stellar atmospheres; stellar chromospheres; stellar coronae; stellar winds; ultraviolet spectroscopy.

This chapter summarizes our present understanding of the outer layers of stars, specifically addressing questions of the physical structures, models, winds, mass loss, chromospheres, and coronae. For both hot and cool stars, ground-based visual spectroscopic measurements and ultraviolet spectroscopy from space experiments are reviewed and compared with theory. With this background, we propose new spectroscopic measurements in the ultraviolet for the space shuttle era, which will address and perhaps resolve important questions concerning the outer layers of stars.

- 19457.** Wildman, D. W., Schumann, L. W., Gallagher, A. C., **Na  $3^2P\text{-}3^2D$  line broadening by Ne, Ar, and Xe**, *J. Quant. Spectrosc. Radiat. Transfer* **24**, No. 1, 19-23 (1980).

Key words: line broadening; sodium.

The normalized emission intensity in the wings of the optically thin Na  $3^2P\text{-}3^2D$  lines broadened by Ne, Ar, and Xe has been measured in emission from a high-pressure discharge. A blended satellite occurs about  $80 \text{ cm}^{-1}$  into the Na-Xe red wing and a progression of increasing red wing intensity from Ne to Ar to Xe is observed. Xe densities of  $2.5$  and  $9.1 \times 10^{19} \text{ cm}^{-3}$  were used, and the pressure dependence of the NaXe line shape indicates that multiple perturber interactions are important in the far wing at the higher noble gas densities.

- 19458.** Franzen, D. L., Day, G. W., **Limitations imposed by material dispersion on the measurement of optical fiber bandwidth with laser diode sources**, *J. Opt. Soc. Am.* **69**, No. 10, p. 1448 (Oct. 11, 1979).

Key words: bandwidth; laser diodes; material dispersion; optical fibers.

Several single heterojunction (SHJ) laser diodes commonly used for the time domain measurement of optical fiber bandwidth (0.8-0.9 micrometers) were evaluated to determine the material dispersion contribution to measured bandwidth.

- 19459.** Fanney, A. H., Liu, S. T., **Comparison of experimental and computer-predicted performance for six solar domestic hot water systems**, (Proc. Symp. on Solar Hot Water Systems, Los Angeles, CA, Feb. 3-7, 1980), *ASHRAE Trans.* **86**, Pt. 1, 823-835 (1980).

Key words: computer; energy; heat transfer; hot water; measurement; modeling; solar; testing.

Currently three computer programs, TRNSYS, f-CHART, and SOLCOST, are being extensively used for the design and evaluation of solar space heating and domestic hot water systems. Although widely used, the accuracy of their predictions needs to be verified with experimental data. In order to provide data required for the validation of these computer programs for solar domestic hot water systems, the staff of the National Bureau of Standards fabricated and instrumented six typical systems at its Gaithersburg, Maryland site. The systems have been operating since June, 1978. This paper describes the testing done, the experimental results, and compares the experimental results with the computer predictions for the first twelve months of operation.



19460. Scalabrin, A., Petersen, F. R., Evenson, K. M., Jennings, D. A., **Optically pumped cw CH<sub>2</sub>DOH FIR laser: New lines and frequency measurements**, *Int. J. Infrared. Millimeter Waves* 1, No. 1, 117-126 (1980).

Key words: CH<sub>2</sub>DOH; CO<sub>2</sub> laser; FIR laser; laser frequency measurement; new laser lines; relative intensity; relative polarization.

We have measured the output powers and relative polarizations of 66 cw FIR laser lines from CH<sub>2</sub>DOH (including 50 not previously reported), which were optically pumped by a CO<sub>2</sub> laser. The frequencies of 43 of these lines were measured relative to stabilized CO<sub>2</sub> lasers.

19461. Day, G. W., Chamberlain, G. E., **Results of a recent attenuation measurement comparison among U.S. Optical Waveguide Manufacturers**, *Proc. 5th European Conf. on Optical Communication, Amsterdam, The Netherlands, Sept. 17-19, 1979*, pp. 19.4-1—19.4-4 (International Congress Centre RAI Europaplein 8, Amsterdam, The Netherlands, 1979).

Key words: attenuation; fiber optics; interlaboratory comparisons; measurements; optical communications; quality control.

In this paper we report the results of a fiber attenuation measurement comparison among U.S. manufacturers in which each laboratory used methods close to those it normally uses in quality control. The data suggest the uncertainties that should presently be applied when similar products of different manufacturers are compared. The study also demonstrates clearly the need for standard measurement procedures and provides a reference from which they can be judged.

19462. Bouloy, D., Omont, A., **Transitions in  $\Lambda$ -doublets of molecules induced by collisions with ions. II.**, *Astron. Astrophys. Suppl.* 38, No. 1, 101-118 (1979).

Key words: calculations; ion-molecule collision;  $J$ -dependence; transitions;  $\Lambda$ -doublets.

The results of a preceding paper are extended to other values of  $J$  and thoroughly discussed. The different multipolar relaxation rates due to ions inside  $\Lambda$ -doublets are calculated exactly by a semi-classical solution of the close-coupled collision equations. The  $J$ -dependence of the results is analyzed. A detailed discussion is given of the conditions of validity of the model, and of the possible importance of deviations from straight line trajectory and of rotational excitation by ions. In order to compare neutral and charged particle rates, rough estimates are given of  $\Lambda$ -doublet rates for neutral particles in the interstellar medium and in the atmospheres of comets. Both rates are comparable when the ionization rate is  $\sim 10^{-5}$  in the interstellar medium, and  $\sim 10^{-4}$  in comets.

19463. Tolliver, D. E., Kyrala, G. A., Wing, W. H., **Observation of the infrared spectrum of the helium-hydride molecular ion  $^4\text{HeH}^+$** , *Phys. Rev. Lett.* 43, No. 23, 1719-1722 (Dec. 3, 1979).

Key words: HeH<sup>+</sup>; infrared spectra; ion beams; laser spectroscopy; molecular spectroscopy.

We have made the first observation of the vibrational-rotational spectrum of the electronic ground state of the helium-hydride molecular ion  $^4\text{HeH}^+$ . The Doppler-tuned ion-beam laser-spectroscopic technique was used. The frequencies of five transitions between 1700 and 1900 cm<sup>-1</sup> have been measured to  $\pm 0.002$  cm<sup>-1</sup> ( $\pm 1$  ppm). The experimental values deviate from current theory by typically 0.2 cm<sup>-1</sup>, and are two orders of magnitude more precise than the theoretical values.

19464. Kanda, M., **Transients in a resistively loaded linear antenna compared with those in a conical antenna and a TEM horn**, *IEEE Trans. Antennas Propag.* AP-28, No. 1, 132-136 (Jan. 1980).

Key words: conical antenna; effective length; FFT; moment method; resistively loaded antenna; TEM horn; time domain measurement; transient response.

The receiving and transmitting transient responses of the resistively loaded linear antenna, the TEM horn, and the conical antenna are investigated theoretically and experimentally using the fast Fourier transform (FFT) technique. The receiving transient response of the resistively loaded linear antenna indicates that the shape of a 70-ps impulse is well preserved.

19465. Rabin, Y., Berman, M., Ben-Reuven, A., **Theory of the double resonance Raman amplifier**, *J. Phys. B* 13, 2127-2136 (1980).

Key words: double resonance; stimulated Raman scattering.

A model is presented for steady-state three-level resonance Raman amplification, based on an algebraic expression for single-molecule amplification (including independently variable relaxation rates) with arbitrarily strong radiative couplings, combined with a numerical solution of non-linear equations governing macroscopic collinear propagation.

19466. Kanda, M., **The time-domain characteristics of a traveling-wave linear antenna with linear and nonlinear parallel loads**, *IEEE Trans. Antennas Propag.* AP-28, No. 2, 267-276 (Mar. 1980).

Key words: fast Fourier transform; linear load; Newton-Raphson iteration method; nonlinear load; time-domain measurements; time-stepping finite-difference technique; transient; traveling-wave antenna.

The time-domain characteristics of a traveling-wave linear antenna with linear and nonlinear parallel loads are discussed. The fast Fourier transform (FFT) is used to analyze the antenna with a linear parallel load. A numerical time-stepping finite-difference equation method is used to analyze the antenna with a nonlinear parallel load. The nonlinear effect is treated by the Newton-Raphson iteration technique. The effects of various linear and nonlinear parallel loads are examined. Physical insight into the nonlinear parallel loading of the antenna is also given in terms of detected time-domain sinusoidal electromagnetic (EM) waves.

19467. Block, S., Piermarini, G. J., Munro, R. G., **Advances in high pressure research with the diamond anvil cell**, *La Recherche* 11, No. 113, 806-813 (1980).

Key words: advances; diamond anvil cell; high pressure; ruby pressure scale.

The significance of pressure as a research variable is reviewed at an introductory level. The role of the diamond anvil cell, which was developed at NBS, is described with illustrations of its many applications. The importance of the ruby pressure scale, also developed at NBS, is discussed in terms of its utility and its impact on high pressure research activity. The effects of pressure on the states of matter are examined in the context of several examples of recent works using diamond anvil cells. The applications that are mentioned include infrared, Raman, and optical spectroscopy, x-ray diffraction, electrical resistance measurements, determinations of the viscosities and glass transition pressures of liquids, and the general topic of phase transitions. Trends for high pressure research in the immediate future are briefly outlined.

19468. Kikuchi, R., Cahn, J. W., **Grain-boundary melting transition in a two-dimensional lattice-gas model**, *Phys. Rev. B* 21, No. 5, 1893-1897 (Mar. 1, 1980).

Key words: adsorbed layers; antiphase boundaries; grain boundaries; lattice gas; phase transitions; surface melting.

A two-dimensional lattice-gas model that is capable of producing gas, liquid, and two orientations of a solid phase is



adopted to study properties of a boundary between two crystal-line grains by use of a nine-site cluster approximation of the cluster-variation method. At a temperature far below the melting temperature  $T_m$ , a gradual but well-defined transition is discovered between the low- and high-temperature structures of the boundary; this transition signals the onset of a liquidlike phase inside the boundary. The thickness of the boundary increases with  $T$ ; the excess entropy due to the boundary diverges as  $-\ln(T_m - T)$  near  $T_m$ ; and the grain boundary is completely wet with liquid at  $T_m$ .

19469. Franzen, D. L., Day, G. W., Measurement of propagation constants related to material properties in high-bandwidth optical fibers, *IEEE J. Quantum Electron.* QE-15, No. 12, 1409-1414 (Dec. 1979).

Key words: group index; material dispersion; optical fibers; propagation.

The material contribution to group index and material dispersion were measured in high-bandwidth graded-index optical fibers. A shuttle-pulse technique provided measurements of group index with precisions and accuracies of 0.1 and 0.2 percent using 5 m lengths of optical fiber. Material dispersion in fibers was measured over the 0.8-0.9  $\mu\text{m}$  wavelength region using different wavelength, short-pulse laser diodes. The influence of material dispersion on fiber bandwidth measurements was evaluated for laser diode sources. Limitations arising from source linewidth were experimentally determined from measurements on a fiber with high microbending enhanced bandwidth.

19470. Bean, V. E., Wood, S. D., The dual melting curves and metastability of carbon tetrachloride, *J. Chem. Phys.* 72, No. 11, 5838-5841 (June 1, 1980).

Key words: carbon tetrachloride; melting curves; metastability; phase diagram; plastic crystal; pressure.

Carbon tetrachloride has three known solid phases at atmospheric pressure: Ia (face-centered cubic), Ib (rhombohedral), and II (monoclinic). Both Ia and Ib melt directly at temperatures some 5 K apart. These phase changes have been traced as a function of hydrostatic pressure up to 350 MPa. Between atmospheric pressure and 100 MPa,  $\text{CCl}_4$  has dual melting curves; one for Ia, and a few degrees higher, one for Ib. The two curves diverge with increasing pressure. Above 100 MPa it was not possible to detect the Ia phase. There appears to be no Ia-Ib-liquid triple point. The metastability associated with these phases is discussed.

19471. Rabin, Y., Ben-Reuven, A., Resonance fluorescence and resonance Raman lineshapes in strong radiation fields, *J. Phys. B* 13, No. 10, 2011-2025 (1980).

Key words: resonance fluorescence; resonance Raman scattering; spectral line shapes.

Lineshapes of three-level resonance Raman scattering and two-level resonance fluorescence, homogeneously broadened by collisions, in the presence of arbitrarily strong coherent radiation, are studied by means of a tetradic (density-matrix) scattering theory. In the case of medium coupling strength  $V_L$  to the radiation field (where  $T_2^{-1} \leq V_L \leq \tau_c^{-1}$ , with  $T_2$  and  $\tau_c$  being the coherence damping and collision times, respectively) the Mollow lineshape for resonance fluorescence is rederived, with proper  $T_2$  and population cross-relaxation effects included. In particular it is shown that relaxation through intermediate non-resonant levels can considerably alter the lineshape in resonance fluorescence. In the case of strong coupling ( $V_L \geq \tau_c^{-1}$ ) the collision rates are modified by the applied field (optical collisions). It is shown that, whereas in self attenuation spectra optical collision rates can be obtained only from line intensity or line wing measurements, in resonance scattering these rates are directly obtained from linewidth measurements.

19472. Davis, R. S., Bower, V. E., Corrections to the Faraday as determined by means of the silver coulometer, (Proc. 6th Conf. on Atomic Masses and Fundamental Constants (AMCO-6), E. Lansing, MI, Sept. 18-21, 1979), Paper in *Atomic Masses and Fundamental Constants*, J. A. Nolen, Jr., and W. Benenson, Eds., pp. 161-165 (Plenum Press, New York, NY, 1980).

Key words: coulometer; coulometry; electrochemistry; Faraday constant; silver.

At the last meeting of the Conference of Atomic Masses and Fundamental Constants (AMCO-5) we presented experimental results for the Faraday constant as determined by the silver coulometer. Those results included an uncertainty estimated at 2 ppm ( $1\sigma$  level) due to impurities in the silver. We are now able to assign an impurity correction based on exhaustive mass spectrographic analysis of the silver used and assumptions concerning the electrochemical behavior of the impurities. A realistic assignment of uncertainty of the impurity correction has also been obtained. The overall correction has lowered the value of the Faraday reported at AMCO-5 by 2 ppm while reducing the uncertainty due to impurities to 0.5 ppm. We believe the impurity analysis to be the most searching ever performed for an electrochemical determination of the Faraday constant.

Agreement between our results and indirect calculations of the Faraday constant remains poor. Possible systematic errors in our measurements are explored.

19473. Willson, R. C., Duncan, C. H., Geist, J., Direct measurement of solar luminosity variation, *Science* 207, 177-179 (Jan. 11, 1980).

Key words: climatology; pyrheliometry; solar constant; solar variability.

Two rocket flights of an absolute pyrheliometer, separated by 30 months, indicate an increase in solar luminosity (solar constant) of 0.4 percent. The significance of this result is considered in light of the instrument performance during the rocket flights and of pre- and postflight intercomparisons with independently maintained pyrheliometers. There is a high probability that the measured difference is real. Additional observations are required to determine whether the difference results from random fluctuations in solar luminosity, a nonrandom change of short duration, or a sustained change that has climatological significance.

19474. Younger, S. M., Electron-impact ionization cross sections for highly ionized hydrogen- and lithium-like atoms, *Phys. Rev. A* 22, No. 1, 111-117 (July 1980).

Key words: distorted wave approximation; electron atom scattering; electron impact ionization; hydrogen isoelectronic sequence; lithium isoelectronic sequence.

Electron-impact ionization cross sections for highly ionized atoms in the hydrogen and lithium isoelectronic sequences have been computed in several variants of the Coulomb-Born and distorted-wave approximations. Electron exchange in the transition matrix element and Coulomb distortion of the partial waves were found to be important. The results are compared to recent crossed-beam experimental data and to other theoretical predictions.

19475. Berger, H., Nondestructive testing in the 80's, *Met. Prog.* 118, No. 3, 33-37 (Aug. 1980).

Key words: automated testing; continuous monitoring; non-destructive testing; radiography; signal processing; tomography; ultrasonics.

Present methods for nondestructive testing are reviewed briefly. The main emphasis in the paper is a look ahead toward the use of NDT in the immediate future. Increased use is seen for computer technology and signal processing, for the nondestructive characterization of both defects and material param-



eters, for traceable NDT measurements and continuous monitoring of machinery, engines and structures. Examples of NDT developments are given to support these predictions.

- 19476.** Kahn, S. M., Linsky, J. L., Mason, K. O., Haisch, B. M., Bowyer, C. S., White, N. E., Pravdo, S. H., *HEAO 1 observations of x-ray emission from flares on dMe stars*, *Astrophys. J.* **234**, No. 2, L107-L111 (Dec. 1, 1979).

Key words: stars, coronae; stars, flare; x rays, sources; x rays, spectra.

We report the detection of two x-ray flares from each of the nearby dMe stars, AT Mic and AD Leo, with the A-2 experiment on board *HEAO 1*. A spectrum obtained during the brighter AT Mic flare, the first x-ray spectrum of a stellar flare, is well matched by a thermal model with a temperature  $\sim 3 \times 10^7$  K and an iron K $\alpha$  emission line. The x-ray luminosities derived are in the range  $1.3\text{--}16 \times 10^{30}$  ergs s $^{-1}$ , while emission measures are in the range  $1.1\text{--}14 \times 10^{53}$  cm $^{-3}$ . The estimated  $L_x/L_{\text{opt}}$  ratios exceed unity and are inconsistent with Mullan's flare model. We propose several scenarios to explain this discrepancy.

- 19477.** Young, R. D., Vorburger, T. V., Teague, E. C., *In-process and on-line measurements of surface finish*, *CIRP Ann.* **29**, No. 1, 435-440 (Aug. 1980).

Key words: diffuseness; in-process; manufacturing engineering; on-line; optical Fourier transform; optical techniques; power spectral density; production engineering;  $R_a$ ; speckle; specular reflectance; surface roughness.

Future trends in surface finish measurement for manufacturing are discussed. It is expected that optical techniques will be used increasingly for measurements of surface roughness and of other parameters as well because these techniques are inherently fast and three-dimensional. Four optical techniques are discussed and evaluated. Stylus techniques, however, will continue to play an important role in research and metrology. Statistical methods for the three dimensional characterization of surfaces are briefly reviewed.

- 19478.** Ott, W. R., Bridges, J. M., Klose, J. Z., *Vacuum-ultraviolet spectral-irradiance calibrations: Method and applications*, *Opt. Lett.* **5**, No. 6, 225-227 (June 1980).

Key words: radiation standards; spectral irradiance; spectral radiance; vacuum ultraviolet radiation; vacuum ultraviolet sources.

A method to determine the spectral irradiance of a radiation source in the vacuum ultraviolet through the use of recently developed spectral-radiance standards is described. The method has been applied between 138 and 310 nm, and the spectral irradiances of several different light sources have been measured on an absolute scale with estimated uncertainties less than 10%.

- 19479.** Konowalow, D. D., Julianne, P. S.,  *$\text{Li}_2$  and  $\text{Na}_2$   $^3\Sigma_g^+ - ^3\Sigma_u^+$  excimer emission*, *J. Chem. Phys.* **72**, No. 11, 5815-5817 (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  $1.8 \times 10^{-15}$  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.

- 19480.** Goodman, D. W., Kelley, R. D., Madey, T. E., White, J. M., *Measurement of carbide build-up and removal kinetics on Ni(100)*, *J. Catal. Notes* **64**, 479-481 (1980).

Key words: carbide; carbon; catalysis; kinetics; methanation; nickel; single crystal.

The rate of carbide build-up on a Ni(100) crystal is shown to be the same as the rate of methane formation in an  $\text{H}_2 + \text{CO}$  mixture. Hydrogenation of a surface carbide appears to be the dominant route to product in the catalytic hydrogenation of CO over Ni catalysts.

- 19481.** Goodman, D. W., Kelley, R. D., Madey, T. E., Yates, J. T., Jr., *Kinetics of the hydrogenation of CO over a single crystal nickel catalyst*, *J. Catal.* **63**, 226-234 (1980).

Key words: carbon monoxide; catalysis; catalytic methanation; hydrogenation; kinetics; nickel.

A specially designed ultrahigh vacuum system has been used to examine the effect of surface chemical composition on the kinetics of the catalytic methanation reaction over a single crystal Ni(100) catalyst. The surface is characterized using Auger Electron Spectroscopy (AES) in an ultrahigh vacuum chamber, and reaction kinetics are determined following an *in vacuo* transfer of the sample to a catalytic reactor contiguous to the AES chamber. The kinetics of CO hydrogenation on a clean Ni(100) surface at 450-800 K are compared with kinetic data reported for high-area supported nickel catalysts. Excellent agreement is observed between specific rates, activation energy, and product distribution measured for the supported catalysts and the single crystal Ni(100). The dependence of the specific rate on total pressure (1-1500 Torr) and on  $\text{H}_2$  and CO partial pressures as well as the product distribution are also reported. These data are consistent with a mechanism in which an active surface carbon species is the dominant route to product.

- 19482.** Goodman, D. W., Kelley, R. D., Madey, T. E., White, J. M., *Summary abstract: Kinetics of carbon deposition from CO on Ru(110) and Ni(100)*, *J. Vac. Sci. Technol.* **17**, No. 1, 143 (Jan./Feb. 1980).

Key words: carbon monoxide; catalysis; kinetics methanation; nickel; ruthenium; single crystal; surface science.

The kinetics of carbon formation on Ru(110) and Ni(100) upon heating in CO have been studied and compared with the kinetics of CO hydrogenation to methane. The apparatus used for these studies allows for an *in vacuo* transfer of the crystal of interest from a high pressure reactor to a UHV surface characterization chamber. For Ru(110) and Ni(100) heating at 600 K in high pressure, CO leads to rapid formation of a carbide-like carbon (as characterized by AES for both Ni and Ru, despite interference in the case of Ru) which saturates at  $\sim 1/2$  monolayer. Reaction at lower temperatures produces a similar carbon species at levels  $< 1/2$  monolayer. This carbide carbon reacts rapidly when exposed to high pressure hydrogen. A graphite-like carbon, which is unreactive toward hydrogenation, can be formed by reaction with CO at temperature  $< 650$  K. The kinetics associated with the hydrogenation of the carbide carbon have also been investigated. The specific rates and activation energies of the carbon formation in CO and its subsequent removal in hydrogen are comparable. Furthermore, for Ru(110) and Ni(100) the specific rates and activation energies of these two processes compare with the specific rates and activation energies measured for the catalytic CO hydrogenation to methane. These data support an active carbon mechanism for the catalytic methanation reaction.

- 19483.** Cavallo, L. M., Golas, D. B., Mann, W. B., *The traceability program for radiopharmaceuticals at the United States National Bureau of Standards*, *At. Energy Aust.* **22**, No. 3-4, 55 (July-Oct. 1979).

Key words: radioactivity; radiopharmaceuticals; traceability.

The regulation of the use of radiopharmaceuticals and the traceability of measurements of their activity to the National



Radioactivity Measurements System in the United States are described.

- 19484.** Thijssse, B. J., Doiron, T., Sengers, J. M. H. L., A new upper bound for a critical anomaly in the dielectric constant of SF<sub>6</sub>, *Chem. Phys. Lett.* 72, No. 3, 546-550 (June 15, 1980).

Key words: comparison with He<sup>3</sup>, Ne; critical anomaly; dielectric constant; differential capacitance cell; SF<sub>6</sub>; 20 microK thermostat.

The dielectric constant of SF<sub>6</sub> on the critical isochore was measured under conditions of high thermal stability and low gravitational disturbance. No direct evidence of a  $t^{1-\alpha}$ -type anomaly was found; an upper bound for its amplitude is presented.

- 19485.** Sugar, J., Kaufman, V., Tokamak-generated tungsten radiation identified in Ag I isoelectronic sequence (W xxviii), *Phys. Rev. A* 21, No. 6, 2096-2098 (June 1980).

Key words: Ag I sequence; Pd I sequence; tokamak; tungsten.

A new interpretation of the tungsten spectrum observed in 1.5-keV tokamak plasmas at Oak Ridge (the ORMAK) and Princeton (the PLT) is given. An isoelectronic extrapolation of the Ag I sequence from newly observed data through Ho xxi strongly suggests that the tokamak radiation belongs to the transition array  $4d^{10}4f-4d^94f^2$  of W xxviii. This is well supported by comparison with a calculation of the spectrum. An earlier interpretation incorrectly attributed the radiation to a superposition of complex transition arrays from much higher ionization stages.

- 19486.** Horton, W. S., International cooperation on characterization and terminology of carbon and graphite, *Pure Appl. Chem.* 51, 1561-1574 (1979).

Key words: carbon; characterization; graphite; nomenclature; standards; terminology; test methods.

A brief progress report is presented on the activities of the International Committee for Characterization and Terminology of Carbon. The first efforts have produced a table of characterization methods for carbon and graphite used in the U.S.A., the Federal Republic of Germany, Italy, The United Kingdom, and by the International Organization for Standardization. A cross index is provided enabling the reader to associate the test numbers for a similar method from these sources.

- 19487.** Tsai, D. H., Trevino, S. F., Thermal relaxation in a liquid under shock compression, (Proc. VIIth International AIRAPT Conf., Le Creusot, France, July 30-Aug. 3, 1979), Paper in *High Pressure Science and Technology*, B. Vodar and P. Marateau, Eds., 2, 1051-1053 (Pergamon Press, Oxford, England, 1980).

Key words: argon; computer simulation; Lennard-Jones potential; liquid; molecular dynamics non-equilibrium processes; second sound; shock wave profile; thermal relaxation.

We have studied the shock compression of a dense Lennard-Jones liquid by means of detailed, molecular-dynamical calculations. Our results show the structure of the shock front as well as the dynamical process of thermal relaxation behind the shock front. Our shock front profiles are qualitatively similar to those obtained by Hoover who solved the Navier-Stokes equations for a continuum, and by Klimenko and Dreminev who also studied the molecular dynamics of this problem. In addition, we find that thermal equilibration in the shock profile occurs at a rate lower than the propagation of the shock front itself. This latter result is in agreement with what we found earlier in a crystalline system, and strengthens substantially our understanding of the mechanism of approach to equilibrium and of the origin of

second sound in a dense system that is driven far from equilibrium.

- 19488.** Deslattes, R. D., Reference wavelengths. Infra-red to gamma-rays, Avogadro's constant, mass and density, *Proc. Course LXVIII "Metrology and Fundamental Constants" Summer School of Physics—Enrico Fermi, Varenna, Italy, July, 1976*, pp. 38-113 (Societa Italiana di Fisica Bologna, Italy, Aug. 1980).

Key words: atomic weights; Avogadro's constant; gamma-ray spectroscopy; stabilized lasers; wavelength standards; x-ray interferometry.

A set of lectures on the subjects indicated was presented at the Summer School of Physics—Enrico Fermi, Varenna, Italy, July 12-24, 1976. The accompanying text reflects, with subsequent revision, lecture notes distributed at the course. This revised version will be published in due time as proceedings of course LXVIII "Metrology and Fundamental Constants." For the present, these notes represent the most complete and up-to-date summary of the entire range of our activities in the field of fundamental constants type work over the past decade. A limited number of these are, therefore, being made available as preprints to interested persons.

- 19489.** Haan, S. W., Mountain, R. D., Hsu, C. S., Rahman, A., Addendum to "density fluctuations in liquid rubidium", *Phys. Rev. A* 22, No. 2, 767-769 (Aug. 1980).

Key words: density fluctuations; Lennard-Jones liquid; liquid rubidium; liquid state; molecular dynamics; velocity autocorrelation function.

We performed molecular-dynamics simulations of liquid rubidium and the Lennard-Jones fluid at several densities and temperatures, and of a system whose pair potential is the repulsive core of the rubidium potential. In all cases, propagating density fluctuations occurred in the rubidiumlike systems at much shorter wavelengths than in the Lennard-Jones system. This indicates that the repulsive part of the pair potential is the dominant factor in determining the relaxation of short-wavelength density fluctuations.

- 19490.** Berger, A. E., Solomon, J. M., Ciment, M., Leventhal, S. H., Weinberg, B. C., Generalized OCI schemes for boundary layer problems, *Math. Comput.* 35, No. 151, 695-731 (July 1980).

Key words: cell Reynolds number; diffusion convection equations; error estimates; higher order finite difference methods; numerical experiments; parabolic equations; singular perturbation problems.

A family of tridiagonal formally fourth-order difference schemes is developed for a class of singular perturbation problems. These schemes have no cell Reynolds number limitation and satisfy a discrete maximum principle. Error estimates and numerical results for this family of methods are given, and are compared with those for several other schemes.

- 19491.** Schooley, J. F., Evans, G. A., Jr., Soulen, R. J., Jr., Preparation and calibration of the NBS SRM767: A superconductive temperature fixed point device, *Cryogenics* 20, No. 4, 193-199 (Apr. 1980).

Key words: cryogenics; pure metals; superconductivity; temperature fixed points; temperature scales; thermometry.

More than 100 cryogenic-temperature reference-point devices based upon the reproducible superconductive transition temperatures of five elements have been distributed through the NBS Office of Standard Reference Materials as SRM 767. The fixed-point temperatures of the device have been noted as reference temperatures of the Provisional Temperature Scale 0.5 K to 30 K. The methods of preparation of the device, the proce-



dures for its calibration, and a summary of the results of the calibration experiments are briefly presented. Suggestions are offered for verification of the device temperatures and for improvements in the device performance.

**19492.** Goodman, D. W., White, J. M., **Measurement of active carbon on ruthenium (110): Relevance to catalytic methanation**, *Surf. Sci.* **90**, 201-203 (1979).

Key words: carbon; catalysis; hydrogenation; kinetics; methanation; ruthenium; single crystal.

A technique is described for the quantitative measurement by Auger Electron Spectroscopy (AES) of carbon on a Ru(110) surface. Previously, the detection of carbon on Ru, even qualitatively, has been difficult because of the interference between the Ru(273 eV) and C(272 eV) transitions. The lineshape of the AES feature associated with the carbon formed by heating in CO is carbidic in nature. This form of carbon is shown to be active toward hydrogenation. The specific rate of its formation in pure CO compares with the rate of methanation in a H<sub>2</sub>/CO mixture.

**19493.** Laufer, A. H., **An excited state of acetylene: Photochemical and spectroscopic evidence**, *J. Chem. Phys.* **73**, No. 1, 49-52 (July 1, 1980).

Key words: acetylene; excited state; ketene; photochemistry; spectroscopy; transient; vacuum ultraviolet.

Absorption spectra of a long-lived transient in the 140 and 157 nm region have been observed as the result of direct excitation of C<sub>2</sub>H<sub>2</sub>. The strongest features also are seen as the result of CH<sub>2</sub>CO photolysis. The carrier is identified as C<sub>2</sub>H<sub>3</sub>. A possible alternate assignment of the transient carrier to a geometrical isomer, such as H<sub>2</sub>C = C(vinylidene) radical is discussed.

**19494.** Penner, S., **Recirculating accelerators with room temperature RF**, *Proc. Conf. on Future Possibilities for Electron Accelerators*, Charlottesville, VA, Jan. 8-10, 1979, pp. G-1—G-22 (Department of Physics, University of Virginia, Charlottesville, VA, 1979).

Key words: cw accelerators; electron accelerators; microtron; recirculating accelerators; room-temperature rf systems.

This paper is a transcript of a talk delivered at the Charlottesville conference on future possibilities for electron accelerators. It discusses the need for cw accelerators for nuclear research, the problems in developing such accelerators, and the NBS/LASL proposal for research aimed at developing recirculating electron accelerators using room temperature rf accelerating techniques.

**19495.** Hanson, A. G., Bloom, L. R., Day, G. W., Gallawa, R. L., Gray, E. M., Young, M., **Optical waveguide communications glossary**, *NTIA-SP-79-4*, 80 pages (U.S. Department of Commerce—National Telecommunications and Information Administration, Sept. 1979).

Key words: communications; fiber optics; guided wave transmission; optical cable; optical communication; optical fiber; optical fiber waveguide; optical transmission; optical waveguide; telecommunications; waveguide.

This glossary defines technical terms specific to optical fiber waveguide communications. The objective is to clarify the vocabulary of this rapidly emerging technology: to provide the nucleus of a common language for communications engineers, manufacturers, systems designers and users.

Selection of terms has been deliberately restrictive. Only those terms specifically relevant to optical waveguide communications have been included. Definitions have been written especially with the communications engineer in mind. This work has

been a joint, interactive effort by communications engineers of the Institute for Telecommunications Sciences and physicists of the National Bureau of Standards. Their experience in the fields of communications engineering and physical measurement has been combined in an attempt to produce a language that is unambiguous to both disciplines.

**19496.** Margolis, S. A., Konash, P. J., **Non-peptide impurities in angiotensin I and other commercial peptides**, *J. High Resolution Chromatogr. & Chromatogr. Commun., Short Commun.* **3**, 317 (June 1980).

Key words: angiotensin I; high resolution liquid chromatography; non-peptide impurities; peptide hormones.

Knowledge of the purity of commercial samples of biologically active peptides is essential to the understanding and interpretation of pharmacological and physiological studies with these substances. However, studies in our laboratory and other laboratories show that these peptides are not pure. The origin and nature of these impurities has not been investigated. In this study we demonstrate that certain impurities found in angiotensin I might originate from the rubber stopper of the container and the container walls, and others might be introduced during the purification of the crude peptide.

**19497.** Collins, L. A., Henry, R. J. W., Norcross, D. W., **Electron collisions with polar molecules: Exchange and polarization in elastic scattering by HCl**, *J. Phys. B: Atom. Molec.* **13**, No. 11, 2299-2307 (June 1980).

Key words: electron collisions; model potentials; polar molecules.

The local free-electron-gas exchange potential is shown to be not only superior to the orthogonalisation approximation to exchange, but also to yield results in good agreement with those from an essentially exact treatment of exchange. The imposition of orthogonalisation *in addition* to the local exchange potential yields a further small improvement in the results. The use of these two approximations in combination appears to be a promising technique. A polarisation potential cut-off at about the position of the H atom yields results for the <sup>2</sup>Σ eigenphase sum that have resonant behaviour more or less where expected on the basis of measured vibrational excitation cross sections. The elastic differential cross section has a strong peak in the backward direction, with important implications for resonant vibrational excitation.

**19498.** Liu, S. T., Fanney, A. H., **Comparing experimental and computer-predicted performance of solar hot water systems**, *ASHRAE J.* **22**, No. 5, 34-38 (May 1980).

Key words: computer; energy; heat transfer; hot water; measurement; modeling; solar; testing.

Three computer programs are currently used for the design and evaluation of solar space heating and domestic hot water systems. In order to provide data required for the validation of these computer programs for solar domestic hot water systems, the National Bureau of Standards fabricated and instrumented six typical systems at its Gaithersburg, MD site. The systems have been operating since June, 1978. This paper describes the testing, and experimental results, and compares these results with the computer predictions for the first twelve months of operation. This paper was presented at a symposium on Solar Hot Water Systems during ASHRAE's 1980 Semiannual meeting in Los Angeles, and will appear in *Transactions*, Vol. 86, Part 1.

**19499.** Johnson, C. R., Neumann, M., **Square roots with positive definite Hermitian part**, *Linear and Multilinear Algebra* **8**, 353-355 (Jan. 1980).

Key words: field of values; Hermitian part; Jordan form; positive definite; square root.



The question of when a square matrix has a square root whose Hermitian part is positive definite is posed and discussed.

19500. Biondi, M. A., Herzenberg, A., Kuyatt, C. E., **Resonances in atoms and molecules**, *Phys. Today*, pp. 44-49 (Oct. 1979).

Key words: atoms; electron scattering; electron scattering resonances; George Schulz; high energy resolution; temporary negative ions.

The history of electron scattering resonances is reviewed, with special emphasis on the work of the late George Schulz.

19501. Walter, F. M., Linsky, J. L., Bowyer, S., Garmire, G., **HEAO 1 observations of active coronae in main-sequence and subgiant stars**, *Astrophys. J.* **236**, L137-L141 (Mar. 15, 1980).

Key words: late-type stars; stellar coronae; x-ray sources.

We have searched the *HEAO 1* data for evidence of x-ray emission from 105 bright late-type stars of luminosity class IV and V, selected on the basis of indirect optical evidence of the presence of a hot corona. Six of the target stars were detected at the  $3\sigma$  level and 15 were coincident with  $2\sigma$  x-ray sources. On a statistical basis no more than 5 of these 21 sources are spurious, and the probability that the identification with the class of active chromosphere stars is spurious is  $< 10^{-5}$ . The sources lie near a line of  $L_x/L_{bol} = 10^{-4}$ , similar to a solar plage, and we conclude that we are observing the most active coronae of late-type stars which are not members of close binary systems. The RS CVn systems discovered to date seem to form a distinct class of coronal x-ray sources, but the lowest x-ray luminosity members of the group, of which Capella may be the prototype, appear to overlap the domain of these single stars with active coronae. The data do not fit the coronal model of Gorenstein and Tucker (1976), but they are consistent with the coronal loop model of Rosner *et al.* as extended by Walter *et al.*

19502. Kearsley, E. A., Zapas, L. J., **Some methods of measurement of an elastic strain-energy function of the Valanis-Landel type**, *J. Rheol.* **24**, No. 4, 483-500 (1980).

Key words: biaxial; elasticity; elastomers; extension; rubber; strain-energy function; Valanis-Landel form.

For some pure elastomers, the strain-energy function can be expressed as the sum of three identical functions of the principal stretch ratios, that is, the strain energy is of the Valanis-Landel form. Methods of measuring this function are derived and demonstrated. Examples are given of evaluation from extension and compression (biaxial extension) and from torsion of a cylinder. The character of the strain-energy function about the undeformed state ( $\lambda = 1$ ) is examined in detail.

19503. Brown, J. E., Birky, M. M., **Phosgene in the thermal decomposition products of poly(vinyl chloride): Generation, detection and measurement**, *J. Anal. Toxicol.* **4**, 166-174 (July/Aug. 1980).

Key words: carbonyl chloride; combustion; decomposition; degradation; electron capture; gas chromatography; infrared spectroscopy; mass spectroscopy; phosgene; polymer; poly(vinyl chloride); PVC; pyrolysis.

An analytical study was made to determine whether carbonyl chloride (phosgene) is formed during the thermal decomposition of poly(vinyl chloride), PVC. Four methods of decomposition were studied: (1) thermal degradation of PVC in a resistively heated furnace, (2) electrical overloading of a PVC clad wire, (3) electrical arcing between electrodes partially covered with PVC, and (4) electric arc initiated flaming combustion in a cup furnace. Results are reported which show that significant quantities of phosgene can be generated from PVC by the electric arc method. Lesser amounts were found in the other scenarios. The measurements, identification and quantification of phosgene

in the decomposition product, were obtained through the use of gas chromatography, infrared spectroscopy and mass spectroscopy. While the study was not mechanistic in nature, phosgene is postulated to result from secondary reactions of the PVC products. Reaction mechanisms are suggested.

19504. Lynn, J. W., Shelton, R. N., **Neutron scattering studies of magnetic superconductors**, *J. Magn. Mater.* **15-18**, 1577-1578 (1980).

Key words: Chevrel-phase; crystal fields; magnetic impurities; magnetic superconductors; rare earths.

Measurements have been carried out on a series of rare earth Chevrel-phase superconductors. In the selenide materials well defined crystal field transitions have been observed, which can be understood to a first approximation on the basis of a cubic crystal field with a magnetic ground state. In  $\text{HoMo}_6\text{S}_8$ , on the other hand, no crystal field excitations have been observed over a wide range of energies. Diffraction data show that essentially the full free-ion moment is readily induced in  $\text{HoMo}_6\text{S}_8$ , but that in  $\text{ErMo}_6\text{S}_8$  less than half the free-ion moment is induced at  $T = 5\text{ K}$  and  $H = 70\text{ kOe}$ . The induced-moment data on  $\text{HoMo}_6\text{S}_8$  can be readily interpreted on the basis of one Ho atom per unit cell, whereas for  $\text{ErMo}_6\text{S}_8$  this appears not to be the case. These data also demonstrate that the only significant magnetic impurity phases in these samples are  $(\text{RE})_2\text{O}_3\text{Se}$ , and these are typically a few percent or less in volume.

19505. Laughlin, C., Victor, G. A., **Intercombination line oscillator strengths for the Mg I isoelectronic sequence**, *Astrophys. J.* **234**, 407-409 (Nov. 15, 1979).

Key words: fine structure; intercombination line; Mg isoelectronic sequence; transition probability.

Accurate calculations of the intercombination line oscillator strengths for the Mg I isoelectronic sequence, through Ar VII, have been carried out using a semiempirical model potential method. The results differ significantly from some earlier semiempirical estimates but are in good agreement with some recent relativistic calculations.

19506. Smith, W. N., Larson, C. F., **Innovation and U.S. research: Problems and recommendations**, (Proc. 178th Meeting American Chemical Society, Washington, DC, Sept. 9-14, 1979), Paper 15 in *Innovation and U.S. Research: Problems and Recommendations*, W. N. Smith and C. F. Larson, Eds., ACS Symposium Series 129, pp. 159-169 (American Chemical Society Washington, DC, 1980).

Key words: bootleg R&D; government laboratories; industrial management; R&D; R&D in World War II.

The talk covers my personal experiences as a worker at the National Bureau of Standards during World War II and the years immediately following. It compares the administration of R&D at NBS and other Government laboratories with that period and the present day.

The talk also touches on the present situation in the management of industrial R&D and points out some of the difficulties with management which is excessively oriented to short-term pay-off.

19507. Wallerstein, G., Greenstein, J. L., **The spectrum of the nebulosity around the symbiotic long-period variable, R Aquar II**, *Publ. Astron. Soc. Pac.* **92**, 275-283 (June 1980).

Key words: density; long-period variable; model; nebulosity; R Aquar II; spectrum; temperature.

Multichannel spectrophotometric and SIT spectrograph data are reported for R Aqr during its deep minimum of September 1977. Line identifications and fluxes are presented. The emission lines are analyzed to yield the following parameters. The reddening, which must be circumstellar at  $b = -70^\circ$ , is 0.67 in



( $B-V$ ). From the ratio of Balmer continuum emission to  $H\beta$  an electron temperature near 11,000 K is derived, with observational uncertainties that allow values from 9000 K to 16,000 K. From [O III] lines we find  $n_e = 3 \times 10^5 - 5 \times 10^6$  on the star position, while from [O I], which is likely to be formed in a H I region, we find  $\log n_e$  to be in the range of 3.5 to 5.5. In lines of sight off the star but on visible nebulosity the densities are lower but only by about a factor of ten. Recombination lines of He I and H show a small enhancement of helium and the ratio of O N from [O I] and [N I] lines shows a substantial enhancement of nitrogen. The ratios of Ne III and S III to O III are nearly normal. A model of R Aqr with a white dwarf or O subdwarf accreting material that is lost by the long-period variable is discussed but to date there is no direct evidence that two separate stars are present. The evidence that the maxima were suppressed when the hot source was bright is used to question the binary hypothesis and to suggest that R Aqr may be a single star with a magnetically active region.

19508. Carroll, J. J., Madey, T. E., Melmed, A. J., Sandstrom, D. R., The room temperature adsorption of oxygen, hydrogen and carbon monoxide on (1120) ruthenium: An ellipsometry—LEED characterization, *Surf. Sci.* 96, 508-528 (1980).

Key words: ellipsometry; flash desorption; LEED; ruthenium.

Experiments involving the room temperature adsorption of oxygen, hydrogen and carbon monoxide on a single crystal (1120) ruthenium surface were performed in ultra-high vacuum by monitoring the accumulation of adsorbates using ellipsometry while simultaneously observing the adsorbates' periodicity (or lack of it) with LEED. Measurements of relative carbon monoxide coverages were made using a temperature programmed desorption (flash desorption) method, and these results correlated well with coverages determined using ellipsometry.

19509. Santoro, A., Wlodawer, A., Absorption correction for Weissenberg diffractometers, *Acta Cryst.* A36, 442-450 (1980).

Key words: absorption correction; diffractometers; flat-cone; macromolecules; neutrons; single-crystal; Weissenberg methods; x rays.

Formulas are derived extending several semi-empirical absorption-correction methods to diffractometers operating in Weissenberg geometries, with particular attention paid to flat-cone geometry. These formulas are useful for a variety of instruments using both areas and linear position-sensitive detectors. While a complete data set can sometimes be corrected using a single absorption reflection, it was found that the best corrections are usually obtained by considering two absorption reflections rather than one. A discussion of the optimum choice of absorption correction when a crystal has at least a twofold symmetry axis is presented. The accuracy of the methods and the limits of applicability have been examined by computer simulations.

19510. Smith, A. V., Goldsmith, J. E. M., Nitz, D. E., Smith, S. J., Absolute photoionization cross-section measurements of the excited 4D and 5S states of sodium, *Phys. Rev. A* 22, No. 2, 577-581 (Aug. 1980).

Key words: absolute cross section measurement; atom; cross section; excited states; photoionization; sodium.

We have measured the absolute cross section for photoionization of the 4D and 5S excited states of sodium for 1.06  $\mu\text{m}$  radiation. The method of measurement is based on saturation of ionization probability at high intensity of the ionizing radiation. The measured cross sections for ionization of unaligned atoms are  $15.2 \pm 1.7$  Mb for the 4D state and  $1.49 \pm 0.13$  Mb for the 5S state, both in excellent agreement with calculated values.

19511. Melmed, A. J., Carroll, J. J., Ellipsometry data analysis aided by derivative plots in  $n, \kappa$ -space, *Appl. Opt.* 19, No. 11, 1735-1736 (June 1, 1980).

Key words: ellipsometry; index of refraction.

A technique involving the use of computer generated  $d\Delta/dd$ ,  $d\psi/dd$  plots as an aid in the analysis of ellipsometry data is described.

19512. Taylor, P. O., Phaneuf, R. A., Dunn, G. H., Absolute cross sections and polarization for electron-impact excitation of the resonance multiplet of the  $\text{Be}^+$  ion, *Phys. Rev. A* 22, No. 2, 435-444 (Aug. 1980).

Key words:  $\text{Be}^+$ ; crossed beams; cross sections; electron impact; excitation; polarization.

Crossed beams of electrons and ground state  $\text{Be}^+$  ions have been used to measure absolute cross sections for electron-impact excitation of the 313.1-nm resonance radiation corresponding to the transition  $\text{Be}^+(2p) \rightarrow \text{Be}^+(2s)$ . Polarization fractions of the emitted light were also measured. Cross sections are absolute in the sense that all measurables including photon flux at 313 nm have been compared to relevant standards. The doublet emission cross section in units of  $10^{-16} \text{ cm}^2$  can be represented as a function of electron energy by  $\sigma = -5.10 \ln E + 23.0$  from 4.4 to 21 eV (extrapolating to  $16 \times 10^{-16} \text{ cm}^2$  at the 3.96-eV threshold) and by  $\sigma = 101 \ln E/E - 151/E$  from 21 to 740 eV. Total uncertainties at a high (approximately 98%) confidence level are about  $\pm 10\%$ . Coulomb-Born II calculations of Bely overestimate the value at threshold by a factor of 1.7, and a recent Coulomb-Born calculation by Mann is about 10% higher at 740 eV. Two- and five-state close-coupling calculations lie, respectively, 28% and 19% above the measurement at threshold. For energies from 5 to 300 eV the measured polarization fractions can be represented by  $P = -0.0708 \ln E + 0.284$  which gives  $P = 0.19$  at threshold.

19513. Hampson, R. F., Chemical kinetic and photochemical data sheets for atmospheric reactions, *U.S. Department of Transportation, Report No. FAA-EE-80-17*, 490 pages (Available from the National Technical Information Service, Springfield, VA, Feb. 1980).

Key words: air pollution; atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant.

A set of individual data sheets for gas phase chemical reactions and photochemistry of neutral species is presented. These data sheets give preferred values for reaction rate constants, photoabsorption cross sections and quantum yields with a brief statement discussing the basis for the preferred value. Recent experimental results are also given. The coverage of this initial set of data sheets issued in February 1980 corresponds to the approximately 400 reactions listed in NBS Special Publication 513, R. F. Hampson and D. Garvin, May 1978. For approximately one quarter of these reactions the data entry has been updated to include the 1979 recommendations of the NASA Panel for Data Evaluation and the CODATA Task Group on Chemical Kinetics. They are intended to provide the basic physical chemical data needed as input data for calculations modeling atmospheric chemistry.

19514. Reader, J., Corliss, C. H., Eds., Line spectra of the elements, Paper in *CRC Handbook of Chemistry and Physics, 61st Edition. Section E—General Physical Constants Line Spectra of the Elements*, R. C. Weast and M. J. Astle, Eds., pp. E-219—E-348 (CRC Press, Inc., Boca Raton, FL, 1980).

Key words: atomic spectra; intensities of lines; line spectra; spectrum lines; tables of spectra; wavelengths.

These tables contain the outstanding spectral lines of neutral (I), singly ionized (II), doubly ionized (III), triply ionized (IV),



and quadruply ionized (V) atoms. Listed are lines that appear in emission from the vacuum ultraviolet to the far infrared. For most atoms the lines were selected from much larger lists in such a way as to include the stronger observed lines in each spectral region. In a few cases prominent monoxide band heads are also given. Literature references for each spectrum are collected at the end of the entire set of tables. The wavelengths range from 40 to 40 000 Å. Many of the intensities represent quantitative estimates of relative line strengths that take account of varying detection sensitivity at different wavelengths. They are on a linear scale. For nearly all of the other lines the intensities represent qualitative estimates of the relative strengths of lines not greatly separated in wavelength.

- 19515.** Howe, D. A., Walls, F. L., Bell, H. E., Hellwig, H., A small, passively operated hydrogen maser, *Proc. 32d Annual Frequency Control Symposium, Atlantic City, NJ, May 3-June 1, 1979*, pp. 554-568 (Electronic Industries Association, 2001 Eye Street, N.W., Washington, DC 20006, 1979).

Key words: dielectrically loaded cavity; frequency stability; frequency standard; hydrogen maser; teflon coating technique.

A compact passive hydrogen maser with many unique features, including a significant reduction in size over previous hydrogen masers, is described. It uses the passive mode of operation, thereby permitting use of a small microwave TE<sub>011</sub> cavity which is dielectrically loaded by a low-loss alumina (Al<sub>2</sub>O<sub>3</sub>). The cavity is 14.6 cm O.D. and 13.7 cm high, weighing only 4.4 kg. The unloaded cavity Q factor is about 6000. With a conventional source, hexapole state selector, and 4 magnetic shields the volume of the entire H-maser resonator package is only about 20 l.

The teflon coated quartz bulb which is common in other masers has been replaced by a teflon coating on the inside wall of the cavity. This has yielded a simpler design and more rugged H-maser package. The technique for the application of liquid emulsion FEP 120 is discussed.

The cavity and attached endcaps comprise the vacuum envelope, thus allowing use of a single vacuum system. The dimensional stability of the ceramic cavity under barometric changes is sufficiently within the range of the electronic cavity servo that a second vacuum system is not needed. For temperature control, a single oven is located in the magnetic shield nest.

The electronics for this small passive hydrogen maser is very similar to that previously developed at NBS. Preliminary measurements on a prototype small maser system yield a frequency stability of approximately  $\sigma_y(\tau) = 6.6 \times 10^{-12} \tau^{-1/2}$  to at least one day, with a measurement bandwidth of 1 kHz.

- 19516.** Milton, H. J., *Dimensional coordination in building*, Chapter 6 in *AIA Metric Building and Construction Guide*, pp. 43-60 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: building module; controlling dimensions; coordinating sizes; dimensional coordination; metric building design; metric building products; modular coordination.

The chapter provides a general outline of the concepts of metric dimensional coordination in building, based on the international building module of 100 mm, and selected multimodules. The development of the idea of dimensional coordination in the U.S. is traced and contrasted with international developments. Definitions are provided of dimensional coordination and modular coordination. Major elements of a systematic approach to dimensional coordination are listed and include: modules and preferred dimensions; space reference systems, or grids; functional activity spaces; controlling dimensions for building design; coordinating dimensions for building products and assemblies; production (work) sizes, rules of fit, and joints; construction layout; and, drawing conventions, symbols and definitions. These elements are illustrated as needed. Detailed discus-

sion deals with: modules and modular dimensions, including a rationale for their selection; reference grids; horizontal, vertical and intermediate controlling dimensions in building; and, preferred component and assembly sizes, and a matrix for their systematic selection. Suggestions for preferred dimensions and sizes are made for a number of building products, such as panels, masonry units, boards, sheet materials, tiles, partitions, doorsets, windows, skylights, and spacing of concealed members. Advantages of dimensional coordination, and pros and cons, have been summarized.

- 19517.** Risley, A., Jarvis, S., Jr., *Study of the dependence of frequency upon microwave power of wall-coated and buffer-gas-filled passive Rb<sup>87</sup> frequency standards*, *Proc. 32d Annual Frequency Control Symposium, Atlantic City, NJ, May 3-June 1, 1979*, pp. 477-483 (Electronic Industries Association, 2001 Eye Street, N.W., Washington, DC 20006, 1979).

Key words: buffer gas; cavity pulling; frequency dependence; line inhomogeneity; Rb<sup>87</sup> frequency standard; wall coating.

Previous studies of a commercial passive gas cell Rb<sup>87</sup> frequency standard showed a strong dependence of the output frequency,  $\nu_{Rb}$ , upon the microwave power,  $P_{\mu\lambda}$ . A major conclusion of that work was that the dependence of  $\nu_{Rb}$  upon  $P_{\mu\lambda}$  was due to a line inhomogeneity effect. The line inhomogeneity interpretation suggested that substituting a wall coating for the usual buffer gas would reduce the dependence upon  $P_{\mu\lambda}$ . As a part of the present work a wall coating (a form of paraffin) was used and a reduction of this dependence by a factor of 100 was obtained.

The present work has led to a more convincing theoretical demonstration of the line inhomogeneity effect. The paper discusses some of the details of the analytical procedure.

There are certain major requirements that a wall coating would have to satisfy if it were to be superior to the usual buffer gas and these are discussed in the text. The advantages demonstrated by the present work indicate that further studies are warranted to determine if an improved standard could be built based on a wall coating.

- 19518.** Mahaffey, C. T., *The effect of metrication on building codes and standards*, Chapter 9 in *AIA Metric Building and Construction Guide*, pp. 85-90 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: building codes; building standards; dimensional coordination; metrication; regulatory coordination; standardization and international harmonization.

The chapter contains an analysis of major metric conversion issues relating to U.S. building standards and codes, with special emphasis on the need for proper planning and coordination. Among technical issues in the change, both the selection of correct SI units, and the consideration of dimensional coordination in the selection of new and preferred metric dimensions are stressed. International progress in standardization and in the harmonization of building regulations is addressed.

- 19519.** Milton, H. J., Packard, R. T., *SI units in architecture*, Chapter 3 in *AIA Metric Building and Construction Guide*, pp. 13-20 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: convenient values; metric conversion; preferred dimensions; preferred values; SI units for building.

The chapter provides advice on conversion approaches, preferred dimensions and values, and SI units for use in architecture and building. Specific discussions relate to SI units for length, area, volume and section modulus, mass, time, and temperature.



**19520.** Milton, H. J., *Guidelines for metric training and the transitional period*, Chapter 10 in *AIA Metric Building and Construction Guide*, pp. 91-100 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: adaptation of building materials; metric familiarization; metric products and non-metric buildings; repair and maintenance.

The chapter deals with two aspects of metrication: the training of people in the construction community, and technical adaptation during the transition period.

Formal metric training programs are contrasted with informal familiarization outside and within the work environment. Training needs of various groups and the scope for construction industry metric training programs are discussed. The value of metric recognition points and mental images as part of the familiarization program is stressed and some typical examples are given.

Strategies are offered for the technical adaptation of materials and components during the transitional phase, both for design and construction. A matrix shows various degrees of complexity of adaptation, ranging from negligible [no or minimal change] to costly and practically impossible, and recommends courses of adaptive action for designers and contractors. The impact of metrication in relation to existing buildings and their maintenance, repair, rehabilitation, extensions and additions is examined and various strategies for the minimization of costs and problems are recommended. Legal and contractual implications of the change are addressed.

**19521.** Martinez, R. I., Huie, R. E., Herron, J. T., *Products of the reaction of hydroxyl radicals with trans-2-butene in the presence of oxygen and nitrogen dioxide*, *Chem. Phys. Lett.* **72**, No. 3, 443-447 (June 15, 1980).

Key words: hydroxyl radical; nitrates ozone; nitrogen dioxide; reaction; trans-2-butene.

The reactions of hydroxy-substituted alkyl radicals, formed as secondary products in the reaction of ozone with trans-2-butene, have been identified in photoionization mass spectrometry studies, using acetaldehyde and nitrogen dioxide as free-radical scavengers. Products derived from 2-hydroxyl-1-methylpropyl in the absence of scavengers include 2,3-butanediol (diacetyl), 3-hydroxy-2-butanone (acetoin), and 2,3-butanediol. In the presence of added acetaldehyde or nitrogen dioxide, the formation of these products is suppressed. In addition, with added nitrogen dioxide, new products are formed which have been identified as a series of oxoalkyl and hydroxy-substituted-alkyl nitrates and peroxy nitrates. These observations may have an important bearing on the chemistry of photochemical smog.

**19522.** Martin, W. C., *Series formulas for the spectrum of atomic sodium (Na I)*, *J. Opt. Soc. Am.* **70**, No. 7, 784-788 (July 1980).

Key words: atomic energy levels; atomic spectra; quantum defects; Rydberg-Ritz series; sodium; spectroscopic series.

The available data on the energy levels of Na I yield Ritz quantum-defect formulas predicting all one-electron ( $nl$ ) levels with an uncertainty of  $\pm 0.03 \text{ cm}^{-1}$  with respect to the  $3s \text{ } ^2S_{1/2}$  ground level. Such formulas are given here for the  $ns$  through  $ni$  series as expressions for the quantum defect  $\delta$  in inverse even powers of  $n - \delta_0$ , with  $\delta_0$  constant for each  $nl$  series. These formulas are usually more convenient for calculations than the formulas in powers of  $n - \delta$  and core-polarization formulas given previously. Term differences or quantum defects predicted by the  $ns$  through  $nh$  formulas are compared with a number of more recent experimental determinations in the range  $n = 13-41$ .

**19523.** Linsky, J. L., *Stellar chromospheres*, *Ann. Rev. Astron. Astrophys.* **18**, 439-488 (1980).

Key words: chromosphere sun; emission-line stars; late-type stars; stellar chromospheres; stellar winds; ultraviolet spectra; x-ray sources.

This is a comprehensive review of recent observational and theoretical studies of stellar chromospheres. Specific topics covered include the definition of a stellar chromosphere, the regions of the H-R diagram in which chromospheres occur, semiempirical models of chromospheres in single stars, theoretical models, the Wilson-Bappu relation, systematic flow patterns, how chromospheres in close binary systems differ from chromospheres in single stars, and future prospects for research.

**19524.** Jespersen, J. L., *Some implications of reciprocity for two-way clock synchronization*, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ.* **2129**, pp. 171-184 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

Key words: clocks; Loran-C; propagation; reciprocity; synchronization.

Two common methods for synchronizing remote clocks are called one-way and two-way. Both of these methods, when operated in the traditional fashion are subject to a number of difficulties related to propagation perturbances. This paper points out however, that under certain circumstances, these difficulties can be circumvented for the two-way scheme. This possibility is explored theoretically, in some detail, with respect to the Loran-C navigation system.

**19525.** Jespersen, J., Kamas, G., Weiss, M., *Voice announcements of time: A new approach*, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ.* **2129**, pp. 363-384 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

Key words: clocks; HF; interference; satellite; spectrum; spectrum conservation; standard; time broadcast stations; voice announcements.

A recent survey by NBS reveals that the voice time announcements provided by radio stations WWV and WWVH are used more often than any other features of the time signals. It is the purpose of this paper to describe some recent NBS work aimed at exploring a different technique for generating voice time announcements. The idea is simply this—a time code from any source, such as those broadcast by WWV, WWVH, WWVB, CHU, or the GOES satellite is translated electronically into a voice announcement. This approach is attractive for several reasons. (1) In many areas voice time announcements are weak and noisy and it is difficult to understand them. In addition, there may be interference from other "standard time broadcast" stations. It is often easy, under such conditions, to detect and error correct a time code. The "cleaned-up" time code is then electronically converted into a noise-free voice announcement. (2) Normal time broadcasts provide voice announcements only at regular intervals of time—such as every minute. With the code-voice conversion technique, a voice announcement is available on demand. (3) Any time code signal may be used. Thus, the GOES satellite which broadcasts only a time code, can be made to "appear" to provide voice time announcements. (4) The same time code may be converted into one or more languages at the receiver. This may be important for solving "the problem" of what language or languages should be broadcast from a standard time satellite broadcast. That is, it may not be necessary to broadcast any voice announcement in any language from the satellite—only a code—and the receiver would contain the option to select the language desired.



NBS has developed equipment to convert time codes from several different sources into voice announcements. Although the emphasis in this development work was intended to demonstrate technical feasibility, rapid progress in the production of commercial electronic voice generation units will, no doubt, make the approach suggested here feasible both technically and economically in the near future.

**19526.** Klais, O., Anderson, P. C., Kurylo, M. J., **A reinvestigation of the temperature dependence of the rate constant for the reaction  $O + O_2 + M \rightarrow O_3 + M$  (for  $M = O_2, N_2$ , and Ar) by the flash photolysis resonance fluorescence technique**, *Int. J. Chem. Kinet.* **12**, 469-490 (1980).

Key words: atmospheric modeling; oxygen atoms; ozone; rate constants; resonance fluorescence.

The flash photolysis resonance fluorescence technique has been used to reinvestigate the kinetics of the oxygen atom-oxygen molecule combination reaction. Third-order rate constants for  $O_2$ ,  $N_2$ , and Ar as deactivant molecules were determined over the temperature range of 219-368 K. The results presented herein are the most extensive data sets available for atmospheric modeling and are used to formulate a recommendation for such purposes. The recommended rate expressions are.

**19527.** Warnick, W. L., Hill, J. E., **The solar collector industry and solar energy**, *Mon. Energy Rev. DOE-EIA Report 0035-02 (80)*, pp. 1-6 (Department of Energy, Energy Information Administration, Washington, DC, Feb. 1978).

Key words: energy estimates; geographical distribution; low temperature collectors; manufacturing activity; medium temperature collector; solar energy; special collectors.

From a 1974 level of 1.3 million square feet, the production of solar collectors increased over ten-fold to 13.9 million square feet in 1979 (based upon the first 6-months' data). However, shipments of the various types of collectors, while increasing over-all, show sporadic growth patterns over the 5 1/2-year period. Furthermore, a 4-year period of exponential growth appears to have ended.

Solar energy incident on the Nation's inventory of solar collectors during 1979 was less than 0.03 quadrillion British thermal units (Btu). It is estimated that during 1979 the usable energy-output from solar collectors in the United States was about 0.008 quadrillion Btu, between 0.01 and 0.02 percent of domestic energy consumption.

**19528.** Beehler, R. E., Davis, D. D., Cateora, J. V., Clements, A. J., Barnes, J. A., Méndez-Quinones, E., **Time recovery measurements using operational GOES and transit satellites**, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ. 2129*, pp. 283-312 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

Key words: satellite; time dissemination.

Users with requirements for timing signals available over wide geographical areas that are accurately referenced to UTC(NBS) or UTC(USNO) can conveniently access either of two operational satellite systems. Two geostationary GOES (Geostationary Operational Environmental Satellite) satellites located at 75° and 135° W longitude provide a continuous NBS-referenced time code to the Western hemisphere, including large portions of the Atlantic and Pacific Ocean areas. Five operational TRANSIT satellites provide timing signals referenced to UTC(USNO) from low-altitude polar orbits, resulting in worldwide coverage on a non-continuous basis. Convenient, fully automatic, microprocessor-based commercial receivers are now available for use with both satellite systems.

Results of regular monitoring of both the GOES and TRANSIT timing signals over a number of months at NBS, Boulder, CO, are presented. The TRANSIT results include an analysis of how received timing accuracy and stability are affected by: (1) averaging over varying numbers of satellite passes; (2) averaging over different combinations of the 5 available satellites; (3) using several independent receivers of the same type; and (4) application of [TRANSIT-UTC(USNO)] published corrections to the received data. Based on monitoring experience to date at NBS, some pros and cons of using each of the available operational systems are discussed.

Updated information on recent improvements incorporated into the GOES time code generation and monitoring system at Wallops Island, VA, is also included.

**19529.** Bergquist, J. C., Wineland, D. J., **Laser to microwave frequency division using synchrotron radiation II**, *Proc. 32d Annual Frequency Control Symposium, Atlantic City, NJ, May 3-June 1, 1979*, pp. 494-497 (Electronic Industries Association, 2001 Eye Street, N.W., Washington, DC 20006, 1979).

Key words: electron; frequency divider; ion trap; laser; microwave; relativistic; synchrotron radiation.

We present a review of theoretical calculations which demonstrate the feasibility of obtaining one step frequency division from optical or infrared laser frequencies to a subharmonic in the microwave spectral region, and include current experimental designs toward a practical realization of this goal. We plan to drive the cyclotron orbit of a single relativistic electron, which is confined in a Penning ion trap, with a laser beam focused to a spot diameter  $\sim \lambda$ . This method is an extension of a common technique used in cyclotrons and synchrotrons where the orbit of high energy particles is driven at a harmonic of the orbit frequency. Our experiment is designed to measure this orbit frequency which is then a subharmonic of the driving (laser) frequency. This technique requires that the uncertainty in the electron orbit dimensions be limited to  $\leq \lambda/2$ , which is possible by radiative cooling and the method of motional side-band excitation. The possibility of a unified optical wavelength/frequency standard is evident.

**19530.** Costain, C. C., Boulanger, J. S., Daams, H., Hanson, D. W., Beehler, R. E., Clements, A. J., Davis, D. D., Klepczynski, W. J., Veenstra, L., Kaiser, J., Guinot, B., Azoubib, J., Parcelier, P., Freon, G., Brunet, M., **Two-way time transfer via geostationary satellites NRC/NBS, NRC/USNO and NBS/USNO via Hermes and NRC/LPTF (France) via Symphonie**, (Proc. 11th Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Goddard Space Flight Center, Greenbelt, MD, Nov. 27-29, 1979), *NASA Conf. Publ. 2129*, pp. 499-519 (National Aeronautics and Space Administration, Scientific and Technical Information Office, Greenbelt, MD, 1979).

Key words: Hermes/CTS; international time comparison; precise time transfer; satellite; time; time scales.

The two-way time transfer using the Hermes (CTS) satellite and the Symphonie satellite began in July, 1978. The Hermes experiment finished at the end of June 1979, and the Symphonie experiment will continue until the end of 1980. The NRC uses terminals at the Communication Research Center about 25 miles from the NRC laboratory, and the time transfer from NRC to CRC is made using line of sight TV reception with frequent checks by portable cesium or rubidium clocks. Initially the USNO used Goddard terminals, and the NBS a HEW terminal in Denver, and both relied primarily on portable clock synchronization. For the last eight months, Comsat terminals were used at the USNO and at NBS, so that no secondary time transfer was required. In France, the PBS Symphonie terminal is in Brittany, 300 miles from the Laboratoire de Temps et Fréquence (LPTF) at the Observatoire de Paris, and the time



transfer to the terminal is made via the TV networks. The uncertainty in this latter link is about 20 ns, but for the other stations the uncertainty is 1 to 5 ns.

In most of the experiments, 1 pps pulses of the station atomic clocks were exchanged between the partners, and a cubic equation was fitted to the 1000 to 2000 second measurements. The equations were exchanged and subtracted to obtain the time difference of the stations. The standard deviation in the fit of the equations varied, depending on conditions, from 1.5 ns to 16 ns. For the last month of the Hermes experiment a 1 MHz signal was used, giving a standard deviation of 0.18 ns.

The comparison of the time scales via satellite and via Loran-C (BIH Circular D) show clearly that some Loran-C links are very good, but that the NBS link varies by 1  $\mu$ s. Via the satellite the frequencies of the time scales can be compared with an accuracy of  $2 \times 10^{-14}$ .

**19531.** Laug, O. B., Constriction resistance measuring system for residential branch circuit connections, *Rev. Sci. Instrum.* **51**, No. 9, 1240-1246 (Sept. 1980).

Key words: constriction resistance; contact resistance; electrical connections.

A constriction resistance measuring system was designed for evaluating the performance of residential branch wiring circuit connections. The measurement system separates the bulk from the constriction resistance by utilizing the nonlinear voltage-current behavior of a connection. The method overcomes some of the past problems with the nonlinear technique by employing a pulse stimulus current coupled to a high-speed data acquisition system under computer control. A least squares nonlinear fit program is used to obtain the best fit of the voltage-current data to an equation which serves as the nonlinear model. The model was verified by simulating connections with a "true 4-wire crossed rod" measurement technique. Measurements on connections formed with aluminium and copper conductors agree closely with the parameters predicted by the model. The method is shown to have the ability to accurately measure the constriction resistance of practical connectors in the presence of widely changing values of bulk resistance. A modification of the technique is proposed and shown to have a potential threefold increase in sensitivity.

**19532.** Newbury, D. E., Methods for quantitative analysis in secondary ion mass spectrometry, *Scanning* **3**, 110-118 (1980).

Key words: ion microprobe mass analysis; microanalysis; quantitative analysis; secondary ion mass spectrometry; sputtering; surface analysis.

Methods for quantitative analysis in secondary ion mass spectrometry must be capable of correcting for strong matrix effects on emitted secondary ion intensities as well as strong instrumental effects on measured secondary ion intensities. Both empirical methods, based on sensitivity factors and working curves, and theoretical models for secondary ion emission, are available. Absolute sensitivity factors are not satisfactory because of the lack of compensation for matrix effects. Working curves are capable of yielding analysis with 5% relative accuracy but offer poor flexibility in dealing with unknowns which differ strongly from the standards. Relative sensitivity factors offer both flexibility in the analysis of unknowns and an error distribution in which 80% of the analyses fall within a factor of 2 of the unknown and 99% within a factor of 5. Numerous physical models for secondary ion emission are available but are generally limited in application due to uncertainties in the required physical data. The local thermal equilibrium (LTE) model is broadly applicable with partial constraint on the composition of the unknown. The LTE error distribution places about 50% of the analyses within a factor of 2 and 80% within a factor of 5. Large errors, exceeding a factor of 10, are observed for heavy elements, possibly due to uncorrected instrument effects.

Future development of analytical methods may combine the relative sensitivity factor method (which minimizes the influence of instrument artifacts) with the theoretical description of secondary ion emission (to calculate matrix effects).

**19533.** Madey, T. E., Stockbauer, R. L., van der Veen, J. F., Eastman, D. E., Angle-resolved photon-stimulated desorption of oxygen ions from a W(111) surface, *Phys. Rev. Lett.* **45**, No. 3, 187-190 (July 21, 1980).

Key words: angular distribution of ions; chemisorption; electron stimulated desorption; ESDIAD; ion energy distributions; ion yield; oxygen; photon stimulated desorption; synchrotron radiation; tungsten.

A definitive determination of angle-resolved photon-stimulated desorption of ions from a well-characterized adsorbate, and a direct comparison with electron-stimulated desorption are reported. Ion angular distributions, energy distributions, and photon excitation spectra for O<sup>+</sup> desorption from W(111) have been measured for oxygen coverages ranging from a fractional monolayer to a multilayer oxide.

**19534.** Radebaugh, R., Lawless, W. N., Siegwarth, J. D., Morrow, A. J., Electrocaloric refrigeration at cryogenic temperatures, *Ferroelectrics* **27**, 205-211 (1980).

Key words: ceramics; cryogenics; dielectric constant; electrocaloric effect; entropy; ferroelectrics; glass-ceramics; heat switches; polarization; refrigeration; specific heat strontium titanate.

Refrigeration utilizing the electrocaloric effect can be produced with no moving parts and thus, promises to be highly reliable. This paper reviews the principles and experimental results on electrocaloric refrigeration, particularly in the 4-15 K temperature range. Many electrocaloric materials were studied but none was found with a sufficiently large reversible electrocaloric effect for a practical refrigerator. The largest effects were seen in a SrTiO<sub>3</sub> ceramic, followed by a KTaO<sub>3</sub> single crystal. Temperature reductions of about 0.3 K at 10 K were observed during depolarization from fields of 20 kV/cm. A theoretical model based on the lattice dynamics of displacive dielectrics is postulated to explain the observed temperature changes in such materials.

**19535.** Bass, A. M., Glasgow, L. C., Miller, C., Jesson, J. P., Filkin, D. L., Temperature dependent absorption cross sections for formaldehyde (CH<sub>2</sub>O): The effect of formaldehyde on stratospheric chlorine chemistry, *Planet Space Sci.* **28**, 675-679 (Feb. 1980).

Key words: absorption cross-section; chlorine chemistry; formaldehyde; ozone; stratosphere.

New measurements are reported of the absorption cross sections of formaldehyde at 296 K and 223 K. These measurements are significantly lower than those reported in the earlier literature at ca. 353 K. The implications of the lower absorption cross sections for stratospheric chlorine chemistry are considered using a one dimensional atmospheric model. A slight modification to CIX partitioning is predicted for the new cross sections, with only a small effect on estimated chlorine-catalyzed ozone perturbations.

**19536.** Troland, T. H., Heiles, C., Johnson, D. R., Clark, F. O., Polarization properties of the 86.2 GHz  $\nu = 1, J = 2 \rightarrow 1$  SiO maser, *Astrophys. J.* **332**, 143-157 (Aug. 15, 1979).

Key words: interstellar, molecules, masers, polarization; stars, long period variables; stars, supergiants.

Complete Stokes parameters have been measured for a small sample of SiO masers associated with variable stars. These sources were found to be typically 15-30% linearly polarized and to exhibit no circular polarization above limits of as low as



a few percent. The Orion Molecular Cloud source exhibited no linear or circular polarization greater than 3% during the present observing period. The Stokes parameters for R Cas, not necessarily including the total intensity, were found to vary over short periods. Comparison of the new profiles for regular variable stars with those obtained several optical periods earlier reveals substantial changes. No apparent correlation exists between these changes and the optical variations of the stars.

- 19537.** Hiza, M. J., Haynes, W. M., **Orthobaric liquid densities and excess volumes for multicomponent mixtures of low molar-mass alkanes and nitrogen between 105 and 125 K**, *J. Chem. Thermodynamics* **12**, No. 1, 1-10 (1980).

Key words: densities; excess volumes; liquid mixtures; LNG components; multicomponent systems; orthobaric.

A magnetic suspension densimeter has been used to determine orthobaric liquid densities of gravimetrically prepared multicomponent mixtures containing the major components of liquefied natural gas, i.e., nitrogen, methane, ethane, propane, isobutane, and normal butane, between 105 and 125 K. These results were obtained to provide a test of the capability of mathematical models to predict the densities of liquefied natural-gas mixtures. Combinations of the subject components were chosen to provide the most severe test of the models and the possibility of using the measured densities to optimize parameters of the models. Deviations are given between the experimental densities for each mixture and values predicted with an extended corresponding-states model optimized to binary-mixture and pure-component orthobaric liquid densities obtained with the same apparatus. Uncertainties of the present results are discussed in relation to the experimental technique, the knowledge of the compositions of the liquid mixtures, and the comparisons between the experimental and predicted results. Approximate total vapor pressures are also given for each mixture at the temperatures studied.

- 19538.** Hanley, H. J. M., Evans, D. J., **Equilibrium and non-equilibrium radial distribution functions in mixtures**, *Mol. Phys.* **39**, No. 4, 1039-1042 (1980).

Key words: computer simulation; conformal solution theory; mixture; molecular dynamics; radial distribution function; soft spheres.

The equilibrium and nonequilibrium radial distribution functions of a binary 50 percent mixture of soft spheres have been estimated using nonequilibrium molecular dynamics on a system of 108 particles. The variation of the functions with size and mass difference of the particles is discussed. It is remarked that this study provides a direct test of conformal solution theory.

- 19539.** Fickett, F. R., Kaplan, S. B., Powell, R. L., Radebaugh, R., Clark, A. F., **Definitions of terms for practical superconductors: 4. Josephson phenomena**, *Cryogenics* **20**, No. 6, 319-325 (June 1980).

Key words: critical parameters; definitions; flux phenomena; Josephson phenomena; stabilization; superconductors; terminology.

The definitions of terms used in describing the phenomenology and measurement practices of practical superconductive materials are proposed. The definitions cover the subject categories of: 1) fundamental states and flux phenomena; 2) critical parameters; 3) fabrication, stabilization, and transient losses; and 4) Josephson phenomena. It is intended that these terms will become the basis for development of standard measurement practices and responses are invited.

- 19540.** Diller, D. E., Chang, R. F., **Composition of mixtures of natural gas components determined by Raman spectrometry**, *Appl. Spectrosc.* **34**, No. 4, 411-414 (1980).

Key words: gas mixture composition; gravimetrically prepared gas mixtures; molar intensity ratios; natural gas components; Raman spectrometric method; spectral line intensity measurements.

The feasibility of using Raman spectrometry for determining the composition of mixtures of natural gas components was examined. Raman intensity measurements were carried out on eight, gravimetrically prepared, binary gas mixtures containing methane, nitrogen, and isobutane at ambient temperature and at pressures of 0.8 MPa. The repeatability of the molar intensity ratio,  $(I_2/y_2)/(I_1/y_1)$ , where  $y_1$  is the concentration of component 1 in the mixture, and  $I_1$  is the intensity of the related line in the mixture spectrum, was examined. The compositions of two gravimetrically prepared methane-nitrogen-isobutane gas mixtures were determined spectrometrically with an estimated precision of about 0.001 in the mole fraction. Typical differences from the gravimetric concentrations were less than 0.002 in the mole fraction. The Raman spectrum of a gravimetrically prepared, eight component, hydrocarbon gas mixture was obtained to show that the Raman spectrometric method has potential for being applicable to natural gas type mixtures.

- 19541.** Cezairliyan, A., Müller, A. P., **Thermophysical measurements on low carbon 304 stainless steel above 1400 K by a transient (subsecond) technique**, *Int. J. Thermophys.* **1**, No. 1, 83-95 (Sept. 27, 1979).

Key words: dynamic measurements; electrical resistivity; emittance; heat capacity; high temperature; melting point; stainless steel; thermodynamics.

Simultaneous measurements, by a subsecond duration transient technique, to determine the specific heat capacity,  $c_p$ , the electrical resistivity,  $\rho$ , and the hemispherical total emittance in the temperature range 1400-1700 K, and the melting point and the radiance temperature at the melting point, of AISI type 304L stainless steel are described. The results are expressed by the relations:  $c_p = 1127 - 7.265 \times 10^{-1} T + 2.884 \times 10^{-4} T^2$ ,  $\rho = 75.59 + 4.695 \times 10^{-2} T - 9.592 \times 10^{-6} T^2$ , where  $c_p$  is in J·kg<sup>-1</sup>·K<sup>-1</sup>,  $\rho$  is in  $\mu\Omega$ ·cm, and  $T$  is in K. The value of the hemispherical total emittance is 0.37 in the range 1700-1900 K. The melting point and the radiance temperature (at 653 nm) at the melting point are 1707 and 1590 K, respectively, yielding a value of 0.385 for the normal spectral emittance at the melting point. Estimated inaccuracies of the measured properties are: 3% for the specific heat capacity, 2% for electrical resistivity, 5% for hemispherical total emittance, and 8 K for melting point and radiance temperature at the melting point.

- 19542.** Bussey, H. E., **Dielectric measurements in a shielded open circuit coaxial line**, *IEEE Trans. Instrum. Meas.* **IM-29**, No. 2, 120-124 (June 1980).

Key words: coaxial line open circuit; coaxial line support bead; dielectric constant; dielectric loss; rf and microwave dielectrics; standard dielectric liquids.

A coaxial transmission line terminated by a shielded open circuit is convenient for dielectric measurements over a frequency range from quasi-static to microwave in a single sample holder. The transmission line analysis including the open circuit termination covered by lossy dielectric is outlined. Examples of measurements of known liquids are given. Errors may arise because the support bead of a coaxial connector may excite various higher modes depending on the perfection of the symmetry and on the product frequency times refractive index of the sample. Criteria are given for the onset of higher modes.

- 19543.** Acquista, N., Reader, J., **Spectrum and energy levels of triply ionized zirconium (Zr IV)**, *J. Opt. Soc. Am.* **70**, No. 7, 789-791 (July 1980).

Key words: spectra; ultraviolet; zirconium.



The spectrum of Zr IV was observed with a sliding spark in the region from 440 to 2670 Å on the 10.7-m normal- and grazing-incidence spectrographs at NBS. About 30 new lines were observed. The level system (Rb I isoelectronic system,  $4p^6nl$ ) was extended to include the series  $ns$  ( $n = 5-8$ ),  $np$  ( $n = 5-7$ ),  $nd$  ( $n = 4-6$ ),  $nf$  ( $n = 4-6$ ), and  $ng$  ( $n = 5-9$ ). The  $nf$  series exhibits irregular fine-structure splittings and quantum defects. The ionization energy was determined from the  $ng$  series to be  $277\,605.8 \pm 1.5 \text{ cm}^{-1}$  ( $34.4190 \pm 0.0002 \text{ eV}$ ). New wavelengths were determined for the  $4s^2p^5-4s4p^6$  transitions of Zr VI.

**19544.** Driver, L. D., Ries, F. X., **A wideband RF voltage comparator**, (Proc. Conf. on Precision Electromagnetic Measurements, Braunschweig, Federal Republic of Germany, June 23-27, 1980), *IEEE No. 80CH1497-71M*, 487-488 (Institute of Electrical and Electronics Engineers, New York, NY, 1980).

Key words: linear voltage response; rf voltage comparator; Schottky-barrier diodes; voltage comparator; wideband comparator.

A wideband rf voltage comparator is described which enables highly accurate rf voltage measurements over the range of 10 mV rms to 20 V rms from less than 100 kHz to beyond 1 GHz. This device uses a pair of matched Schottky-barrier diodes in each of two independent dual channel configurations. The coaxial line sections are impedance compensated to assure a VSWR of less than 1.03 up to 1 GHz.

**19545.** Weber, M. J., Hegarty, J., Blackburn, D. H., **Laser-induced fluorescence line narrowing of  $\text{Eu}^{3+}$  in lithium borate glass**, (Proc. Conf. on Boron in Glass & Glass Ceramics, Alfred, NY, June, 1977), Paper in *Borate Glasses: Structure, Properties, Applications*, L. D. Pye, V. D. Frechette, and N. J. Kreidl, Eds., pp. 215-226 (Plenum Press, New York, NY, 1978).

Key words: europium lithium borate glass; fluorescence line narrowing; glass; laser; laser glass; laser-induced fluorescence.

The energy levels and transition probabilities of  $\text{Eu}^{3+}$  ions in an alkali borate glass are investigated using laser-induced fluorescence line narrowing. Because of site-to-site variations in the local fields, spectroscopic properties of paramagnetic ions in glass are characterized by large inhomogeneous linewidths and nonexponential excited-state decays. When a narrowband laser is used, only those ions resonant to within the homogeneous linewidth are excited. If the laser is pulsed and the emission is observed before any ion-ion cross relaxation occurs, a line-narrowed fluorescence arising from a selected subset of ions is observed. By tuning the laser within an inhomogeneous absorption band, the full range of local environments in the glass is probed.

Measurements were made at liquid helium temperatures using pulsed laser excitation tuned across the  $^5\text{D}_0$  and  $^5\text{D}_2$  absorption bands of  $\text{Eu}^{3+}$ . Fluorescence was observed from the  $^5\text{D}_0$  state to levels of the  $^7\text{F}$  multiplet.

**19546.** Nyyssonen, D., Jerke, J. M., **Linewidth measurement: From fine art to science**, *Proc. Int. Electron Devices Meeting, Washington, DC, Dec. 4-6, 1978*, 78CH1324-3ED, pp. 437-440 (Electron Devices Society of Institute of Electrical and Electronics Engineers, New York, NY, 1978).

Key words: linewidth measurement; microlithography; micrometrology; microscopy.

Traditional methods of linewidth measurement on integrated circuit photomasks and wafers have employed an optical microscope with some type of measuring eyepiece. In recent years, the push to finer line geometries has revealed systematic measurement differences between instruments as large as  $1.0 \text{ }\mu\text{m}$ . Modeling of linewidth measurement systems has shown that

these differences may be attributed to differences in edge detection criteria. New techniques have been developed at the NBS for accurate optical edge detection and calibration of other optical linewidth measurement systems.

**19547.** Wise, S. A., Bonnett, W. J., May, W. E., **Normal and reverse-phase liquid chromatographic separations of polycyclic aromatic hydrocarbons**, (Proc. 4th Int. Symp. on Polynuclear Aromatic Hydrocarbons, Columbus, OH, Oct. 4-6, 1979), Paper in *Polynuclear Aromatic Hydrocarbons: Chemistry and Biological Effects*, A. Bjorseth and A. Dennis, Eds., pp. 791-806 (Battelle Press, Columbus, OH, 1980).

Key words: air particulates; high performance liquid chromatography (HPLC); normal-phase HPLC; polycyclic aromatic hydrocarbons (PAH); retention data; reverse-phase HPLC.

The high performance liquid chromatographic (HPLC) retention indices, based on polycyclic aromatic hydrocarbon (PAH) standards, are reported for over 80 PAH on two octadecylsilane ( $\text{C}_{18}$ ) reverse phase columns and on an aminosilane ( $\text{NH}_2$ ) column. Several  $\text{C}_{18}$  reverse phase columns were compared and found to have different selectivities for PAH. Normal phase HPLC on an  $\text{NH}_2$  column and reverse phase HPLC on a  $\text{C}_{18}$  column were utilized to analyze a mixture of PAH extracted from urban air particulates.

**19548.** Margolis, S. A., Schaffer, R., **Reverse phase liquid chromatographic analysis of the impurities in nicotinamide adenine dinucleotides**, *J. Liq. Chromatogr.* 2, No. 6, 837-849 (1979).

Key words: impurities; nicotine adenine dinucleotides; reversed phase liquid chromatography.

Commercial preparations of several different nicotine adenine dinucleotides were examined by liquid chromatography on an octadecylsilane column (Margolis, S., et al., *Clin. Chem.*, 22, 1322, 1976). Seven impurity peaks were detected in  $\text{NADP}^+$ , eight in  $\text{NADPH}$ , and five in  $\text{NAD}^+$ . The estimated purity of  $\text{NADP}^+$  from different commercial suppliers varied from 89 to 95 percent. For  $\text{NADPH}$  the purity ranged from 77.5 to 96 percent and for  $\text{NAD}^+$  from 90 to 93.5 percent. Preparations of  $\text{NAD}^+$  contained AMP, ADPR, nicotinamide, and two unidentified impurities. The impurities found in  $\text{NADP}^+$  and  $\text{NADPH}$  preparations did not correspond to compounds that we could identify. Four of the impurity peaks found in  $\text{NADPH}$  form under acidic storage conditions. Five of the impurity peaks observed in  $\text{NADP}^+$  and three of the impurity peaks in  $\text{NAD}^+$  form as products of alkali-catalyzed rearrangements.

**19549.** Batts, M. E., Cordes, M. R., Simiu, E., **Sampling errors in estimation of extreme hurricane winds**, (Proc. ASCE Engineering Mechanics Division Specialty Conf., Austin, TX, Sept. 17-19, 1979), *J. Struct. Div.* 106, No. ST10, 2109-2115 (Oct. 1980).

Key words: climatological sampling errors; hurricanes; simulation sampling errors; wind loads.

An investigation is presented into the magnitude of sampling errors in the estimation of extreme hurricane winds by Monte Carlo methods. It is shown that the coefficient of variation of the sampling errors is of the order of 10% for wind speeds with mean recurrence intervals of the order of 50 years.

Results of calculations are presented showing the influence upon the estimates of the number of climatological data and the number of simulated hurricanes.

**19550.** Tobler, R. L., Mikesell, R. P., Reed, R. P., **Cryogenic effects on the fracture mechanics parameters of ferritic nickel alloy steels**, *Am. Soc. Test. Mater. Spec. Tech. Publ.* 677, pp. 85-105 (1979).



Key words: fatigue (materials); fracture (materials); low temperature tests; mechanical properties; nickel alloys; steels.

Fracture toughness ( $K_{Ic}$ ,  $J_{Ic}$ ) and fatigue-crack growth ( $da/dN$ ) data for quenched and tempered low-carbon ferritic 3.5 Ni and 9 Ni steels were measured at temperatures between 295 and 4 K. The tests were performed using 25- and 31-mm-thick compact specimens having fracture planes parallel to the rolling direction (TL orientation). The fracture toughness results for both steels showed qualitatively similar trends: at decreasing temperatures below 295 K,  $J_{Ic}$  increased by about 20 percent prior to the onset of classical ductile-to-brittle transitions involving cleavage. The transitions occurred between 172 and 100 K for 3.5 Ni steel, and between 76 and 4 K for 9 Ni steel. Transitional behavior also was evident in the fatigue crack growth behavior. The room-temperature fatigue crack growth rates for these nickel steels are typical of ferritic steels, but the rates at subtransition temperatures are accelerated drastically, in association with cleavage and other brittle cracking modes. Data comparisons between the 3.5 Ni and 9 Ni steels tested here and other nickel alloy steels are included.

**19551.** Eisenhower, E. H., **Standardization: Where we have been and where we are going**, Paper in *Health Physics: A Backward Glance*, pp. 185-196 (Pergamon Press Inc., Elmsford, NY 10523, Apr. 1980).

Key words: history; ionizing radiation; measurements; measurement standards; radiation; radiation hazards; radiation safety; radiation standards; standardization; standards.

This paper summarizes the history of efforts in the United States to place measurements of ionizing radiation on a common reference basis. The need for such actions was generally stated in the founding documents of the country. Some of the key actions taken in the area of radiation began in 1913, when a radium standard arrived at the National Bureau of Standards. Early applications of radiation didn't include adequate recognition of associated health hazards. In the late 1920's, NBS began to develop x-ray and radium protection standards, as well as physical measurement standards. Although most of the radium concoctions were worthless, beneficial use of radiation for therapeutic purposes began during this period. As applications expanded, the need for increased NBS services was felt. Present services are summarized, and trends which will influence the nature of future NBS programs are described.

**19552.** Muria, S., Wenzel, J., Sanders, D., **Vaporisation in an unstirred soda—lime—silica glass melt**, *Phys. Chem. Glasses* **21**, No. 4, 150-155 (Aug. 1980).

Key words: carrier gas saturation; diffusion in melt; glass; incongruent vaporization; surface depletion; transpiration; unstirred glass melt; vapor density; vaporization.

Vaporisation of a 16—10—74 soda—lime—silica glass was studied by following the mass loss of an unstirred melt in a transpiration experiment at 1335 °C using a nitrogen-water carrier gas. Measurements were made at twelve carrier gas flow rates between 20 and 2500 ml/min. A large number of sample boats was included to verify that the carrier gas was saturated with glass vapour at all flow rates.

At the lowest flow rate the sodium vapour density had a value characteristic of the stirred melt. As the flow rate increased to 800 ml/min, the vapour density decreased monotonically to about half of its stirred value, and at higher flow rates, the vapour density remained constant. For a congruently vaporising substance this behaviour would indicate that carrier gas saturation and the absence of gas phase diffusion were achieved only at flow rates in excess of 800 ml/min. However, independent tests showed saturation at all flow rates and the absence of diffusion at low flow rates, so an alternative explanation must be introduced. One such possibility involves steady state incongru-

ent vaporisation and the assumption that the vapour density varies with the surface composition: the carrier gas depletes the glass surface of sodium oxide, and higher flow rates deplete the surface more, thus lowering the vapour density, until finally the liquidus composition is reached at a flow rate of 800 ml/min. For faster flow rates the sodium and calcium oxide concentration at the liquidus are maintained by precipitation of a silica-rich phase, resulting in a constant vapour density level.

**19553.** Behrens, J. W., **Systematics of fission cross sections in the MeV range—An update**, (Proc. 1980 Annual Meeting American Nuclear Society, Las Vegas, NV, June 9-12, 1980), *Transactions (TANSO 34 1-899)* **34**, 770-771 (1980).

Key words: fission cross sections; MeV range; neutron-induced; systematics.

A study has shown straightforward systematic behavior as a function of constant proton and neutron number for neutron-induced fission cross sections of the actinide elements in the incident-neutron energy range 3-5 MeV. These trends are re-examined for a total of 57 isotopes of elements ranging from radium through einsteinium.

**19554.** Cohen, A., Hertz, H. S., Mandel, J., Paule, R. C., Schaffer, R., Sniegoski, L. T., Sun, T., Welch, M. J., White, E., **Total serum cholesterol by isotope dilution/mass spectrometry: A candidate definitive method**, *Clin. Chem.* **26**, No. 7, 854-860 (1980).

Key words: cholesterol; definitive method; gas chromatography/mass spectrometry; isotope dilution/mass spectrometry; reference method; statistical analysis; total serum cholesterol.

A highly accurate and precise method for the determination of serum cholesterol using isotope dilution mass spectrometry is described. The method was developed for a study group of the AACC Standards Committee for use in establishing the accuracy of a candidate reference method, and fulfills their criteria for a definitive method.

Cholesterol-d<sub>7</sub> is added to serum, keeping the ratio of it to the total cholesterol near to 1:1. The esters are hydrolyzed and the cholesterol is separated and converted into the trimethylsilyl ether derivative for GC/MS. The intensity ratio of the molecular ions at  $m/z$  465 and 458 is measured for the derivative from each sample and two bracketing calibration mixtures, according to a prescribed protocol.

The method was applied to 5 serum pools over several weeks. Statistical analysis shows excellent overall precision: the coefficient of variation for a single measurement is 0.36%. The absence of interferences in our method was demonstrated by measurements at several other masses.

**19555.** MacCrehan, W. A., Durst, R. A., Bellama, J. M., **Electrochemical detection in liquid chromatography: Application to organometallic speciation**, *Anal. Lett.* **10**, No. 14, 1175-1188 (1977).

Key words: electrochemical detector; high performance liquid chromatography; methylmercury; organometals; speciation.

The development of a new technique for the measurement of organometallic species is presented. It combines the resolution of high performance liquid chromatography with sensitive electrochemical detection used in a reductive mode. Past difficulties with this detection system have been overcome including the choice of a suitable working electrode and purification of the solvent.

**19556.** Kaufman, V., Artru, M. C., **Wavelengths and energy levels of quadruply ionized magnesium (Mg<sup>IV</sup>)**, *J. Opt. Soc. Am.* **70**, No. 9, 1135-1139 (Sept. 1980).



Key words: configuration interaction; energy levels; magnesium; wavelengths.

The spectrum of  $\text{Mg}^{4+}$  was observed between 95 and 400 Å. New wavelengths result in revised-energy level values and some resolved term structure. Parametric calculations with configuration interaction were made for the  $2s2p^5$ ,  $2s^22p^33s$ , and  $2s^22p^33d$  configurations. These support rejection of some levels and some new identifications.

19557. Prats, F., Harper, E. P., Maximon, L. C., Reaction  $^3\text{He}(\gamma, 2p)n$  at intermediate photon energies, *Phys. Rev. C* **22**, No. 1, 7-16 (July 1980).

Key words: Coulomb effects; intermediate energy calculation; three-nucleon photodisintegration of  $^3\text{He}$ .

Proton energy distributions and the differential cross section for the reaction  $^3\text{He}(\gamma, 2p)n$  for incident photon energies between 80 and 120 MeV have been calculated. In order to compare with available experimental data, we consider the situation in which both protons emerge close to a direction perpendicular to the incident photon beam. It is shown that in that case the dominant contribution is given by the direct breakup of  $^3\text{He}$  into a free neutron and an interacting singlet  $p$ - $p$  pair. The nucleon momentum distribution in  $^3\text{He}$  used in the calculation is obtained from a phenomenological fit to momentum distributions observed in quasifree ( $p, 2p$ ) scattering experiments on  $^3\text{He}$ . If the Coulomb interaction between protons is ignored, the calculated energy distribution agrees, at lower photon energies ( $\sim 50$  MeV), with previous calculations in which the nuclear interaction was included fully in the final state, but only the dipole electromagnetic operator was included. The Coulomb interaction changes the shape of the proton energy distribution completely, bringing it and the differential cross section into agreement with the experimental data.

19558. Sniegoski, L. T., Moody, J. R., Determination of serum and blood densities, *Anal. Chem.* **51**, No. 9, 1577-1578 (Aug. 1979).

Key words: blood density; serum density; specific gravity of blood and serum.

A simple semi-micro method for the determination of blood and serum densities was developed. The density values were in good agreement with those obtained by the use of a 10-mL pycnometer.

19559. Cole, B. E., Ederer, D. L., Stockbauer, R., Codling, K., Parr, A. C., West, J. B., Poliakoff, E. D., Dehmer, J. L., Wavelength and vibrational-state dependence of photoelectron angular distributions. Resonance effects in  $5\sigma$  photoionization of CO, *J. Chem. Phys.* **72**, No. 11, 6308-6310 (June 1980).

Key words: angle resolved photoemission; angular distributions; carbon monoxide; CO; photoelectron spectra; photoionization; shape resonance; synchrotron radiation.

Vibrationally resolved photoelectron angular distributions are reported for the  $5\sigma$  channel of CO. The wavelength dependence of the angular distributions of the first four vibrational levels were obtained at 0.5 eV intervals over a photon energy range of 16 to 26 eV. The instrument used monochromatized from the light NBS synchrotron storage ring (SURF) to photoionize CO molecules in the gas phase. The photoelectron angular distributions were measured by rotating a spherical analyzer. The variation in the angular distributions of the different vibrational states as a function of photon energy is interpreted as arising from autoionization in the low energy range and from shape resonance effects in the high energy range.

19560. Fatiadi, A. J., Pseudooxocarbons. Synthesis of 1,2,3-tris(dicyanomethylene) croconate salts. A new bond-delocalized dianion, croconate blue, *J. Organ. Chem.* **45**, No. 7, 1338-1339 (Mar. 1980).

Key words: acid; aromatic; bond-delocalized; croconic; dianion; malononitrile; nonbenzenoid; pseudooxocarbons; salt; synthesis.

The synthesis and characterization of new bond-delocalized dianions, e.g., 1,2,3-tris(dicyanomethylene) croconate salts have been described. The dianions reported are new additions to the aromatic oxocarbons, and represent a new class of aromatic, nonbenzenoid compounds, named pseudo-oxocarbons.

19561. Bowers, G. N., Jr., McComb, R. B., Christensen, R. G., Schaffer, R., High-purity 4-nitrophenol: Purification, characterization, and specifications for use as a spectrophotometric reference material, *Clin. Chem.* **26**, No. 6, 724-729 (1980).

Key words: enzyme activity; molar absorptivity (molar absorption coefficient).

We describe specifications for high-purity 4-nitrophenol, which is suitable for spectrophotometric standardization. Such a reference material is needed in clinical enzymology to establish the proper molar absorptivity of 4-nitrophenol under final reaction conditions, particularly for measuring alkaline phosphatase activity in human serum. Some lots of 4-nitrophenol available commercially met these specifications, but several did not. The latter can be purified to meet our specifications by recrystallization or sublimation. The molar absorptivity of 4-nitrophenol (35  $\mu\text{mol/L}$ ) in 10 mmol/L NaOH at 25 °C at 401 nm is  $18\,380 \pm 90 \text{ L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$ .

19562. Artru, M. C., Kaufman, V., Additions to the analysis of Al VI, *J. Opt. Soc. Am.* **70**, No. 9, 1130-1135 (Sept. 1980).

Key words: aluminum; configuration interaction; energy levels; sodium; wavelengths.

The spectrum of five-times ionized aluminum was investigated in the 85-113 Å and 100-1500 Å wavelength regions. New energy levels were found in the  $2s^22p^33s$ ,  $3p$ , and  $3d$  configurations. Parametric calculations were made for the  $2s^22p^33p$  configuration. They were also done for the interacting  $2s2p^5$ ,  $2s^22p^33s$ , and  $2s^22p^33d$  configurations in both Na IV and Al VI. The results are compared with similar calculations in Mg V.

19563. Ledbetter, H. M., Room-temperature elastic constants and low-temperature sound velocities for six nitrogen-alloyed austenitic stainless steels, *Metall. Trans. A* **11A**, 1067-1069 (June 1980).

Key words: elastic constants; iron alloys; low temperatures; magnetic transitions; sound velocities; stainless steels.

Despite large composition differences, ultrasonic-velocity measurements in six nitrogen-strengthened stainless steels show that their elastic constants differ only slightly except as affected by low-temperature magnetic transitions.

19564. Engen, G. F., A review of the six-port network analyzer development at NBS, (Proc. Conf. on Precision Electromagnetic Measurements, Braunschweig, Federal Republic of Germany, June 23-27, 1980), *IEEE Cat. No. 80CH1497-71M*, pp. 323-324 (Institute of Electrical and Electronics Engineers, New York, NY, 1980).

Key words: automatic network analyzer; microwave measurements; six-port.

In recent years a network analyzer, providing both amplitude and phase, has been developed which is based upon the use of a non-ideal six-port network and four detectors which provide amplitude response only. The interest in this method is reflected by a bibliography of more than forty items which span the past seven years.

This paper will review this development, highlight the important features, and identify remaining problem areas.



**19565.** Savitsky, R., **Determining cost effectiveness of automatic typewriters**, *J. Syst. Manage.* **31**, No. 2, 28-31 (Feb. 1980).

Key words: automatic typewriters; cost effectiveness; typewriter evaluation; typewriter productivity; typewriters; word processing.

In order to justify the acquisition and continuing usage of automatic typewriters, definable criteria for determining their cost effectiveness can be developed and applied in an office. The criteria are based upon the relative costs and productivity of equipment to determine a breakeven level of utilization. The assumed benefit of automatic word processing equipment is in saved staff hours in the preparation of text. If the labor saved compensates for increased equipment costs, the automatic typewriter would be considered as cost effective.

The analysis can be simplified by constructing graphs showing how intensively office equipment should be used so as to reach cost effectiveness. This would facilitate analysis of equipment.

Decision rules for evaluating automatic typewriters can thus be derived. The decision rules should be useful in that managers would then be in a position to weigh factors affecting cost effectiveness. Managers might not only be able to develop "rules of thumb" helpful in evaluating individual machines, but could also have a better awareness of what factors are to be considered in making recommendations on office equipment configurations throughout the organization.

**19566.** Bennett, L. H., Watson, R. E., **Parameters in semi-empirical theories of alloy phase formation**, (Proc. Symp. 108th AIME Annual Meeting, New Orleans, LA, Feb. 19-20, 1979), Paper in *Theory of Alloy Phase Formation*, L. H. Bennett, Ed., pp. 390-424 (The Metallurgical Society of AIME, Warrendale, PA, June 1980).

Key words: alloy phase formation; alloy stability; atomic size; electronegativity; heats of formation; structural stability.

Many theories of alloy solubility, structural stability of compounds, and heats of formation in alloying rely on parameters such as valence, size or electronegativity for their predictions. Nature, of course, requires only one parameter, the nuclear charge, to completely specify all the electronic properties of the elements. Thus, the atomic parameters are, of necessity, intimately connected with one another. It is our object in this presentation to review the physical origins of some of the more popular parameters used. We will emphasize the relationship of the different electronegativity scales to each other, and the relationship of electronegativity to other parameters such as atomic size. Structural stability maps employing electronegativity and some other parameters are shown for intermetallic compounds formed from different classes of elements: main group-main group, transition metal-main group, and transition metal-transition metal.

**19567.** Watson, R. E., Bennett, L. H., **What's special about transition metals in alloy phase formation?**, (Proc. Symp. 108th AIME Annual Meeting, New Orleans, LA, Feb. 19-20, 1979), Paper in *Theory of Alloy Phase Formation*, L. H. Bennett, Ed., pp. 425-450 (The Metallurgical Society of AIME, Warrendale, PA, June 1980).

Key words: alloy phase formation; charge transfer; Coulomb energy; d-electrons; Mossbauer isomer shifts; transition metals.

The d-electrons are, of course, special, though their bonding properties remain to be completely understood. It has been recognized, since the work of the Friedel school, that d-band broadening is the dominant term contributing to transition metal cohesion. Similarly, it is generally recognized that in compound formation between transition-metals and polyvalent metals, hy-

bridization between d-bands and polyvalent atom p-bands is of energetic significance (for example there is such a term in Miedema's scheme). What is less generally realized is that d-band hybridization leads to changes in d-electron counts at a transition metal site which are *opposite* in sign to the net charge transfer on or off the site. In this paper we review the "renormalized atom" picture of cohesion of the pure transition metals and consider the experimental evidence and the theoretical understanding of d-charge transfer going the "wrong way." A picture of the electronegativity of transition metals based on this trend developed. Charge transfer associated with equalizing the local chemical potentials in alloys is estimated. The implications of the experimental charge transfer information from Mossbauer isomer shifts to model alloy calculations and to the strength of the Coulomb energy associated with charge transfer is considered.

**19568.** Ledbetter, H. M., Collings, E. W., **Low-temperature magnetic and elastic-constant anomalies in three manganese stainless steels**, (Proc. Symp. 107th AIME Annual Meeting, Denver, CO, Mar. 2, 1978), Paper in *The Metal Science of Stainless Steels*, E. W. Collings and H. W. King, Eds., pp. 22-40 (The Metallurgical Society of AIME, Warrendale, PA, 1978).

Key words: elastic constants; iron-base alloys; low temperatures; magnetic susceptibility; manganese alloys; Neel transition; physical properties; stainless steels.

Elastic properties of three austenitic stainless steels—Fe-22Cr-13Ni-5Mn, Fe-21Cr-6Ni-9Mn, and Fe-18Cr-3Ni-13Mn—were studied between room temperature and either liquid-nitrogen or liquid-helium temperature. A dynamic (pulse-echo, 10 MHz) method was used to determine longitudinal and transverse sound-wave velocities, which were converted to elastic constants—Young's modulus, shear modulus, bulk modulus, and Poisson's ratio. At low temperatures all the elastic constants are anomalous, correlating with what appear to be spin-glass-type magnetic transitions detected by magnetic-susceptibility measurements. The transition temperatures depend strongly on Mn content. Higher Mn content results in a higher transition temperature and a larger elastic-constant anomaly.

**19569.** White, H. J., Jr., **Fifty years of international cooperation on the properties of steam**, (Proc. 9th Int. Conf. Properties of Steam, Munich, Germany, Sept. 10-14, 1979), Paper in *Water and Steam, Their Properties and Current Industrial Applications*, J. Straub and K. Scheffler, Eds., pp. 18-24 (Pergamon Press, New York, NY, 1980).

Key words: critically evaluated data; reference data; steam; water.

Since the 1st International Conference on the Properties of Steam was held in London in 1929, the current 9th International Conference on the Properties of Steam marks the golden jubilee of cooperative international steam research. It is, therefore, a fitting time for a look at research and the preparation of critically evaluated reference data on steam from an historical point of view.

A brief summary will be given of the International Conferences, the activities generated by them, and the development of the International Association for the Properties of Steam, which now serves to organize the International Conferences, provide continuity between conferences, and encourage and coordinate research on the properties of steam and on the chemistry of steam power cycles.

**19570.** Alvarez, R., Rook, H. L., **NBS standard reference materials 1567, Wheat Flour, and 1568, Rice Flour, certified for concentrations of selected trace element nutrients and environmentally important constituents**, *Proc. Tenth Natl. Conf. on Wheat Utilization Research*, Tucson, AZ, Nov. 16-18, 1977, pp. 156-162 (Office of the Regional Administrator for Federal



Research (Western Region), Science and Education Administration, U.S. Dept. of Agriculture, Berkeley, CA 94705, Aug. 1978).

**Key words:** environmental trace elements; NBS standard reference materials; SRM 1567, Wheat Flower; SRM 1568, Rice Flower; trace element nutrients.

The National Bureau of Standards has issued two unfortified flour Standard Reference Materials—a bleached wheat flour and a rice flour. The Certificates of Analysis for SRM 1567, Wheat Flour, and SRM 1568, Rice Flour list concentration values for selected trace element nutrients, environmentally important elements, and other trace elements of undefined function. These SRM's were developed because of the importance of trace elements, which are present in foods at or below the parts-per-million level and because of the difficulty of determining them reliably. The certified reference materials are intended primarily for evaluating the accuracy of these elemental determinations in flours and other cereal foods. They will be useful for developing reliable trace element methods, for calibrating the instrumentation used in these analyses, and for providing certified values to which experimental data acquired at different times by the same or different laboratories can be compared.

**19571.** Alvarez, R., **Report on reference materials and standard solutions**, *Referee Reports: J. Assoc. Off. Anal. Chem.* **61**, No. 2, 323 (1978).

**Key words:** environmental analysis; foliar analysis; food analysis; organic solvents; standard reference material; water analysis.

As General Referee on Reference Materials and Standard Solutions for the Association of Official Analytical Chemists, I have identified SRMs issued by NBS that are applicable to AOAC activities. These include: SRM 1643, a simulated fresh water with certified concentrations of 17 trace elements; SRM 1570, Spinach, and SRM 1575, which are certified for major, minor, and trace constituents; and SRMs 2661-2667, Organic Solvents on Charcoal which have certified amounts of organic toxic agents. The AOAC membership has been requested to communicate requirements for new SRMs.

**19572.** Bertocci, U., **Applications of a low noise potentiostat in electrochemical measurements**, *J. Electrochem. Soc.* **127**, No. 9, 1931-1934 (Sept. 1980).

**Key words:** aluminum; copper; impedance measurements; noise measurements; pitting; potentiostat.

Measurements on two electrochemical systems, copper in copper sulfate and aluminum in boric acid: sodium tetraborate buffer with and without chloride added, have been carried out employing a low-noise potentiostat developed and built at NBS by recording the amplitude spectrum of the fluctuations in the current density. In the case of copper, the current spectra resulted to be the deterministic response of the electrode to the noise voltage generated by the potentiostat. The electrode characteristics for charge-transfer and for diffusion could be obtained from the impedance plots derived from the measurements when the level of the applied signal was of the order of  $10^{-7}$  V. In the case of aluminum, the deterministic response observed in the absence of pitting was overcome by random fluctuations in the current in conditions leading to pitting. It is shown that the onset of pit formation can be detected from noise measurements. The significance of the information obtained in electrochemical noise measurements is briefly discussed.

**19573.** Kelley, R. D., Cavanagh, R. R., Rush, J. J., Madey, T. E., **Neutron inelastic scattering study of  $C_2H_4$  adsorbed on Raney nickel**, *Surf. Sci.* **97**, L335-L338 (1980).

**Key words:** catalyst; chemisorbed  $C_2H_4$ ; neutron inelastic scattering; Raney nickel; vibrational spectrum.

We report here the use of neutron inelastic scattering (NIS) in a study of the chemisorption of ethylene on a high area Raney Ni catalyst. In this preliminary account, a reduced Raney Ni sample was exposed to  $C_2H_4$  at 143 K, warmed to 300 K, and subsequently cooled to 77K for the measurement of the vibrational loss spectrum.

**19574.** Uriano, G. A., **The use of standard reference materials for quality assurance of environmental measurements**, *Proc. Natl. Conf. on Quality Assurance of Environmental Measurements*, Denver, CO, Nov. 27-29, 1978, pp. 23-30 (Information Transfer, Inc., 9300 Columbia Blvd., Silver Spring, MD 20910, 1979).

**Key words:** definitive methods; environmental measurements; quality assurance; reference methods; standard reference materials.

Standard Reference Materials (SRMs) are well characterized, homogeneous materials (or simple artifacts) with specific properties (e.g., chemical composition) measured and certified by the National Bureau of Standards (NBS). Over 900 different SRMs are now available from NBS for use in a variety of measurement applications including: (1) calibration of measurement instruments and methods, (2) assurance of intra-laboratory measurement quality control, and (3) assurance of long-term interlaboratory measurement compatibility. During the last year, NBS distributed over 37,000 SRM units to approximately 10,000 users throughout the world. Over 75 SRMs are now available for use in environmental measurement applications. Available environmental SRMs now include: (1) analyzed gas mixtures used for applications involving monitoring of ambient air, stationary sources and mobile sources, (2) a series of trace element and organic compositional standards for analyzing toxic substances in a variety of matrices such as coal, oil, fly ash, water, botanical and biological materials, and (3) a number of radionuclide standards certified for  $\alpha$ - and  $\beta$ -particle or  $\gamma$ -ray emission rates, which are used for the calibration of counting equipment and low-level monitoring of radioactive substances in the environment. In addition to their direct use in measurement and quality assurance systems, SRMs also help assure the establishment of a sound measurement basis necessary for the development and enforcement of fair and equitable environmental regulations.

**19575.** Uriano, G. A., **The NBS Standard Reference Materials program: SRMs today and tomorrow**, *Am. Soc. Test. Mater. Stand. News* **7**, No. 9, 8-13 (1979).

**Key words:** definitive methods; measurement compatibility; reference methods; standard methods; standard reference materials.

Some general concepts related to the development, certification and use of SRMs are presented. The role of SRMs together with reference methods of test or analysis in assuring the compatibility of measurements is discussed. The use of NBS thermal resistance SRMs for fiberglass insulating materials together with ASTM Standard Methods in the first National Laboratory Accreditation Program is given as an example of the systems approach to accurate measurement. The major changes in the NBS Standard Reference Materials (SRMs) inventory during the last decade are reviewed. The current status of the inventory is summarized as are future plans for the production of new SRMs.

**19576.** Hosler, W. R., White, G. S., Negas, T., **Electrical conductivity mechanisms in iron-containing slags**, *Proc. 7th Int. Conf. on MHD Electrical Power Generation*, Massachusetts Institute of Technology, Cambridge, MA, June 16-20, 1980, pp. 220-225 (1980).

**Key words:** coal slag; conductivity; electrical; electrical conductivity; ferric; ferric/ferrous ratio; ferrous; ionic; ionic conductivity; magnetohydrodynamics iron; MHD; silicates.



Understanding the electrical conductivity of coal slags of various compositions and the effect of current transport on the underlying materials at conditions found in an MHD generator channel is essential to the success of a generating power system. A unique method for determining the electrical conductivity of coal slag has been developed which eliminates the errors usually encountered due to surface oxidation or reduction and slag creep over the sides of the boat or slag container. Slag conductivities at high temperatures (above 1400 °C) are independent of oxygen pressure and of seed content up to amounts likely to be incorporated in the slag in an operating channel. The lack of O<sub>2</sub> pressure dependence of the conductivity implies that the iron ion charge ratio is also not a dominant factor in the conductivity magnitude at high temperature. The Fe<sup>2+</sup>/Fe<sup>3+</sup> ratio in Bow, NH slag has been determined by wet chemistry methods after the slag was treated at a series of temperatures and quenched to room temperature. Equilibration times at these temperatures have been determined. As expected, the iron ion ratio (i.e., the charge state of the iron in slag) is a function of temperature in air. It appears that the movement of iron ions is the primary factor in the high temperature conductivity due mostly to the higher inherent charge and small size of the iron ions in comparison with potassium. At lower temperatures, where the slag is no longer liquid, the conductivity depends on the crystalline state of the component materials.

**19577.** Rosasco, G. J., Roedder, E., **Application of a new Raman microprobe spectrometer to nondestructive analysis of sulfate and other ions in individual phases in fluid inclusions in minerals**, *Geochim. Cosmochim. Acta* **43**, 1907-1915 (1979).

Key words: chemical analysis; fluid inclusions; gemmology; microanalysis; mineralogy; Raman spectroscopy.

Rosasco *et al.* (1975), reported the first successful application of laser-excited Raman spectroscopy for the identification and nondestructive partial analysis of individual solid, liquid, and gaseous phases in selected fluid inclusions. We report here the results of the application of a new instrument, based on back-scattering, that eliminates many of the previous stringent sample limitations and hence greatly expands the range of applicability of Raman spectroscopy to fluid inclusions.

Fluid inclusions in many porphyry copper deposits contain 5-10 µm 'daughter' crystals thought to be anhydrite but too small for identification by the previous Raman technique. Using the new instrument, we have verified that such daughter crystals in quartz from Bingham, Utah, are anhydrite. They may form by leakage of hydrogen causing internal autooxidation of sulfide ion. Daughter crystals were also examined in apatite (Durango, Mexico) and emerald (Muzo, Colombia).

Valid analyses of sulfur species in solution in small fluid inclusions from ore deposits would be valuable, but are generally impossible by conventional methods. We present a calibration procedure for analyses for SO<sub>4</sub><sup>2-</sup> in such inclusions from Bingham, Utah (12,000 ± 4000 ppm) and Creede, Colo. (probably <500ppm). A fetid Brazilian quartz, originally thought to contain liquid H<sub>2</sub>S, is shown to contain only HS<sup>-</sup> in major amounts.

**19578.** Feldman, A., **Bistable optical systems based on a Pockels cell**, *Opt. Lett.* **4**, 115-117 (Apr. 1979).

Key words: optical bistability; optical power regulator; Pockels cell; ultralinear modulator.

The performance of a bistable intensity modulator based on a Pockels cell can be optimized if a voltage proportional to a linear combination of input and output intensities is applied to the Pockels cell. The bistable response can more closely approximate a step function. The output-optical-power regulation can be improved at levels close to the input-power level. The operating point of an ultralinear modulator can be maintained at the most linear portion of the response curve. Some of the

above features are demonstrated experimentally. Analogous modifications can be made to advantage on other bistable optical systems.

**19579.** Feldman, A., Waxler, R. M., **Strain-induced splitting and oscillator-strength anisotropy of the infrared transverse-optic phonon in calcium fluoride, strontium fluoride, and barium fluoride**, *Phys. Rev. Lett.* **45**, No. 2, 126-129 (July 1980).

Key words: anisotropy; BaF<sub>2</sub>; CaF<sub>2</sub>; effective charge; oscillator strength; photoelastic; piezo-birefringence; piezo-optic; SrF<sub>2</sub>; strain; stress; transverse optic-phonon.

Strain-induced splittings of the infrared-active TO phonon in CaF<sub>2</sub>, SrF<sub>2</sub>, and BaF<sub>2</sub> are calculated from a least-squares fit of photoelastic dispersion data by an undamped oscillator model. The strain-induced oscillator-strength anisotropy appears negligible; the Szigeti effective charge remains a scalar. The shear deformation potential for [100] strain is ~170 cm<sup>-1</sup> in all the materials; for [111] strain it is -82 cm<sup>-1</sup> for CaF<sub>2</sub>, -54 cm<sup>-1</sup> for SrF<sub>2</sub>, and -50 cm<sup>-1</sup> for BaF<sub>2</sub>.

**19580.** Bell, M. I., **Effects of stress on the Raman-active modes in semiconductors**, *Proc. VIIIth Int. Conf. on Raman Spectroscopy, Ottawa, Canada, Aug. 4-9, 1980*, pp. 76-77 (North-Holland Publ. Co., Amsterdam, The Netherlands, Aug. 1980).

Key words: covalent bonding; diamond structure; elastic constants; gallium arsenide; indium antimonide; ionicity; optical phonons; Raman scattering; semiconductors; stress; zinc-blende structure.

Previous calculations of the stress dependence of the Raman frequencies of covalent (diamond-structure) semiconductors are extended to include the effects of electrostatic interactions in partially ionic (zinc-blende structure) crystals. Results are obtained for GaAs and InSb which agree as well with experiment as those obtained previously for silicon, germanium, and diamond.

**19581.** Cassatt, W., **Atmospheric particulate measurement development at the National Bureau of Standards**, *Proc. 25th Annual Technical Meeting, "Learning To Use Our Environment," Seattle, WA, Apr. 30-May 2, 1979*, pp. 275-277 (The Institute of Environment Sciences, 940 East Northwest Highway, Mt. Prospect, IL, 1979).

Key words: aerosols; atmospheric particulate measurements; Doppler shift spectrometry; fine particles; micro Raman spectrometry; Raman scattering theory; standard reference materials; urban particulate standards.

The atmospheric particulate measurement development efforts at the National Bureau of Standards focus upon three areas, namely experimental measurement techniques, Standard Reference Materials (SRMs) and theory. Areas of application that are addressed by Bureau scientists in their atmospheric particulate measurement research include smoke particle characterization, the sizing of particles produced by aerosol generators, the calibration of fine particle detectors, standards for urban dust analysis, chemical characterization of bulk samples or discrete particles collected from atmospheric aerosols, and the investigation of resonance absorption of light by micrometer size particles.

**19582.** Heuer, A. H., Tighe, N. J., Cannon, R. M., **Plastic deformation of fine-grained alumina (Al<sub>2</sub>O<sub>3</sub>): II, basal slip and nonaccommodated grain-boundary sliding**, *J. Am. Ceram. Soc.* **63**, No. 1-2, 53-58 (Jan.-Feb. 1980).

Key words: alumina; basal slip; cavitation; deformation texture; electron microscopy; grain boundary sliding; plastic deformation.

Plastic deformation was studied in fine-grained alumina polycrystals (grain sizes 1 to 5 µm); several deformation mechanisms occur simultaneously. This paper is concerned with basal slip



and unaccommodated grain-boundary sliding (GBS). The basal slip can give rise to a deformation texture. Cavitation occurs due to the occurrence of both unaccommodated GBS and basal slip, because of the marked plastic anisotropy of alumina.

- 19583.** Rosasco, G. J., Blaha, J. J., **Raman microprobe spectra and vibrational mode assignments of talc**, *Appl. Spectrosc.* **34**, No. 2, 140-144 (1980).

Key words: Raman spectroscopy; talc; vibrational mode.

The Raman spectra of talc microparticles have been obtained with the Raman microprobe over the frequency range 100 to 3800  $\text{cm}^{-1}$ . The vibrational modes are discussed in terms of an idealized unit cell (1-M polymorph) of  $C_{2h}$  symmetry. An electrostatic dipole-dipole interaction is used to compare the Raman and infrared active branches. Assignments of the Raman active stretching modes of the silicate sheet are found to support previous infrared assignments. Estimates of intrasheet dipole-dipole interactions are obtained.

- 19584.** Lawn, B. R., Hockey, B. J., Wiederhorn, S. M., **Thermal effects in sharp-particle contact**, *J. Am. Ceram.—Discussions and Notes* **63**, No. 5-6, 356-358 (May-June 1980).

Key words: adiabatic heating; elastic-plastic contact; glass; indentation; surface melting.

At sufficiently high loading rates, the penetration of solid surfaces with sharp indenters or particles often results in melting at the contact site. This phenomenon can be explained in terms of localized energy dissipation during elastic-plastic contacts. In this paper, a model describing the adiabatic temperature rise is developed in terms of indentation theory, with specific reference to contact data for soda-lime-silicate glass.

- 19585.** Brown, D. W., Lowry, R. E., Smith, L. E., **Kinetics of hydrolytic aging of polyester urethane elastomers**, *Macromol.* **13**, No. 2, 248-252 (Mar.-Apr. 1980).

Key words: hydrolytic degradation; polyester urethane elastomers.

The hydrolytic degradation of polyester urethane elastomers is due to the acid-catalyzed hydrolysis of the ester group. Acid content ( $A$ ) and the reciprocal of the number average molecular weight ( $M^{-1}$ ) increase by equivalent amounts indicating that each molecular chain scission produces one acid group. The time ( $t$ ) dependence of  $A$  and  $M$  is given by  $A = A_0 e^{kt}$  and  $M^{-1} = M_0^{-1} + A_0(e^{kt} - 1)$ , where the subscripts denote initial values. The fractional rate of increase in acidity,  $k$ , is a pseudo-first-order rate constant because the ester and water contents change only slightly with degradation. Values of  $k$  at 85 °C and 100% relative humidity are in the range 15-20% per day for polyurethanes, based on poly(caprolactone and tetramethylene adipate diols). At 100% relative humidity  $k$  obeys the Arrhenius equation between 35 and 85 °C with activation energies in the range 68-83 kJ/mol (16-20 kcal/mol). Values of  $k$  decrease with relative humidity, becoming zero in dry air.

- 19586.** Stein, S. R., **Space applications of superconductivity: Resonators for high stability oscillators and other applications**, *Cryogenics* **22**, No. 7, 363-372 (July 1980).

Key words: aerospace; frequency standards; high-Q cavities; navigation; oscillator; ranging; resonators; superconductivity.

This is the last in a seven part series on the potential applications of superconductivity in space. Superconducting oscillators have achieved better frequency stability than any other device for averaging times of 10 s to 1000 s. This high stability results from the use of solid niobium resonators having Q factors greater than  $10^{10}$ . Such oscillators have direct applications as clocks and spectrally pure sources. They may also be used for accurate measurements of many physical quantities and to perform a

variety of experiments on fundamental constants, relativity, and gravity waves.

- 19587.** Unassigned.

- 19588.** Fuller, E. R., Jr., Thomson, R., **Theory of chemically assisted fracture. Part 2—Atomic models of crack growth**, *J. Mater. Sci.* **15**, 1027-1034 (1980).

Key words: atmosphere-assisted slow crack growth; chemically assisted fracture; fracture; fracture models; reaction rate theory; slow crack growth; surface chemistry.

In this concluding paper of a two-paper series, we have applied the one-dimensional model of a crack to the problem of the simple form of chemically assisted fracture when the external atmosphere is composed of diatomic molecules. Predictions of the stress dependence can be made on the basis of this model which show a power law dependence whose exponent varies from 3/2 to 2 depending on the form of the atomic bonds of the solid. General conclusions are that chemical activity accentuates and extends the intrinsic slow crack growth phenomenon because of the surface adsorption activation barrier, and that the "chemical" and "mechanical" contributions to the activation energy for slow crack growth are not separable.

- 19589.** Wiederhorn, S. M., Lawn, B. R., **Strength degradation of glass impacted with sharp particles: I, annealed surfaces**, *J. Am. Ceram. Soc.* **62**, No. 1-2, 66-70 (1979).

Key words: ceramics; fracture: impact energy; strength degradation.

The strength characteristics of annealed brittle surfaces impacted with sharp particles were studied. A theory of the degradation process is constructed in three steps: (1) A sharp particle delivers an impulsive load to the target surface via a plastic contact; (2) the contact loading initiates and propagates median cracks in the surface; (3) the cracks thus induced reduce the strength of the material. Static indentation tests provide essential contact parameters for the degradation equations, thereby allowing for prediction of strengths under in-service conditions. Strength tests on soda-lime glass laths impacted with SiC grit confirm basic predictions of the theory. Higher toughness and lower hardness are the main material requirements for improved resistance to degradation. Initial flaw population in the target surface and projectile geometry are not important factors in the damage process. The study shows that impact energy is the important service variable in determining the extent of strength loss.

- 19590.** Blaha, J. J., Rosasco, G. J., **Raman microprobe spectra of individual microcrystals and fibers of talc, tremolite, and related silicate minerals**, *Anal. Chem.* **50**, No. 7, 892-896 (June 1978).

Key words: mineralogy; Raman microprobe; Raman spectroscopy; sheet and chain silicates.

With a recently developed Raman microprobe, vibrational spectra have been obtained from individual microcrystals and fibers of sheet and chain silicate minerals. Species such as talc, tremolite, low-iron anthophyllite, and actinolite give distinct spectra. No systematic differences exist between spectra of the fibrous and nonfibrous forms of a given mineral.

- 19591.** Yap, W. T., Cummings, A. L., Margolis, S. A., Schaffer, R., **Estimation of water content by kinetic method in Karl Fischer titration**, *Anal. Chem.* **51**, No. 9, 1595-1596 (Aug. 1979).

Key words: dissolution; Karl Fischer water determination; mass fraction of water; rate constant; saturation; titration curve.



An analytical expression was derived for describing the titration curve obtained by the continuous Karl Fischer determination of water in slow-to-dissolve samples. By fitting the theoretical curve to the experimental results, the amount of water in the sample can be determined. The method is illustrated by the Karl Fischer titration of water in magnesium gluconate and in sucrose.

**19592.** Kaase, H., Stephan, K. H., Burton, W. M., Hatter, A. T., Ridgeley, A., Canfield, L. R., Madden, R. P., **Intercomparison of radiometric irradiance scales in the 90-250-nm wavelength range**, *Appl. Opt.* **19**, No. 15, 2529-2532 (Aug. 1, 1980).

Key words: calibration; detectors; irradiance; light source; photodiode; radiometry.

The work described in this paper covers an intercomparison of absolute irradiance calibration methods applied at the U.S. National Bureau of Standards (NBS), the SRC Appleton Laboratory, Astrophysics Research Division (ARD), the Max-Planck-Institut fuer Extraterrestrische Physik (MPE), and the Physikalisch-Technische Bundesanstalt (PTB). This was done by determining the MPE and PTB quantum efficiencies of two different calibrated transfer standards developed by the NBS and ARD. The comparison shows that the calibrations agreed within the estimated bounds of uncertainty and also suggests that the uncertainty in the measured electron temperature required in the argon arc source technique may be less than was estimated.

**19593.** Currie, L. A., Kunen, S. M., Voorhees, K. J., Murphy, R. B., Koch, W. F., **Analysis of carbonaceous particulates and characterization of their sources by low-level radiocarbon counting and pyrolysis/gas chromatography/mass spectrometry**, *Proc. Conf. on Carbonaceous Particles in the Atmosphere, University of California, Berkeley, CA, Mar. 20-22, 1978*, 13 pages (U.S. Department of Energy, Washington, DC, June 1979).

Key words: atmospheric pollution; carbonaceous particles; fossil carbon; insoluble carbonaceous material; low level counting; pyrolysis/gas chromatography/mass spectrometry; radiocarbon.

The chemical nature and fossil fuel contribution to urban, rural and indoor atmospheric carbonaceous particulate samples have been studied by a combination of pyrolysis/gas chromatography/mass spectrometry, (Py/GC/MS) and low-level miniradiocarbon counting. The latter method is applied here for the first time to just milligram amounts of atmospheric particulate material (~10 mg carbon), and it has shown a striking difference between the biogenic/fossil carbon content of urban and desert samples. Application of Py/GC/MS to the insoluble carbonaceous fraction has provided information on sources and characteristics of the primary carbonaceous material.

**19594.** Wiederhorn, S. M., Lawn, B. R., Hockey, B. J., **Effect of particle impact angle on strength degradation of glass**, *J. Am. Ceram. Soc.* **62**, No. 11-12, 639-640 (Nov.-Dec. 1979).

Key words: ceramics; erosion; glass; impact; indentation fracture; strength.

**19595.** Waterstrat, R. M., Giessen, B. C., Koch, R., Manuszewski, R. C., **The tantalum-palladium constitution diagram**, *Metall. Trans. A* **9A**, 643-648 (May 1978).

Key words: constitution diagram; intermetallic compounds; palladium alloys; phase diagram; phase transformations; tantalum alloys.

The Ta-Pd system was investigated over the entire composition range by metallography, X-ray diffraction and electron microprobe analysis. The solubility limits of terminal and intermediate phases and solidus temperatures were determined.  $\alpha$ -Ta dissolved ~20 at. pct Pd at 255 °C and ~10 at. pct Pd at 1000

°C;  $\alpha$ -Pd dissolves ~22 at. pct Ta at 1730 °C and ~18 at. pct Ta at 1000 °C. The presence of four intermediate phases  $\sigma$ , ( $\beta$ -U type),  $\alpha$ -TaPd (TiCu type), TaPd<sub>2</sub> (MoPt<sub>2</sub> type), and TaPd<sub>3</sub> (TiAl<sub>3</sub> type) was confirmed; they melt or decompose ( $\alpha$ -TaPd) at about 2550, 1410; 1800, and 1770 °C, respectively. In addition, an equiatomic high temperature phase,  $\beta$ -TaPd was found which melts at ~1720 °C and may be an extension of and isomorphous with the  $\alpha$ -Pd solution. Seven three-phase reactions are described.

**19596.** Michel, K. H., Rowe, J. M., **Existence of an orientational glass state in (KCN)<sub>x</sub>(KBr)<sub>1-x</sub> mixed crystals**, *Phys. Rev. B* **22**, No. 3, 1417-1428 (Aug. 1, 1980).

Key words: dipole glass; (KCN)(KBr); order parameter; orientational; strain dipole; translation-rotation.

Recent neutron scattering experiments by Rowe *et al.* on mixed crystals of (KCN)<sub>x</sub>(KBr)<sub>1-x</sub> cannot be explained by a previous dynamic theory by Michel *et al.* The appearance of a narrow central line in the scattering spectrum suggests the onset of an orientational glass state characterized by a freezing in of the CN orientations. Starting from a microscopic lattice dynamical description of the coupling of orientational impurities with acoustic lattice modes, we demonstrate that an orientational freezing in produces a freezing in of lattice strains. We introduce an orientational glass state parameter and a corresponding susceptibility. The neutron scattering law is formulated, taking into account interference between translations and orientations. The orientational glass state and its coupling to the lattice leads to an additional elastic line in the scattering law, the intensity of which reflects the temperature behavior of the order parameter. The bilinear coupling of translations and orientations leads to an explanation of characteristic asymmetries of equal intensity contours of the elastic line in  $Q$  space. The temperature minima in the transverse acoustic-phonon frequencies are related to a cusp in the orientational glass state susceptibility.

**19597.** Kearsley, E. A., **Determining an elastic strain-energy function from torsion and simple extension**, *J. Appl. Phys.* **51**, No. 8, 4541-4542 (Aug. 1980).

Key words: elasticity; elastomers; finite deformation; rubber; strain energy; Valanis-Landel form.

The elastic properties of rubbery materials can often be represented by a strain-energy function expressed as the sum over the three principal extension ratios of a function of a single extension ratio, the Valanis-Landel form. In that case, the strain-energy function can be completely determined from uniaxial extension data combined with data on the torque of a cylinder in torsion. The method is an improvement over other methods for determining the strain-energy function because the necessary experiments are particularly convenient.

**19598.** Hertz, H. S., Brown, J. M., Chesler, S. N., Guenther, F. R., Hilpert, L. R., May, W. E., Parris, R. M., Wise, S. A., **Determination of individual organic compounds in shale oil**, *Anal. Chem.* **52**, No. 11, 1650-1657 (Sept. 1980).

Key words: gas chromatography; liquid chromatography; mass spectrometry; quantitation; shale oil; trace organic analysis.

Several techniques have been investigated for quantitating individual organic compounds in shale oil. Acid-base extraction and high performance liquid chromatography were emphasized as independent methods of shale oil fractionation. Gas chromatography, gas chromatography-mass spectrometry, and high performance liquid chromatography were used for individual compound quantitation utilizing external and/or internal standards or standard addition techniques. The following compounds were measured in the shale oil: pyrene, fluoranthene, benzo[*a*]pyrene, benzo[*a*]pyrene, phenol, *o*-cresol, acridine, and



2,4,6-trimethylpyridine. Comparable results were obtained by the various methods for extraction and quantitation.

- 19599.** Caswell, R. S., Coyne, J. J., Randolph, M. L., **Kerma factors for neutron energies below 30 MeV**, *Radiat. Res.* **83**, No. 2, 217-254 (1980).

Key words: absorbed dose; biology and medicine; kerma factors; neutron dosimetry.

Kerma factors for neutrons have been calculated from thermal neutron energies to 30 MeV. In addition to a "point" at 0.0253 eV, there are 116 contiguous energy bins extending from 0.026 eV to 30 MeV. Values are given for 19 elements or nuclides: H,  $^6\text{Li}$ ,  $^7\text{Li}$ , B, C, N, O, F, Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca, and Fe. The chief source of nuclear data is the Evaluated Nuclear Data File ENDF/B-4. The basis of the calculations is discussed, and comparison is made with some other tabulations.

- 19600.** Huggett, C., **Estimation of rate of heat release by means of oxygen consumption measurements**, *Fire Mater.* **4**, No. 2, 61-65 (1980).

Key words: calorimetry; fire test; heat of combustion; heat release; oxygen consumption; oxygen consumption calorimetry; rate of heat release.

Measurement of the rate of oxygen consumption provides a simple, versatile and powerful tool for estimating the rate of heat release in fire experiments and fire tests. The method is based on the generalization that the heats of combustion per unit of oxygen consumed are approximately the same for most fuels commonly encountered in fires. A measurement of the rate of oxygen consumption can then be converted to a measure of rate of heat release. Data on heats of combustion are presented to support this generalization. The applicability of the technique to combustion under fire conditions is examined, possible sources of error in the measurements are discussed, and applications of the method are reviewed. It is concluded that the accuracy of oxygen consumption based rate of heat release measurements should compare favorably with those derived from conventional colorimetric measurements.

- 19601.** Unassigned.

- 19602.** Saloman, E. B., Pearlman, J. S., Henke, B. L., **Evaluation of high efficiency CsI and CuI photocathodes for soft x-ray diagnostics**, *Appl. Opt.* **19**, No. 5, 749-753 (Mar. 1, 1980).

Key words: CsI; CuI; photoabsorption cross sections; photocathodes; plasma diagnostic detectors; radiometry; soft x-ray diagnostics.

The photoefficiency of CsI and CuI photocathodes was measured for photons in the 22–240-eV (50–560-Å) energy range. The within-batch and batch-to-batch variation in photoefficiency were studied as was the sensitivity of the samples to storage under dry nitrogen. The effect of exposure to air was investigated. The shape of the photoefficiency curves was found to agree quite well with the expected from the photoabsorption cross sections of the materials. CsI in particular appears useful as a detector in soft x-ray diagnostics, especially as a narrow-band detector in the 100-eV photon energy range where peak measured efficiencies can exceed 300%.

- 19603.** Rosenstock, H. M., Stockbauer, R., Parr, A. C., **Photoelectron-photoion coincidence study of the bromobenzene ion**, *J. Chem. Phys.* **73**, No. 2, 773-777 (July 15, 1980).

Key words: benzene; benzonitrile ion; coincidence; fragmentation; kinetics; photoelectron; photoionization; unimolecular.

The technique of variable time photoelectron-photoion coincidence mass spectrometry has been applied to the fragmentation

of bromobenzene ion producing a phenyl ion. A detailed analysis of the variation of the breakdown curve with parent ion residence time was performed. The results lead to  $\Delta H^\circ_0(\text{phenyl ion}) = 270$  kcal/mole in close agreement with recalculated results from an earlier study on chlorobenzene. This, combined with other photoionization results leads to  $\Delta H^\circ_0(\text{phenyl radical}) = 83 \pm 3$  kcal/mole, slightly higher than the value  $80.9 \pm 2$  kcal/mole obtained from neutral kinetics. The analysis leads to a rate-energy dependence for the fragmentation process and an equivalent 1000 K Arrhenius pre-exponential factor of  $\sim 9.4 \times 10^{14} \text{ sec}^{-1}$ , which may be compared to the value  $2 \times 10^{15} \text{ sec}^{-1}$  for the analogous neutral process. The possible contribution of spin orbit splitting is discussed.

- 19604.** Koon, N. C., Rhyne, J. J., **RPA theory of magnetic excitations in rare earth-transition metal compounds: Application of  $\text{ErCo}_2$  and  $\text{ErFe}_2$** , *J. Magn. Magn. Mater.* **15-18**, 349-350 (1980).

Key words: crystal fields; exchange interaction; magnetism; neutron scattering; rare earth compounds; spin excitations.

We have calculated the magnetic excitation spectrum and neutron scattering intensities appropriate to the Laves phase compounds  $\text{ErCo}_2$  and  $\text{ErFe}_2$  using standard basis operator Greens functions in the random phase approximation. The results are in excellent agreement with recent neutron inelastic scattering data.

- 19605.** Tighe, N. J., Kuroda, K., Mitchell, T. E., Heuer, A. H., **In situ oxidation of  $\text{Y}_2\text{O}_3$ -doped  $\text{Si}_3\text{N}_4$** , *Electron Microsc.* **1980** **4**, 310-312 (1980).

Key words: ceramic; high voltage electron microscopy; *in situ*; oxidation; silicon nitride; yttria-doped silicon nitride.

Specimens of  $\text{Y}_2\text{O}_3$ -doped  $\text{Si}_3\text{N}_4$  were oxidized in an environmental cell in a 600 kV electron microscope. This ceramic oxidizes passively at temperatures greater than 1000 °C but oxidizes catastrophically at  $\sim 750$  °C. The *in situ* experiments showed that oxidation occurs by nucleation and growth of  $\text{SiO}_2$  and  $\text{Si}_2\text{N}_2\text{O}$  on the  $\beta\text{Si}_3\text{N}_4$  surfaces and by volatilization of W inclusions. The paper discusses the HUEM methodology and the oxidation results.

- 19606.** Rush, J. J., Rowe, J. M., Maeland, A. J., **Neutron scattering study of hydrogen vibrations in polycrystal and glassy  $\text{TiCuH}$** , *J. Phys. F, Lett. to the Ed.* **10**, L283-L285 (1980).

Key words: hydride; interstitial holes; metallic glass; neutron scattering; structure; vibration spectrum.

Neutron vibrational spectra have been measured for both crystalline and amorphous titanium copper hydride from 40-200 meV. A rather narrow distribution of optical (hydrogen) vibrations is observed for the crystalline alloy  $\text{TiCuH}_{0.93}$  with maxima at 142 and 157 meV, very close to previous results for  $\gamma\text{-TiH}_2$ . Amorphous  $\text{TiCuH}_{1.3}$ , however, exhibits a very broad band of hydrogen vibrations ( $\sim 75$  meV FWHM) peaked at about 145 meV. This density of states provides a probe of the local environments of the hydrogen atoms residing in holes in the metallic glass structure and suggests an 'average' occupation of tetrahedral holes, but considerable fluctuations in local symmetry around these sites.

- 19607.** West, J. B., Parr, A. C., Cole, B. E., Ederer, D. L., Stockbauer, R., Dehmer, J. L., **Shape-resonance-induced non-Franck-Condon vibrational intensities in  $3\sigma_g$  photoionisation of  $\text{N}_2$** , *J. Phys. B: Atom. Molec. Phys. Lett. to the Ed.* **13**, L105-L108 (1980).

Key words: branching ratios; Franck-Condon factors; ion; nitrogen;  $\text{N}_2$ ; photoelectron spectra; photoionization; shape resonance; synchrotron radiation; vibrational intensity distribution.



We report a broad pattern of non-Franck-Condon vibrational intensities extending over about 25 eV of the  $3\sigma_g$  photoionisation continuum of  $N_2$ . The effect was recently predicted theoretically to arise from shape-resonance-enhanced coupling between electronic and nuclear motion. Here experiment and theory are compared directly for the first time. Qualitative agreement verifies the basic theoretical concept, yet significant quantitative differences indicate the need for further work.

**19608.** Reader, J., Luther, G., *Spectra of very highly charged Cu- and Zn-like ions*, *Phys. Rev. Lett.* **45**, No. 8, 609-613 (Aug. 25, 1980).

Key words: highly ionized atoms; laser-produced plasma; spectrum; ultraviolet.

The  $4s-4p$ ,  $4p-4d$ , and  $4d-4f$  transitions of ten copperlike and zinclike ions from  $Ba^{26+}$  to  $W^{45+}$  have been observed by means of a laser-produced plasma and a 2.2-m grazing-incidence spectrograph. The spectra are accompanied by a prominent continuum lying just below the  $4p^2P_{1/2}-4d^2D_{3/2}$  transitions in the copperlike ions. The results support the identification of the resonance lines of  $Xe^{24+}$  and  $Xe^{25+}$  in the Princeton University ST tokamak by Hinnov.

**19609.** Lucatorto, T. B., McIlrath, T. J., Mehlman, G., *Time-resolved measurements of the far UV output of a BRV source*, *Appl. Opt.* **18**, No. 17, 2916-2917 (Sept. 1, 1979).

Key words: far ultraviolet; light pulse shape; vacuum spark.

The temporal behavior of the BRV-type vacuum spark source was studied at two wavelengths (300 and 600 Å). The position of the peak output was measured relative to the maximum spark current and values for the pulse width obtained.

**19610.** Burkhalter, P. G., Reader, J., Cowan, R. D., *Spectra of Mo XIII-XVIII from a laser-produced plasma and a low-inductance vacuum spark*, *J. Opt. Soc. Am.* **70**, No. 8, 912-919 (Aug. 1980).

Key words: ion; laser-produced-plasma; molybdenum; vacuum-ultraviolet; wavelengths.

The spectrum of Mo from 20 to 90 Å was obtained with a laser-produced plasma and a low-inductance vacuum spark. Wavelengths and line identifications were determined for transitions of the type  $3d-4p$  and  $3d-4f$  in Mo XIII-XVI and for  $3p-3d$  type transitions in Mo XVI-XVIII. The line identifications were obtained with the aid of relativistically corrected Hartree-Fock calculations. Energy-level diagrams are given for the  $3d^4p$  and  $3d^4f$  configurations of Mo XVI.

**19611.** Unassigned.

**19612.** Rowe, J. M., Rush, J. J., Shapiro, S. M., Hinks, D. G., Susman, S., *Neutron scattering studies of (CN)<sup>-</sup> defects in KBr*, *Phys. Rev. B* **21**, No. 10, 4863-4868 (May 15, 1980).

Key words: defect; KBr; KCN; libration; translation-rotation coupling; tunnelling.

We have studied both the librational and the tunneling excitations of (CN)<sup>-</sup> ions in a KBr matrix through the interaction of these modes with the acoustic phonons of the KBr host. From our measurements on a sample containing 0.00034 mole fraction of KCN in KBr, we find the  $A_{1g}-T_{2g}$  tunnel splitting to be  $0.28 \pm 0.05$  meV ( $2.3 \pm 0.4$  cm<sup>-1</sup>). From measurements on a more concentrated system, 0.0045 mole fraction of KCN in KBr, the  $A_{1g}-E_g$  librational excitation energy is found to be  $1.6 \pm 0.1$  meV ( $13.0 \pm 1.0$  cm<sup>-1</sup>). These values are consistent with the results of optical measurements.

**19613.** Rush, J. J., Rowe, J. M., Glinka, C. J., Vagelatos, N., Flotow, H. E., *Coherent neutron scattering study of the vibrations of interstitial deuterium in  $\alpha$ -VD<sub>0.7</sub>*, *Phys. Rev. B* **21**, No. 12, 5613-5616 (June 15, 1980).

Key words: alloy; elastic constants; interstitial defect; metal hydride; neutron scattering; phonon.

The lattice dynamics of a single crystal of  $\alpha$ (bcc)VD<sub>0.7</sub> have been investigated by *coherent* inelastic neutron scattering measurements at 295 K. Since the scattering cross section of vanadium is almost entirely incoherent, this study offers a unique opportunity to directly measure the "band" modes associated with vibrational displacements of the light atom interstitials as a function of wave vector ( $\vec{k}$ ) and  $\omega$ . Transverse and longitudinal acoustic-phonon groups were observed in the three symmetry directions at energies up to 27 meV. These are generally at higher energies than corresponding modes measured in vanadium by x-ray scattering. The vibrational "density of states" for V and VD<sub>0.7</sub> are also shown to be grossly different. Careful measurement of "band-mode" intensities for several different phonon branches as a function of  $\vec{k}$  and  $\omega$  indicate that the deuterium motions are strongly coupled to the metal lattice. Peaks due to optical vibrations are also observed, which indicate little dispersion of the optic branches in the crystal.

**19614.** Parr, A. C., Stockbauer, R., Cole, B. E., Ederer, D. L., Dehmer, J. L., West, J. B., *An angle resolved photoelectron spectrometer for atoms and molecules*, *Nucl. Instrum. Methods* **172**, No. 1-2, 357-361 (May 15, 1980).

Key words: electron spectrometer; photoelectron spectra; synchrotron radiation.

An angle resolved photoelectron spectrometer has been constructed and coupled to the high throughput 2 m normal incidence monochromator now in operation at SURF-II. The electron analyzer whose design has been previously reported [2] scans the angular distribution of the ejected photoelectrons in a plane perpendicular to the partially polarized exit beam from the monochromator. The intensity of the photon beam from the monochromator is monitored by measuring the photocurrent from a screen in front of a three mirror polarization analyzer which is used to determine the degree of polarization of the photon beam. The function of the spectrometer is under computer control which also acquires and processes the data output from the apparatus. Two novel features are employed to make the system highly effective: one is a capillary which channels the monochromatized output photon beam to the gas-photon-interaction zone and isolates the  $10^{-4}$  vacuum in the spectrometer chamber from the  $10^{-9}$  vacuum in the monochromator; the second feature is high speed cryopump which permits a high density gas jet to interact with the photon beam while maintaining a high enough vacuum to minimize electron scattering and permit operation of the channeltron electron detector. These features combined with output fluxes of  $5 \times 10^{10}$  photons/s<sup>-1</sup> Å<sup>-1</sup> permit vibrationally resolved photoelectron spectra of  $N_2$  and CO to be obtained in about 15 min.

**19615.** Shingleton, J. G., Cassel, D. E., McCabe, M. E., *The use of operational results to identify potential improvements in the thermal performance of air solar heating systems and to establish performance criteria*, *Proc. Conf. Solar Heating and Cooling Systems—Operational Results Colorado Springs, CO, Nov. 27-30, 1979, SERI/TP-245-430*, pp. 203-209 (U.S. Department of Energy/Solar Energy Research Institute (SERI), Golden, CO, 1980).

Key words: air corrections; air leakage; computer simulation; damper leakage; performance criteria; solar heating systems.

The National Bureau of Standards is developing definitive performance criteria for solar heating, cooling, and hot water systems. This study was performed to quantify the effect of air leakage on the thermal performance of air type solar heating systems.

Field air flow measurements taken at seven instrumented residential air type solar heating systems show substantial air leak-



age. A TRNSYS computer model was developed based on the system at one instrumented site where air flow measurements were taken. Air leakage from this system had been reduced as much as possible. The effect of air leakage on system performance was examined analytically by including the measured air leakage in the system model.

The results of the computer simulations show that by eliminating all of the measured air leaks that remained after the modeled system was repaired, a reduction of as much as 19 percent in seasonal auxiliary energy can be realized. The relationship between air leakage and auxiliary energy use in this system is described.

**19616.** Rhyne, J. J., Koon, N. C., Alperin, H. A., **Magnetic excitations in TbFe<sub>2</sub>**, (Proc. Fourteenth Rare Earth Research Conf., North Dakota State University, Fargo, ND, June 25-28, 1979), Paper in *The Rare Earths in Modern Science and Technology*, G. J. McCarthy, J. J. Rhyne, and H. B. Silber, Eds., 2, 313-314 (Plenum Publ. Corp., New York, NY, 1980).

Key words: laves-phase; magnetism; neutron scattering; physics; rare earths; solid state spin waves.

Magnetic excitations in TbFe<sub>2</sub> have been studied by inelastic neutron scattering and the results correlated with calculations based on a linear spin wave theory. Exchange and anisotropy parameters have been obtained and compared with other similar systems.

**19617.** Fish, G. E., Rhyne, J. J., Brun, T., Viccaro, P. J., Niarchos, D., Dunlap, B. D., Shenoy, G. K., Sankar, S. G., Wallace, W. E., **Neutron scattering studies of hydrides of the Laves phase rare earth compounds RFe<sub>2</sub>**, (Proc. Fourteenth Rare Earth Research Conf., North Dakota State University, Fargo, ND, June 25-28, 1979), Paper in *The Rare Earths in Modern Science and Technology*, G. J. McCarthy, J. J. Rhyne, and H. B. Silber, Eds., 2, 569-570 (Plenum Publ. Corp., New York, NY, 1980).

Key words: hydrides; Laves-phase; neutron scattering; rare earth-iron intermetallics; sublattice magnetization.

We have used neutron scattering to study the effect of hydrogen on the structure and magnetic ordering of the Laves-phase rare earth-iron compounds RFe<sub>2</sub>. Depending on temperature and pressure, stable hydrides can be formed with nominally 2, 3.5, and 4 H(D) per formula unit. The RFe<sub>2</sub>H<sub>2</sub> and RFe<sub>2</sub>H<sub>3.5</sub> phases retain the cubic C15 structure with a substantial increase in lattice parameter. The parent RFe<sub>2</sub>'s order ferrimagnetically at T<sub>c</sub> ~ 600 K with the free ion moment for R and ~1.6 μ<sub>B</sub> for iron at saturation; in the hydrides, both T<sub>c</sub> and the R moment are reduced markedly, while the Fe moment is essentially unchanged. In ErFe<sub>2</sub>, ErFe<sub>2</sub>D<sub>2</sub> and ErFe<sub>2</sub>D<sub>3.5</sub>, μ<sub>Er</sub> = 8.8, 7.5, and 4.3 μ<sub>B</sub>. Previous Mössbauer experiments have shown that the local moment on each R in the hydrides is about the free ion value. This indicates that the weakened exchange and randomization of anisotropy field due to H results in a non-collinear R spin ordering similar to the "fanning" of R moment seen in amorphous RFe<sub>2</sub> materials which reduces the bulk ordered moment seen in the neutron experiments. Preliminary inelastic studies reveal hydrogen vibrational modes at 110 and 80 meV in HoFe<sub>2</sub>D<sub>3.5</sub> and at 145 and 120 meV in ErFe<sub>2</sub>H<sub>3.5</sub>, suggesting a distorted tetrahedral environment for H(D) with no evidence of octahedral occupancy. High resolution neutron diffraction experiments are in progress to locate the H site.

**19618.** Klais, O., Laufer, A. H., Kurylo, M. J., **Atmospheric quenching of vibrationally excited O<sub>2</sub>(<sup>1</sup>Δ)**, *J. Chem. Phys.* 73, No. 6, 2696-2699 (Sept. 15, 1980).

Key words: atmospheric; flash photolysis; kinetics; ozone O<sub>2</sub>(<sup>1</sup>Δ); vibrational deactivation.

Flash photolysis of O<sub>3</sub> in the Hartley band has been coupled with absorption spectroscopic detection of O<sub>2</sub>(<sup>1</sup>Δ, v = 0) and

resonance fluorescence detection of O(<sup>3</sup>P) to analyze the fate of O<sub>2</sub>(<sup>1</sup>Δ, v ≥ 1) in an atmospheric environment. The results indicate a rapid vibrational deactivation under atmospheric conditions. The same analysis permits an estimate of the relative quantum yield of O<sub>2</sub>(<sup>1</sup>Δ, v ≥ 1) in the photolysis. Similarly, an upper limit for the channel of the O(<sup>1</sup>D) + O<sub>3</sub> reaction yielding O<sub>2</sub>(<sup>1</sup>Σ) is derived.

**19619.** Shingleton, J. G., Cassel, D. E., McCabe, M. E., **Computer modeling of air leakage in a solar air heating system**, *Proc. 2d Annual Systems Simulation and Economic Analysis Conf., San Diego, CA, Jan. 23-25, 1980, SERI/TP-351-131*, pp. 265-271 (U.S. Department of Energy/Solar Energy Research Institute (SERI), Golden, CO, 1980).

Key words: air leakage; computer simulation; performance criteria; solar air heating systems; solar collector.

A detailed TRNSYS computer model developed to permit evaluation of the effects of air leaks on the performance of a solar air heating system is described. The model was developed to define reasonable limits of air leakage for specification in performance criteria for solar heating and cooling systems in commercial and residential buildings.

The computer model, based on a physical system in the HUD demonstration program, was designed to utilize air flow rates as measured in the physical system after extensive repairs had been made to reduce air leaks. The model accounts for the existence of air leaks in the collector array, the storage container, and the control dampers for both an actually measured and various hypothetical conditions. The subroutine developed to account for collector air leakage incorporates the equations of Close and Yusoff to model collector leakage with either infiltration or exfiltration. The subroutine developed to control system model operation varies the air flow rates and leak rates for each mode of operation according to preset parameters based on the field measurements.

Hour-by-hour simulations were performed for an entire heating season for various air leakage rates. Hourly simulation results are presented to demonstrate the immediate system effects (reduced collector outlet and house supply temperatures) that are the cause of long-term system performance degradation.

Seasonal simulations performed with the model indicate that the elimination of all the measured air leakage results in a 19 percent reduction in auxiliary energy use. Short-term simulations show that collector and storage air leakage is accompanied by lower collector outlet and house supply temperatures, higher collector array operating efficiency, and increased auxiliary energy use.

**19620.** Marshak, H., Turrell, B. G., **γ-ray emission from oriented nuclei in a multiaxis nuclear spin system: <sup>166m</sup>Ho <sup>165</sup>Ho**, (Proc. Fourteenth Rare Earth Research Conf., North Dakota State University, Fargo, ND, June 25-28, 1979), Paper in *The Rare Earths in Modern Science and Technology*, G. J. McCarthy, J. J. Rhyne, and H. B. Silber, Eds., 2, 285-286 (Plenum Publ. Corp., New York, NY, 1980).

Key words: gamma rays; low temperatures; multiaxes nuclear spin system; γ-ray multipolarity; <sup>166m</sup>Ho single crystal; <sup>166m</sup>Ho.

Gamma-ray emission from the multiaxis nuclear spin system <sup>166m</sup>Ho<sup>165</sup>Ho is presented. The results show that the spin axes form a single cone with a half-angle of 80.4 ± 0.4°.

**19621.** Unterweger, M. P., Coursey, B. M., Schima, F. J., Mann, W. B., **Preparation and calibration of the 1978 National Bureau of Standards tritiated-water standards**, *Int. J. Appl. Radiat. Isot.* 31, 611-614 (Mar. 1980).

Key words: half-life; internal gas proportional counting; tritiated water standards; tritium.



The National Bureau of Standards activity standards for tritiated water, SRM 4926 and SRM 4927, have been recalibrated by the method of internal gas-proportional counting, and a new series of standards has been prepared. These standards are used in measurements made by the International Atomic Energy Agency and the World Meteorological Organization (IAEA/WMO) Tritium Monitoring Network. The agreement between the 1961 and 1978 gas counting measurements is 0.7%, assuming the adopted half-life of 12.35 yr. The results are, however, in complete agreement if, instead, a half-life of 12.44 yr is used. A half-life of  $12.43 \pm 0.05$  yr, based on measurements of the NBS tritiated-water standards over a span of 18 yr, is suggested.

19622. Ugiansky, G. M., Johnson, C. E., Thompson, D. S., Gillespie, E. H., **Slow strain-rate stress corrosion testing of aluminum alloys**, (Proc. Stress Corrosion Cracking—The Slow Strain-Rate Technique, Toronto, Canada, May 2-4, 1977), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 665, pp. 254-265 (1980).

Key words: air; alternate immersion test; aluminum alloys; ductility; elongation; heat treatment; NaCl; plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 2124-T851; 7075; 7075-T6; 7075-T7351.

The use of the slow strain rate stress corrosion testing technique for testing aluminum alloys is discussed. This technique is compared to the more frequently used alternate immersion test technique used for evaluating the susceptibility of aluminum alloys to stress corrosion cracking. Aluminum alloys (2124 and 7075) each in three heat treatments with differing susceptibilities to stress corrosion cracking were tested by both the statically loaded alternate immersion test and by the slow strain rate technique. The results of the tests are compared, and the slow strain rate test is shown to be a viable, rapid technique for determining the SCC susceptibility of aluminum alloys.

19623. Ugiansky, G. M., Johnson, C. E., **Slow strain-rate stress corrosion testing of metals in gaseous atmospheres at elevated temperatures**, (Proc. Stress Corrosion Cracking—The Slow Strain-Rate Technique, Toronto, Canada, May 2-4, 1977), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 665, pp. 113-131 (1980).

Key words: austenitic stainless steels; coal gasification; elevated temperatures; ferritic stainless steels; gaseous environments; nickel alloy 671; nickel alloy 800; oxidizing/sulfidizing gas; premature failure; stress corrosion cracking.

A total of six different alloys—stainless steel (SS) Types 310, 310S, 347, and 446, and nickel alloys 800 and 671—were tested using the slow strain-rate test technique in oxidizing/sulfidizing and in oxidizing/sulfidizing/carburizing simulated coal gasification environments, and in helium (and other inert environments) at both 450 and 600 °C at a strain rate of  $10^{-6}$ /s. Of the six alloys, four (Types 310 stainless steel and 310S stainless steel, nickel alloy 800, and nickel alloy 671) were found to be susceptible to cracking at 600 °C by possibly different mechanisms, however, all were detected by the slow strain-rate technique.

For cracking, the nickel alloy 671 required no reactive environment; it suffered internal cracking in helium and all other test environments used. However, the stainless steel Type 310, Type 310S, and nickel alloy 800, all of which failed through surface initiated cracking, required increasingly severe environments for cracking. The Type 310 stainless steel required very little reactive environment; it cracked not only in the simulated coal gasification gases but also in low vapor pressure  $O_2$  or water ( $H_2O$ ) environments, or both (for example, helium), as did the Type 310S stainless steel, although with greater ductility than the Type 310 stainless steel. The nickel alloy 800 required the rather reactive environment of the simulated coal gasification gases; it did not crack in the low vapor pressure  $O_2$  and  $H_2O$  environments.

The detection of the environmentally independent failure of Alloy 671 shows that the use of the slow strain-rate technique

need not be limited to use for testing for susceptibility to cracking by stress corrosion cracking. The slow strain-rate technique is shown to be a viable testing method for detecting an alloy's propensity to premature failure in simulated coal gasification environments.

19624. Skarstad, P. M., Hubbard, C. R., Roth, R. S., Parker, H. S., **The crystal structure of the cation-disordered phase  $(Tl_{0.75}Pb_{0.25})_4Cl_5$** , *J. Solid State Chem.* 30, No. 1, 65-78 (Oct. 1979).

Key words: cation disorder; coordination polyhedra; crystal structure; thallium lead chloride;  $Tl_3PbBr_5$ ;  $Tl_3PbCl_5$ .

The 3:1 compound in the  $TlCl$ - $PbCl_2$  system crystallizes in the noncentrosymmetric space group  $P4_32_12(D_4)$  or its enantiomorph  $P4_32_12(D_4)$ . Lattice constants are  $a = 8.450(1)\text{\AA}$  and  $c = 14.927(1)\text{\AA}$ . Single-crystal x-ray diffraction data were collected using  $AgK\alpha$  radiation. The structure was determined by analysis of Patterson and difference Fourier syntheses. Least-squares refinement of 41 parameters with 402 unique data converged with  $R_w = 0.036$ . In the structure the  $Tl(I)$  and  $Pb(II)$  ions are disordered over two eightfold sites. The formula is therefore appropriately written as  $(Tl_{0.75}Pb_{0.25})_4Cl_5$ . A difference in size of the two positions suggests a preferential concentration of  $Pb(II)$  in the smaller site. The disordering of aliovalent cations together with a three-dimensional network of face-sharing polyhedra of cations surrounding the anions of the structure suggests  $(Tl_{0.75}Pb_{0.25})_4Cl_5$  as a particularly favorable case for enhancement of chloride ion conductivity by doping with  $TlCl$ . Irregularities in the coordination polyhedra about the cations can be explained by the presence of stereochemically active lone-pair electrons of the cations. The structure of  $(Tl_{0.75}Pb_{0.25})_4Cl_5$  is similar to that of the alloy  $Zr_5Si_4$ .

19625. Hayward, E., **What's new in nuclear photon scattering?**, (Proc. 1980 RCNP Int. Symp. on Highly Excited States in Nuclear Reactions, Osaka, Japan, May 12-16, 1980), Paper in *Highly Excited States in Nuclear Reactions*, H. Ikegami and M. Muraoka, Eds., pp. 523-542 (Research Center for Nuclear Physics, Osaka University, Suita Osaka, Japan, 1980).

Key words: dispersion relation; electric quadrupole; giant resonance; optical theorem; photon scattering.

Our present understanding of photon scattering is reviewed. The results of new experiments to test the Dynamic Collective Model are summarized. An experimental measurement of the E2 strength in  $^{12}C$  is described.

19626. Penner, S., **Emitance growth in high current beam transport**, *Proc. Heavy Ion Fusion Workshop, Brookhaven National Laboratory, Upton, NY, Oct. 17-21, 1977*, pp. 127-130 (Associate Universities, Inc., Upton, NY, Feb. 1978).

Key words: beam transport; high current ion beams; inertially-confined fusion; numerical simulation; space charge.

The transport of heavy-ion particle beams in a symmetric FODO quadrupole focusing channel is calculated by a numerical simulation. For sufficiently high beam currents, a rapid initial growth rate of the beam emittance is found, for beams whose current density is similar to that of the Kapchinsky-Vladimirsky distribution. After the initial emittance growth, continued transport of the beam results in a much less rapid growth rate.

19627. Ledbetter, H. M., **Correlation between superconducting transition temperature and the Cauchy discrepancy in body-centered-cubic transition metals**, *Phys. Lett.* 77A, No. 5, 359-361 (June 9, 1980).

Key words: body-centered-cubic metals; Cauchy discrepancy; elastic constants; many-atom effects; superconductivity; transition metals; transition temperature.



For body-centered-cubic transition metals, an empirical relationship exists between the superconducting transition temperature and the Cauchy discrepancy. This correlation may arise from many-atom effects.

**19628.** McCoubrey, A. O., Goldman, T. D., **Units, physical**, Paper in *Academic American Encyclopedia* 19 (TUV), 465-467 (Arete Publ. Co., Inc., Princeton, NJ, 1980).

Key words: measurements; metric; metrology; SI; standards; units.

The article reviews the historical development of the Metric System of measurements, the basis for its structure and trends for the future.

**19629.** Lynn, J. W., **Crystal field effects in magnetic superconductors**, (Proc. Crystal Fields and Structure in *4f* Electron Systems, Philadelphia, PA, Nov. 12-15, 1979), Paper in *Crystalline Electric Field and Structural Effects in f-Electron Systems*, J. E. Crow, R. P. Guertin, and T. W. Mihalisin, Eds., pp. 547-560 (Plenum Publ. Corp., New York, NY, 1980).

Key words: Chevrel phase; crystal fields; Laves-phase; magnetic superconductor; neutron scattering; reentrant superconductor.

Neutron scattering experiments have been carried out as a function of temperature and magnetic field on a series of superconducting materials containing rare earth ions. In  $(\text{Ce}_{1-x}\text{Ho}_x)\text{Ru}_2$  the crystal field splittings are large in comparison with characteristic magnetic energies, and the magnetic properties at low temperatures, in particular the development of ferromagnetic correlations, are determined by the triply degenerate  $\Gamma_5$  crystal field ground state. For the superconductors  $\text{ErMo}_6\text{Se}_8$ ,  $\text{HoMo}_6\text{Se}_8$ , and  $\text{TbMo}_6\text{Se}_8$ , which display long range magnetic order at low temperatures, well-defined crystal field transitions are also observed. Moreover the effects of the crystal field on the magnetic moments have been directly determined by measuring the field dependence of the induced moment. In the reentrant ferromagnetic superconductor  $\text{HoMo}_6\text{Se}_8$ , on the other hand, no crystal field transitions have been found over a wide range of energies, and the full moment is readily induced by a magnetic field. Temperature dependent intrinsic linewidths have been observed in these systems, but no correlation with the superconducting transition temperatures has been found.

**19630.** Koon, N. C., Rhyne, J. J., **Exchange and crystal field excitations in rare-earth iron and rare-earth cobalt Laves-phase compounds**, (Proc. Crystal Fields and Structure in *4f* Electron Systems, Philadelphia, PA, Nov. 12-15, 1979), Paper in *Crystalline Electric Field and Structural Effects in f-Electron Systems*, J. E. Crow, R. P. Guertin, and T. W. Mihalisin, Eds., pp. 125-140 (Plenum Publ. Corp., New York, NY, 1980).

Key words: crystal fields; inelastic scattering; magnetism; neutron scattering; rare earths; spin waves.

We have examined the magnetic excitations in several rare earth iron ( $\text{RFe}_2$ ) and cobalt ( $\text{RCo}_2$ ) cubic Laves phase compounds using inelastic neutron scattering. Both ground state excitations at low temperatures and excited state transitions at elevated temperatures have been observed, and the results correlated with a Greens function RPA theory for a ferrimagnet including crystal field interactions. By appropriate choice of crystal reflections, structure factor considerations as calculated from the model allow one to resolve separately modes involving in-phase and out-of-phase spin precessions of both rare earth and transition metal spins.

The cobalt compounds studied ( $\text{ErCo}_2$  and  $\text{HoCo}_2$ ) both exhibit exchange interactions more than a factor of two lower than the corresponding Fe compounds. In all cases the R-R exchange interactions have been found to be negligibly small, giving rise to dispersionless branches in the spin wave spectra.

In addition to the principal acoustic mode, a second highly-dispersive in-phase mode involving the transition metal spins has been observed in the Fe compounds with dispersion equal to that of elemental Fe. Although predicted by the model, the equivalent Co in-phase mode has not been observed experimentally, raising questions about possible lifetime broadening effects.

The crystal field parameters found from analysis of the data are similar for both Fe and Co compounds, and are in closer agreement with the point charge values than previous bulk measurements have indicated.

**19631.** Fiori, C. E., Newbury, D. E., **Artifacts in energy dispersive x-ray spectrometry in the scanning electron microscope (II)**, (Proc. Annual Review of Scanning Electron Microscopy, Chicago, IL, Apr. 20-24, 1980), Paper in *Scanning Electron Microscopy*, pp. 251-258 (SEM Inc., Chicago, IL, 1980).

Key words: analytical electron microscope; energy dispersive x-ray spectrometry; scanning electron microscope; silicon (Li) detector; spectral artifacts; x-ray spectrometry.

The quality of x-ray spectra obtained with an energy dispersive x-ray spectrometer on an electron beam instrument can be severely compromised by the presence of electromagnetic interference. Sources of electromagnetic interference include ground currents and signals generated by time-varying currents in instrument components such as scan coils. Spectrometer resolution can be degraded by the accumulation of ice and vacuum oil on critical components of the device. Operation at high electron energy can cause artifacts in spectra due to direct entry of electrons and spurious x-rays into the detector. Processing high energy photons (above 40 keV) can lead to detector saturation effects which degrade resolution and affect dead time correction. Transmission of high energy x-rays through the detector accompanied by Compton scattering can lead to a distortion of the low energy portion of the spectrum.

**19632.** Johnson, L. B., Paffenbarger, G. C., **The role of zinc in dental amalgams**, *J. Dent. Res.* 59, No. 8, 1412-1419 (Aug. 1980).

Key words: comprehensive strength of amalgam; density of dental amalgam; dental amalgam; dimensional change in dental amalgam; mercury/alloy ration in dental amalgam; mercury content in dental amalgam; zinc in dental amalgam.

Twenty-five Ag-Sn alloys containing various additions of Zn were amalgamated and the amalgams tested for physical properties pertinent to dental restoration use. The mercury retained, dimensional change, compressive strength, and creep were all functions of the Zn content.

**19633.** Rabolt, J. F., Fanconi, B., **Raman scattering from finite polytetrafluoroethylene chains and a highly oriented TFE-HFP copolymer monofilament**, *Macromolecules* 11, No. 4, 740-745 (July-Aug. 1978).

Key words: orientation; perfluoro *n*-alkanes; polarization; polytetrafluoroethylene; Raman spectroscopy; tetrafluoroethylene-hexafluoroethylene copolymer.

Raman polarization studies on a highly oriented tetrafluoroethylene-hexafluoropropylene (TFE-HFP) copolymer have been used to make band assignments for the PTFE homopolymer. In addition, band progressions observed in the Raman spectra of a series of isostructural perfluoro-*n*-alkanes have been used to plot out portions of the  $\omega_3$ ,  $\omega_6$ , and  $\omega_8$  experimental dispersion curves for PTFE. Comparisons of band assignments and experimental dispersion curves with previous normal mode calculations indicated a lack of agreement between mode symmetries and a sizable discrepancy in the  $\omega_6$  branch for phase values greater than  $120^\circ$ . Normal mode calculations, based on an isolated chain model, have been performed in which the valence



force field constants have been refined to improve the agreement with experimental results.

19634. Unassigned.

19635. Wise, S. A., Chesler, S. N., Hertz, H. S., May, W. E., Guenther, F. R., Hilpert, L. R., **Determination of trace level hydrocarbons in marine biota**, (Proc. Conf. Int. Congress on Analytical Techniques in Environmental Chemistry, Barcelona, Spain, Nov. 27-30, 1978), Paper in *Analytical Techniques in Environmental Chemistry*, J. Albaiges, Ed., pp. 41-51 (Pergamon Press, New York, NY, 1980).

Key words: aliphatic hydrocarbons; aromatic hydrocarbons; gas chromatography; headspace sampling; high-performance liquid chromatography; interlaboratory comparison; polycyclic aromatic hydrocarbons.

A method is described for the determination of hydrocarbons in marine biota. This method utilizes dynamic headspace sampling of an aqueous caustic tissue homogenate to extract and collect volatile organic components. Interfering polar biogenic (non-anthropogenic) components are removed by normal-phase high-performance liquid chromatography (HPLC) prior to quantitation and identification of the hydrocarbons by gas chromatography and gas chromatography-mass spectrometry. After headspace sampling the non-volatile polycyclic aromatic hydrocarbons are solvent extracted from the tissue homogenate, isolated using normal-phase HPLC, and analyzed by reversed-phase HPLC with ultraviolet (UV) and fluorescence detection.

Results of an interlaboratory comparison of determinations of hydrocarbons in mussel tissue are also reported.

19636. Wiederhorn, S. M., Ritter, J. E., Jr., **Application of fracture mechanics concepts to structural ceramics**, (Proc. 11th Natl. Symp. Fracture Mechanics, Blacksburg, VA, June 12-14, 1978), Paper in *Fracture Mechanics Applied to Brittle Materials*, S. Freiman, Ed., pp. 202-214 (American Society for Testing and Materials, Philadelphia, PA, June 1979).

Key words: ceramics; crack growth; delayed failure; fracture; mechanical reliability; mechanics; strength.

Techniques of improving the reliability of ceramic materials in structural applications are described. Based on fracture mechanics concepts, these techniques use strength, or fracture mechanics methods of measurement to characterize the delayed failure behavior of ceramic materials. The techniques have been tested experimentally; for several materials, agreement between theory and experiment is satisfactory. For other materials agreement is not satisfactory, suggesting that additional experimentation is needed to evaluate the limits of the theory fully and to identify those materials for which the theory is applicable.

19637. Negas, T., Roth, R. S., McDaniel, C. L., Parker, H. S., Olson, C. D., **Influence of K<sub>2</sub>O on the cerium oxide-ZrO<sub>2</sub> system**, *Proc. 12th Rare Earth Research Conf., Vail, CO, July 18-22, 1976*, C. E. Lundin, Ed., II, Session J-T, 605-614 (University of Denver, Denver, CO, 1976).

Key words: ceria-zirconia system; magnetohydrodynamics; oxidation-reduction; perovskite; phase equilibria; potassium ceria-zirconia system; pyrochlore.

Cerium electrode bodies (cathode and anode) containing 82 (mol %) ZrO<sub>2</sub>-18CeO<sub>2</sub>, 50ZrO<sub>2</sub>-50CeO<sub>2</sub>, and 25ZrO<sub>2</sub>-75CeO<sub>2</sub> were among materials recently tested (127 hrs) at the U-02 MHD (magnetohydrodynamics) facility in Moscow as part of a joint US-USSR effort. Materials were subjected to surface temperatures as high as 1750 °C and a plasma "seeded" with potassium. This laboratory participated actively in the pre- and post-test chemical characterization of the materials utilized.

To obtain a fundamental understanding of the chemical behavior of CeO<sub>2</sub>/ZrO<sub>2</sub> materials, subsolidus phase relations in the system CeO<sub>2</sub>-ZrO<sub>2</sub> were investigated up to 1600 °C in air. This

system, although the subject of several previous investigations, is not a true binary as CeO<sub>2</sub> and CeO<sub>2</sub>/ZrO<sub>2</sub> mixtures reduce at elevated temperatures (>1000 °C) even under relatively oxidizing conditions. Thermal microbalance measurements together with conventional x-ray diffraction and phase equilibrium methods were used to, (a) delimit the extent of the cubic fluorite and the tetragonal zirconia homogeneity regions in the system and, (b) define deviations from ideal oxygen stoichiometry of these (Ce,Zr)O<sub>2-x</sub> solid-solutions. Reactions of materials with oxygen, followed *in situ* with the thermal microbalance, are reversible and response to temperature changes is nearly instantaneous. The data indicate that for a given isotherm, additions of ZrO<sub>2</sub> to CeO<sub>2</sub> enhance the degree of reduction of Ce<sup>4+</sup> to Ce<sup>3+</sup> only within the cubic fluorite solid solution region. For example, at 1600 °C compositions containing Ce/Ce + Zr contents of 1.0, 0.90, 0.75, 0.60 and 0.50 contain Ce<sup>3+</sup>/Ce<sup>3+</sup> + Ce<sup>4+</sup>(%) values of 3.5, 6.2, 10.5, 14.5, and 17.6%, respectively. These were calculated from observed weight losses. The tetragonal zirconia homogeneity region is characterized by less reduced solid-solutions.

X-ray diffraction analyses of tested electrode ceramics revealed significant chemical alteration of the CeO<sub>2</sub>/ZrO<sub>2</sub> materials at the cathode wall. Within the cooler zones (<1400 °C) of the electrodes, potassium reacted with the initial phase or phase assemblage to yield new products. Reactions of materials in the CeO<sub>2</sub>-ZrO<sub>2</sub> system with K<sub>2</sub>O were accomplished in the laboratory and results correlate well with the x-ray analysis data of tested materials. A laboratory study of condensed phase relations in the cerium oxide-ZrO<sub>2</sub>-K<sub>2</sub>O system is difficult. A source for reactive K<sub>2</sub>O is unavailable for experiments at subsolidus temperatures sufficiently high for reactions to proceed. Consequently, pre-reacted CeO<sub>2</sub>/ZrO<sub>2</sub> mixtures were heated between 1000-1350 °C with excess molten K<sub>2</sub>CO<sub>3</sub> or KOH. Tetragonal zirconia solid solutions, for example 82ZrO<sub>2</sub>-18CeO<sub>2</sub>, when reacted with K<sub>2</sub>O decompose, ultimately forming nearly pure ZrO<sub>2</sub> (monoclinic at room temperature) plus a new cubic perovskite (*a* = 4.097 Å) having a nominal composition, KCeZr<sub>2</sub>O<sub>6</sub>. Small (<.1 mm) single crystals of this olive-green material containing Ce<sup>3+</sup> were grown from molten K<sub>2</sub>CO<sub>3</sub>. Compositions initially containing Ce/Zr > 0.5 react with K<sub>2</sub>O to ultimately form perovskite plus nearly pure CeO<sub>2</sub>.

19638. Negas, T., Roth, R. S., McDaniel, C. L., Parker, H. S., Olson, C. D., **Oxidation-reduction reactions of CeMO<sub>4+x</sub> (M = Ta or Nb) phases**, *Proc. 12th Rare Earth Research Conf., Vail, CO, July 18-22, 1976*, C. E. Lundin, Ed., II, Session J-T, 747-756 (University of Denver, Denver, CO, 1976).

Key words: cerium niobate; cerium tantalate; fergusonite; oxidation-reduction; scheelite; thermogravimetric analysis.

Phase equilibrium methods, single crystal and powder x-ray diffraction analyses, thermogravimetric analysis and magnetic susceptibility measurements were utilized to define subsolidus phase relations *in air* for the systems cerium oxide-Ta<sub>2</sub>O<sub>5</sub> and cerium oxide-Nb<sub>2</sub>O<sub>5</sub>. Pertinent crystal growth and crystallographic data are the subject of a separate paper (this conference) while magnetic data will be published elsewhere.

19639. Goldman, D. T., **The metric system: Costs vs. benefits: A summary overview**, (Proc. AAAS Symp.—The Metric System: Cost vs. Benefits, Houston, TX, Jan. 3, 1979), Paper in *The Metric Debate*, D. F. Bartlett, Ed., pp. 117-123 (Colorado Associated University Press, Boulder, CO, 1980).

Key words: base units; convention of the meter; economic benefits; epistemology; measurement system; metric system; SI.

The author's views on the desirability of conversion to the Metric System are presented as the summary paper of a session of the American Association for the Advancement of Science. The Metric System or rather the SI version is internationally



agreed upon, simple to use, and will ease communication. These benefits far outweigh the disadvantages inherent upon changing from the familiar. The economic benefit to industry has been the driving force towards the adoption of SI in this country and will continue to be gathering momentum as more sectors convert.

**19640.** Rife, J., Osantowski, J., **Mirror reflectivities from 50-150 eV**, *Nucl. Instrum. Methods* **172**, 297-301 (1980).

**Key words:** extreme ultraviolet mirrors; extreme ultraviolet telescopes; optical constants; reflectivity; reflectometer; solid state physics; synchrotron radiation; ultraviolet optical system design; ultraviolet spectroscopy.

An accurate reflectometer has been set up on the 2.2 meter monochromator at the NBS SURF-II synchrotron radiation facility to determine optical constants of materials from 50 to 150 eV. Properties of the monochromator, reflectometer and NBS windowless photodiode detector are discussed. Reflectivity data from 70 to 300 Å for two low expansion glasses, a recrystallized glass and a high silica glass, are reported and preliminary optical constants for one glass are presented.

**19641.** Madden, R. P., **A status report on the SURF II synchrotron radiation facility at NBS**, *Nucl. Instrum. Methods, Part I*, **172**, 1-8 (1980).

**Key words:** radiometry; storage ring; synchrotron; vacuum ultraviolet; VUV standards.

Recent work to upgrade the SURF II (Synchrotron Ultraviolet Radiation Facility) storage ring are described, resulting in reliable operation up to 252 MeV at currents in the range 10-20 mA. A wide variety of experiments are now in progress at the facility, encompassing solid state physics, atomic and molecular physics and molecular biology, as well as the all-important radiometric standards work. The instrumentation used for these experiments is described; brief details of the experiments themselves are also given.

**19642.** Newbury, D. E., **The impact of instrumental sensitivity variations on analysis with the local thermal equilibrium model in secondary ion mass spectrometry**, *Electron Micros.* **1980**, **3**, 212-213 (1980).

**Key words:** local thermal equilibrium model; microanalysis; secondary ion mass spectrometry; sensitivity factors; sputtering; surface analysis.

Errors in quantitative analysis with the local thermal equilibrium model in secondary ion mass spectrometry have been attributed in the past to failure of the physical model or a lack of accurate input parameters. Experimental evidence suggests that instrumental discrimination has a great deal of influence on the errors observed in the analysis of heavy elements. A strong correlation is found between the relative elemental sensitivity factor and the error factor from LTE analysis.

**19643.** Newbury, D. E., **Instrumental effects on quantitative analysis by secondary ion mass spectrometry**, (Proc. 2d Int. Symp. on Secondary Ion Mass Spectrometry, Stanford University, Stanford, CA, Aug. 27-30, 1979), Paper in *Secondary Ion Mass Spectrometry*, A. Benninghoven, Ed., pp. 53-57 (Springer-Verlag, New York, NY, 1979).

**Key words:** ion microanalysis; ion microprobe; microanalysis; quantitative analysis; secondary ion mass spectrometry; surface analysis.

Quantitative analysis procedures for secondary ion mass spectrometry (SIMS) have been primarily designed to correct for the strong matrix effects on secondary ion intensities. Experimental results obtained on glass samples by 22 different SIMS instruments reveal the existence of strong instrumental effects on relative secondary ion signals. Instrumental discrimination

against high atomic number elements is not compensated in an existing quantitation procedure based on the local thermal equilibrium model.

**19644.** Negas, T., **Chemistry of ceramic oxide MHD electrodes**, (Proc. 173d ACS Natl. Meeting—Materials from a Chemical Viewpoint, New Orleans, LA, Mar. 21-22, 1977), Paper in *Materials and National Policy*, pp. 55-65 (American Chemical Society, Washington, DC, 1978).

**Key words:** ceramic oxides; electrodes;  $\text{LaCrO}_3$ ; magnetohydrodynamics; spinels; zirconia.

During recent years, ERDA has sponsored an active program for testing of magnetohydrodynamic (MHD) electrode materials using facilities in the Soviet Union and in the USA. Efforts in the USSR are focused on ceramic oxides operating at temperatures exceeding 1600 °C and in an environment consisting of clean fuel combustion products seeded with potassium salts. In the USA, emphasis is placed on metals and/or oxides operating in a "slagging" environment generated by the combustion of coal.

Pertinent mechanical and physical properties (thermal and electrical conductivity, thermal expansion, etc.) together with appropriate engineering design are crucial factors in the development of MHD electrodes. Too often, however, the fundamental chemistry of a material selected is ignored after initial synthesis, characterization, development and fabrication. When exposed to the severe temperature and electrical gradients; the large heat fluxes and current densities; and the corrosive action of slag and/or condensed potassium seed of an MHD environment, chemical alteration is almost inevitable. Laboratory experiments remain important to define potentially deleterious chemical reactions to be expected and which should be minimized, if possible, by thoughtful material fabrication and electrode design. Pre- and post-test chemical aspects of several real electrode oxide materials will be explored. These include zirconia/ceria, iron oxide-containing spinels, and  $\text{LaCrO}_3$ .

**19645.** Chow, L. C., Guo, M. K., Hsieh, C. C., Hong, Y. C., **Reactions of powdered human enamel and fluoride solutions with and without intermediate  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  formation**, *J. Dent. Res.* **59**, No. 8, 1447-1452 (Aug. 1980).

**Key words:** acid pretreatment; acidulated phosphate fluoride; apatitic fluoride; sodium fluoride; stannous fluoride; topical fluoridation.

Powdered human enamel treated for three minutes each with a  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  forming solution and a fluoride solution, and then suspended in "synthetic saliva" for 72 hours acquired a large amount of apatitic fluoride. This apatitic fluoride appears to form after the fluoride treatment.

**19646.** Geist, J., Zalewski, E. F., **The quantum yield of silicon in the visible**, *Appl. Phys. Lett.* **35**, No. 7, 503-506 (Oct. 1, 1979).

**Key words:** quantum efficiency; quantum yield; silicon; silicon photodetector; spectral response; visible.

Extremely high accuracy measurements of the internal quantum efficiency of shallow-junction silicon photodetectors were fit with various theoretical models. The internal quantum efficiency was found to be rather model independent indicating its possible use as a radiometric standard. The results of this investigation indicate that the quantum yield of silicon is unity to within a few tenths of one percent in the visible.

**19647.** Chickerur, N. S., Tung, M. S., Brown, W. E., **A mechanism for incorporation of carbonate into apatite**, *Calcif. Tissue Int.* **32**, 55-62 (1980).

**Key words:** apatite; carbonate apatite; hydrolysis; impurities; octacalcium phosphate; sodium; tooth enamel.



Octacalcium phosphate ( $\text{Ca}_8\text{H}_2(\text{PO}_4)_6 \cdot 5\text{H}_2\text{O}$ ) is considered to be a precursor in the formation of apatite in bones and teeth; a crucial step for incorporation of impurities appears to occur during its hydrolysis. The present study examines the role that octacalcium phosphate plays in the process of incorporation of carbonate into apatite. Chemical, x-ray diffraction, and infrared techniques were used.

When octacalcium phosphate is hydrolyzed in the presence of sodium and carbonate ions in aqueous media, approximately one sodium and one carbonate ion seem to substitute for a calcium and phosphate ion, respectively, in forming apatite, and the  $\alpha$  axis is shortened. The infrared spectrum of the product indicates that the carbonate is in the type B site, which is presumed to be a phosphate site. This mechanism is of particular importance since the presence of carbonate in human enamel appears to be related to caries susceptibility. A structural mechanism for the incorporation of impurities during hydrolysis of octacalcium phosphate is presented.

**19648.** Golan, S., Adler, L., Cook, K. V., Nanstad, R. K., Bolland, T. K., **Ultrasonic diffraction technique for characterization of fatigue cracks**, *J. Nondestr. Eval.* **1**, No. 1, 11-19 (1980).

Key words: crack closure; crack surfaces; fatigue crack; NDE; ultrasonic diffraction.

This paper describes an ultrasonic diffraction technique for characterizing fatigue cracks. The angular field of energy scattered from a crack tip was computed. Using the theoretically predicted and experimentally verified optimum range of angles, we measured the crack profiles by the ultrasonic diffraction technique. Ultrasonic measurements agreed very well with direct destructive measurements. In addition, fatigue crack closure was detected and information on crack surfaces was obtained.

**19649.** Fletcher, R. A., Bright, D. S., Chabay, I., **Low Reynolds number fluid flow induced by settling aerosol and detected by the particle Doppler shift spectrometer**, *J. Phys. Chem.* **84**, No. 12, 1611-1614 (1980).

Key words: fluid flow generated by settling aerosol; low Reynolds number fluid flow; particle Doppler shift spectrometer; particle induced air circulation; particle induced fluid flow.

The generation of uniform fluid flow by gravitationally settling 5-15  $\mu\text{m}$  diameter aerosol has been observed. The magnitude of the flow phenomena is derived from measurements of the particle settling velocities using the optical particle Doppler shift spectrometer (PDSS) which can determine particle velocity and size with high accuracy due to the inherent internal calibration characteristic of the instrument. The fluid flow velocity is dependent on the particle number concentration. Experimental evidence verifying the flow pattern is presented.

**19650.** Blaha, J. J., Etz, E. S., **Some experimental problems in the Raman analysis of microsamples**, (Proc. 15th Annual Conf. Microbeam Analysis Society, Reno, NV, Aug. 4-8, 1980), Paper in *Microbeam Analysis—1980*, D. Wittry, Ed., pp. 183-184 (San Francisco Press, San Francisco, CA, 1980).

Key words: laser-induced effects; light scattering; microanalysis; particle analysis; Raman microprobe; Raman spectroscopy.

The Raman microprobe, developed at the National Bureau of Standards, has been shown to be an effective tool for the analysis of microsamples. Some of the more common problems in analyzing samples arise from excessive heating of the sample when the laser beam is absorbed and the sample is not able to dissipate the excess energy. Common methods of circumventing these problems are to decrease the laser power in the sample or change the frequency of the exciting laser beam. These are not

always successful. Chemical reactions of microsamples, especially with water vapor, also complicate the analysis. In these cases, special sample handling is necessary. A number of other techniques have been utilized to protect samples from adverse effects of the measurement process. These are expected to aid in further analyses of microsamples.

**19651.** Sanchez, I. C., Chang, S. S., Smith, L. E., **Migration models for polymer additives**, *Polym. News* **6**, 249-256 (1980).

Key words: equilibrium partitioning; Fickian diffusion; food package; interaction parameter; migration; partition coefficient; radiolabeled additive; solubility.

An important problem in food packaging is the absorption into food of chemicals present in the packaging material. For the past two years, the Polymer Science and Standards Division of the National Bureau of Standards has been studying the migration of additives from polymeric packaging materials to food simulating solvents. This study has been carried out under an interagency agreement with the Bureau of Foods of the U.S. Food & Drug Administration. Our primary goal in this research program has been to develop a migration model which can be used as a guide for the food packaging industry and serve as a sound scientific basis for FDA regulatory decisions. What follows is a brief progress report of our study.

**19652.** Sanchez, I. C., **Statistical thermodynamics of bulk and surface properties of polymer mixtures**, *J. Macromol. Sci.-Phys.* **B17**, No. 3, 565-589 (1980).

Key words: chemical potential; combinatorial entropy; equation of state; interfacial tension; lattice fluid; miscibility; spinodal.

A generalized version of the lattice fluid theory of solutions is considered. Necessary and sufficient conditions for phase stability in a binary mixture are defined by a spinodal inequality. From the general properties of the spinodal, the necessary conditions for polymer/polymer miscibility and bimodal behavior of the spinodal are defined. A general theory of interfacial tension in phase separated multi-component mixtures is formulated. The interfacial tension theory can be combined with lattice fluid theory to obtain a unified theory of bulk and interfacial properties.

**19653.** Poser, C. I., Sanchez, I. C., **Surface tension theory of pure liquids and polymer melts**, *J. Colloid Interface Sci.* **69**, No. 3, 539-548 (May 1979).

Key words: Cahn-Hilliard theory; chemical potential; density gradient; equation of state; inhomogeneous fluid; lattice fluid; long-range interactions; surface entropy.

Using the lattice fluid model in conjunction with the Cahn-Hilliard theory of inhomogeneous systems, an accurate method has been developed for calculating the surface tension of nonpolar and slightly polar liquids of arbitrary molecular weight. For low molecular weight liquids, the surface tension can be computed from the triple point to 0.7 of the gas-liquid critical temperature with an error of less than 5%. The theory is somewhat less accurate for polymer melts because it tends to overestimate the surface entropy. The molecular weight dependence of the surface tension and entropy is closely related to the dependence of liquid density on molecular weight.

**19654.** Weiss, G. H., Rubin, R. J., **Internal configurations of span-constrained random walks**, *J. Stat. Phys.* **22**, No. 1, 97-109 (1980).

Key words: Poisson transformation; polymer configurations; random walks; spans; stable laws.

The spans of a random walk on a simple cubic lattice are the sides of the smallest rectangular box with sides parallel to the coordinate axes that entirely contain the random walk. We



consider the position, at dimensionless time  $\tau$ , of a random walker constrained by a set of spans  $S$ . We show in one dimension that if  $S^2 \gg 4\tau$ , the random walker tends to be located at the extremities of the span, while in the contrary case the random walker is most likely to be found halfway between the extremities. This is true whether the single-step transition probabilities have a finite or an infinite variance, as is shown by example. In higher dimensions the position of the random walker in the direction of the largest span tends to lie at the span extremities, while the position in the direction of the smallest span tends to be in the middle.

- 19655.** Peterlin, A., **The lowest laser—Raman active accordion (ALR) type oscillations in crystalline polymers**, *J. Mater. Sci.* **14**, 2994-2998 (1979).

Key words: accordion-type longitudinal oscillation; basic node; higher nodes; polyosieethylene; Raman.

The longitudinal accordion-type mode (LAM) frequencies of crystals of linear polymers with the chains perpendicular to the lamella surface are imagined as corresponding to the longitudinal eigenfrequencies of an ideally elastic rod of length  $D$  having the maximum amplitude at its ends. In such a case the eigenmodes have a wavelength  $\lambda = 2D, 2D/2, 2D/3, \dots$ . Among them only those corresponding to  $\lambda_1, \lambda_3, \dots$  having a node in the centre of the rod are Raman active. They can be labelled ALR1, ALR2,  $\dots$  since only these wavelengths  $\lambda_{Rn}$ , frequencies  $\nu_{Rn} = c_{ac}/\lambda_{Rn}$  or wave numbers  $\nu_{Rn}^{*}/c_{opt}$  are observed in the laser Raman scattering experiment. Here  $c_{ac} = (E/\rho)^{1/2}$  is the sound velocity and  $c_{opt} = 3 \times 10^8 \text{ m sec}^{-1}$  is the light velocity. The ratio of the corresponding eigenfrequencies or wave numbers is expected to be 1:3:5:  $\dots$ . Small deviations can be easily attributed to end groups, chain folds, strong repulsive forces, and similar small effects which shift the eigenfrequencies of the elastic rod to a lower value if they contribute a mass, and to a higher value if they contribute an additional restoring force.

- 19656.** Mazur, J., McCrackin, F., **Configurational properties of star-branched polymers**, *Macromolecules* **10**, No. 2, 326-332 (Mar.-Apr. 1977).

Key words: branched polymers; expansion factor; mean-square radius of gyration; Monte-Carlo; reduced moments; star-branched polymers.

Mean-square radii of gyration were computed for star-branched polymers simulated by a lattice model that incorporated both excluded volume and attractive energies between non-bonded segments of the polymer. The ratios,  $g$ , of the radius of gyration of a star polymer to that of a linear polymer of the same molecular weight were 6 to 15% (for star polymers of 3 to 9 branches) greater at the theta point than the corresponding ratios calculated by the unrestricted random-walk model of the polymer. The  $g$  ratios were smaller in good solvents than in theta solvents. The expansion factors, the ratios of the radius of gyration of a molecule in a good solvent to its radius of gyration in a theta solvent, were also calculated. The expansion factor decreased with the degree of branching, which is at variance with perturbation theory applied to the random walk model of star-branched polymers.

- 19657.** Lashmore, D., **Thin zinc films on aluminum**, *J. Electrochem. Soc.* **127**, No. 3, 573-578 (Mar. 1980).

Key words: aluminum; electrodeposition; epitaxy; plating coatings; zinc.

As part of a study of plating on aluminum, the deposition of thin zinc films on aluminum substrates was investigated by transmission electron microscopy and by electron diffraction. Zinc coatings on 99.999% aluminum were formed by immersion in aqueous solutions of sodium zincate. It was found that zinc initially forms epitaxial semicontinuous films on all aluminum principal planes. Subsequent zinc growth continued in the form

of separate crystallites (2000Å diam) which grew upon the initial film while continuing to maintain the epitaxial relationship. Using dark field transmission electron microscopy in combination with electron diffraction, it was found that Zn: (0001)  $\langle 10\bar{1}0 \rangle // \text{Al}$  (100)  $\langle 010 \rangle$ , Zn: (0001)  $\langle 11\bar{2}0 \rangle // \text{Al}$  ( $1\bar{1}0$ )  $\langle 111 \rangle$ , and Zn: (0001)  $\langle 11\bar{2}0 \rangle // \text{Al}$  (111)  $\langle 1\bar{1}0 \rangle$ .

- 19658.** Misra, D. N., Bowen, R. L., Antonucci, J. M., Cuthrell, W. F., **Adsorption of a polyfunctional surface-active amine accelerator on hydroxyapatite**, *J. Colloid Interface Sci.* **77**, No. 1, 143-150 (Sept. 1979).

Key words: adsorption; chemisorption; composites; coupling agent; dental adhesion; PolySAM.

Adsorption of a polyfunctional surface-active amine polymerization accelerator ("PolySAM-1") from chloroform solutions on synthetic hydroxyapatite is exhaustive and completely irreversible until the formation of a "monomolecular layer," at which point the additional adsorption is reversible. At relatively low equilibrium concentrations the adsorption is not exhaustive and the isotherm is linear. Adsorption isotherms of the adsorbate which is reversibly bound and of the adsorbate on a hydroxyapatite sample containing a preadsorbed monolayer of the same are identical and follow the Langmuir plot. Evidence shows that the irreversibly adsorbed material is probably chemisorbed. The tensile strength of a polymer, filled with synthetic hydroxyapatite having an adsorbed monolayer of PolySAM-1, did not exceed that of the polymer filled with untreated apatite for any of the polymerization-initiating systems that were studied. This implies that tertiary aromatic amine accelerators of this type do not form free radical sites capable of initiating or terminating significant graft polymerization under these conditions after their reaction with benzoyl peroxide.

- 19659.** Ritter, J. J., Kruger, J., **A qualitative ellipsometric-electrochemical approach to the study of film growth under organic coatings**, *Surf. Sci.* **96**, 364-374 (1980).

Key words: chromates; coated metals; corrosion inhibitor; corrosion mechanisms; ellipsometry; simulated paint films.

A study was made to determine if qualitative ellipsometry could be used together with electrochemical pH and potential measurements as a technique for the study of metal substrates protected by transparent organic coatings. The objective was to gain a deeper understanding of the mechanisms governing the corrosion protective actions of paints on metal surfaces. Computer modeling and experiments with colloid coatings on iron substrates indicated that changes in the ellipsometric parameter  $\Delta$  could, for the most part, be safely interpreted as thickness alterations in the substrate oxide film. Experiments with the Fe-colloid system in dilute chloride solutions exhibited three sequential stages of activity, two of which could be interpreted in terms of corrosion mechanisms using the optical and electrochemical measurements. Chromate ion as a corrosion inhibitor in coatings was also studied using this technique, and was shown to have significant effects upon the development of the subcoating processes.

- 19660.** Newbury, D. E., Myklebust, R. L., **Calculations of electron beam spreading in composite thin foil targets**, (Proc. 15th Annual Conf. Microbeam Analysis Society, Reno, NV, Aug. 4-8, 1980), Paper in *Microbeam Analysis—1980*, D. B. Wittry, Ed., pp. 173-175 (San Francisco Press, San Francisco, CA, 1980).

Key words: analytical electron microscopy; electron scattering; energy dispersive x-ray spectrometry; microanalysis; Monte Carlo electron trajectory simulation; spatial resolution.

Electron beam spreading limits the spatial resolution of analysis in thin foils by analytical electron microscopy. The interpre-



tation of recent experimental evidence which suggests that beam spreading is not as severe as previously predicted by electron scattering models is shown to be in error. The experiment in question involved measurement of a thin slab of material in a matrix. Adaptation of a simple model for scattering to this specimen configuration gives a closer agreement to the observed experimental signal profiles. Exact calculations of the configuration with a Monte Carlo electron trajectory simulation give close agreement with the experimental profiles. It is further demonstrated that beam spreading can produce errors of a factor of two or more in the apparent concentration when the object of interest is smaller than the interaction volume.

**19661.** Peterlin, A., *Diffusion with discontinuous swelling. IV. Type II diffusion into spherical particles*, *Polym. Eng. Sci.* **20**, No. 4, 238-241 (Mar. 1980).

Key words: concentration distribution; diffusion; glass-gel boundary; sphere weight gain.

In the last few years some new features of the so-called type II diffusion have been established which confirm the first theoretical description of such a material transport into a semi-infinite glassy medium which at a certain concentration of the sorbate is transformed into a gel. The boundary between the glass and the gel progresses at a constant velocity into the interior of the sample thus yielding a linear term in the weight gain. The gradual establishment of the concentration profile in front of this boundary yields at the beginning a square root term in the weight gain. A detailed analysis of the extensive measurements of Hopfenberg, *et al.* of the diffusion of n-hexane into extremely small polystyrene spheres demonstrates that the weight gain always starts with a square root of time term. In sufficiently large spheres this contribution is soon completely overridden by the term linear in time. The spherical geometry substantially modifies the concentration profile and the weight gain. In particular the weight gain divided by the square root of time vs. the square root of time shows a maximum as soon as the geometrical factors prevail over the effect of the constant velocity progression of the boundary between the glass and the gel.

**19662.** Peterlin, A., *Transport phenomena and polymer morphology*, *Makromol. Chem., Suppl.* **3**, 215-232 (1979).

Key words: diffusivity; elastic deformation; fractional free volume; permeability; plastic deformation; semicrystalline polymers; sorption.

The presence of the crystals in the semicrystalline polymer reduces the mass fraction, determines the space distribution and modifies the transport properties of the amorphous component which is responsible for practically all the sorption, diffusion, and permeability. The conventional determination of the diffusion coefficient from the sorption or diffusion transient is strongly affected by the geometry of the sample. The spin echo method of the nuclear magnetic resonance in a pulsed magnetic field gradient measures the diffusion directly and hence reflects the anisotropy of the orientation of the amorphous component without any distortion by the shape of the sample. The anisotropy of a single amorphous layer of a thickness of less than 10 nm, however, cannot be detected by this method which measures the molecule displacement over about 300 nm.

**19663.** Peterlin, A., *Solution properties of polymers*, Paper in *Contemporary Topics in Polymer Science*, R. D. Ulrich, Ed., **1**, 209-231 (Plenum Publ. Corp., New York, NY, 1978).

Key words: birefringence of spheroid suspension; fibrous structure; intrinsic viscosity of macromolecules; intrinsic viscosity of spheroids; longitudinal gradient flow; permeability of polymers; plastic deformation of crystalline polymers; plastic deformation of fibrous structure; radical formation upon tensile loading; transverse gradient flow.

My Ph. D. thesis work was concerned with the intrinsic viscosity of a suspension of rigid spheroids with symmetry axis  $a_1$  and perpendicular axis  $a_2$ . The most important result was the derivation of angular distribution of symmetry axis as function of axial ratio  $p = a_1/a_2$  and dimensionless velocity gradient parameter  $\sigma = \dot{\gamma}/D_r$  where  $\dot{\gamma}$  is the transverse velocity gradient and  $D_r$  is the rotational diffusion coefficient of the symmetry axis of the spheroid. The steady state distribution function permits the calculation of the gradient dependence of intrinsic viscosity  $[\eta]$ , streaming birefringence  $[\Delta n]$  and extinction angle  $\chi$ . The intrinsic viscosity calculated according to the then accepted rules of excess energy dissipation by the spheroids exhibited an initial increase with a maximum and subsequent drop to a finite value  $[\eta]_{\infty} < [\eta]_0$ . Much later, Kuhn suggested a modification of energy dissipation by inclusions of the contribution of Brownian motion which increased  $[\eta]_0$  by a factor 2 and made disappear the initial increase and maximum of intrinsic viscosity. The final formulation of excess energy dissipation by Saito was used by Scheraga for the correct calculation of gradient dependence of intrinsic viscosity of spheroid suspension.

**19664.** Saloman, E. B., *The use of synchrotron radiation for detector calibrations*, *Nucl. Instrum. Methods, Part III. Radiometry*, **172**, 79-87 (1980).

Key words: detectors; extreme ultraviolet radiation; instrumentation; radiometric transfer standards; radiometry; synchrotron radiation.

The National Bureau of Standards (NBS) VUV radiometric detector program calibrates photodiode detectors as radiometric transfer standards over the wavelength range between 50 and 2500 Å (5-250 eV photon energy). Our calibration uncertainty is 10% or better over this full range.

The source of radiation used for calibration in the spectral region below 600 Å is synchrotron radiation from the NBS Synchrotron Ultraviolet Radiation Facility (SURF) while a duoplasmatron source is used above 600 Å. A noble gas double ionization chamber is used as the absolute detector between 400-1000 Å while a single ionization chamber is used below 400 Å and a thermopile referred to the double ionization chamber is used above 1000 Å.

At wavelengths above 1200 Å magnesium fluoride windowed photodiodes with cesium or rubidium telluride photocathodes serve as transfer standards. For wavelengths below 1200 Å specially prepared  $Al_2O_3$  photodiodes are used. Their photocathodes are made by evaporating about 1800 Å of aluminum onto a quartz disc. Then a 150 Å thick layer of  $Al_2O_3$  is formed through anodization to serve as the photoemitting surface. The properties of these diodes prove to be very sensitive to contamination especially at wavelengths below 200 Å. It is particularly important that hydrocarbon oils not be cracked on their surface since this tends to form a carbonaceous photoemitting surface. We are also investigating tungsten photocathodes as a possible transfer standard for the shorter wavelengths.

In collaboration with groups at LASL and NRL studies have been made of the photoefficiency of several "practical" photocathode materials at wavelengths between 50-584 Å. Results will be shown for natural aluminum, gold, and carbon. The studies include evaluation of the stability of photoefficiency with time and the sensitivity of the photoefficiency to contamination with use in plasma machine diagnostics. In collaboration with DOE and the University of Hawaii a study was made of some high photoefficiency materials for radiometric diagnostic work. Results for CuI and CsI will be reported as will a study of some "disposable" radiometric detectors.

**19665.** Nagel, R. N., VanderBrug, G. J., Albus, J. S., Lowenfeld, E., *Experiments in part acquisition using robot vision*, (Proc. Autofact II, Robots IV Conf., Detroit, MI, Oct. 29-Nov. 1, 1979), *Soc. Mfg. Eng. Tech. Paper MS79-784*, pp. 1-14 (Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48128, 1979).



Key words: part manipulation; robotics; robot vision.

The National Bureau of Standards (NBS) vision system is mounted on the wrist of the robot, and provides both depth and part orientation information to the robot control system. The principle components of the vision system are a solid state camera, a structured light source, and a camera interface system. In experiments performed with the NBS vision system, the robot has been able to acquire both rectilinear and curved parts. This paper reviews the hardware configuration, provides an overview of the software and describes the experiments.

**19666.** Currie, L. A., **Scientific uncertainty and societal decisions: The challenge to the analytical chemist**, *Anal. Lett., Guest Editorial* 13, No. A1, 1-31 (1980).

Key words: basic research; challenge to the analytical chemist; chemical measurement process; energy; environment; health; modelling; scientific uncertainty; societal decisions; socioscientific problems; theory; time constants.

A large portion of the problems facing society today have an intrinsic scientific component. Because of imperfect scientific information, decisions concerning such problems, for example in the areas of energy, the environment or health, must be made in the presence of (scientific) uncertainty. Absence of firm predictions or accurate observations make many such decisions dependent on theoretical models, and the phenomena involved often have far-reaching consequences (long time constants, global extent). The analytical chemist has a crucial part to play in providing the information needed for optimal societal decisions through: basic research, development of new and more sensitive measurement processes, development and validation of theoretical models, and rigorous and meaningful specification of uncertainty bounds.

**19667.** Chesler, S. N., Guenther, F. R., Christensen, R. G., **An electrically heated sampler/injector suitable for use with high efficiency gas chromatographic columns**, *J. High Resolution Chromatogr. & Chromatogr. Commun., Short Commun.*, pp. 351-352 (1980).

Key words: capillary columns; concentrator; electrically heated inlet; gas chromatography; injector; vapor sampler.

The construction and performance of an electrically heating sampler/injector is described. The apparatus is found useful in collecting organic vapors and subsequently injecting these vapors rapidly onto wall coated open tubular columns. Little or no loss of chromatographic efficiency is observed with its use.

**19668.** Peterlin, A., **Diffusion with discontinuous swelling. V. Type II diffusion into sheets and spheres**, *J. Polym. Sci.: Polym. Phys. Ed.* 17, 1741-1756 (1979).

Key words: diffusivity; glass-gel boundary; sheets; spheres; type II diffusion.

Type II diffusion into uniform spheres (radius  $R$ ) and sheets (thickness  $2l$ ) is calculated under the assumption that the glass-gel boundary proceeds at a constant velocity  $v$  from the surface towards the interior of the sample, that the diffusion coefficient  $D_g$  in the glass is constant and that the diffusion coefficient  $D_r$  of the rubbery gel is so much higher than  $vR$  or  $vl$  that practically no sorbate gradient is needed for the transport through the gel of the sorbate. The diffusion process is completed when this boundary reaches the center of the sample. The concentration profile of the sorbate in the glassy matrix in front of the boundary varies with time and velocity  $v$ . It does not, however, influence the boundary propagation velocity. Hence the often observed increase of the rate of the weight gain just at the end of the diffusion process is not considered at all. The relative weight gain of the sample  $W(t)/W_\infty$  as a function of time is the only quantity usually measured. From the ordinate intercept  $A$  and the initial slope  $B$  of the plot of  $W(t)/t^{1/2}W_\infty$  vs.  $t^{1/2}$ , one

can calculate the characteristic transport properties, i.e., the diffusion coefficient  $D_g$  of the glass and the velocity  $v$  of the glass-gel boundary.

**19669.** Zalewski, E. F., Geist, J., **Solar cell spectral response characterization**, *Appl. Opt.* 18, No. 23, 3942-3947 (Dec. 1, 1979).

Key words: radiometry; silicon cell; solar cell; spectral response.

The absolute spectral response of solar cells is reported in the 400-1000-nm spectral region. Measurements were performed using two different types of monochromatic sources: amplitude-stabilized cw laser lines and interference filters with an incandescent lamp. Both types of calibration procedures use electrical substitution radiometry as the basis of traceability to absolute SI units. The accuracy of the calibration is shown to be limited by the nonideal characteristics of the solar cells themselves, specifically spatial nonuniformities and nonlinearities induced by high light levels.

**19670.** Coxon, B., Reynolds, R. C., **The synthesis and n.m.r. spectroscopy of derivatives of 6-amino-6-deoxy-D-galactose-6-<sup>15</sup>N**, *Carbohydr. Res.* 78, 1-16 (1980).

Key words: carbon-13 n.m.r.; nitrogen-15 coupling constants; nucleophilic substitution; paramagnetic broadening; proton n.m.r.; selective coupling; 6-amino-6-deoxy-D-galactose-6-<sup>15</sup>N derivatives.

Derivatives of 6-amino-6-deoxy-D-galactose-6-<sup>15</sup>N have been synthesized by reaction of the 6-deoxy-6-iodo (1) or 6-*O*-tolylsulfonyl derivative of 1,2:3,4-di-*O*-isopropylidene- $\alpha$ -D-galactopyranose with potassium phthalimide.<sup>15</sup>N. The reaction of 1 also yielded an elimination product, 6-deoxy-1,2:3,4-di-*O*-isopropylidene- $\beta$ -L-arabino-hex-5-enopyranose. The structures of the 6-amino-6-deoxy-D-galactose derivatives and their precursors were characterized by proton- and <sup>13</sup>C-n.m.r. spectroscopy, with confirmation of the <sup>13</sup>C assignments by selective, proton decoupling. Selective broadening of the C-1, C-4, C-5, and C-6 resonances of 6-amino-6-deoxy-1,2:3,4-di-*O*-isopropylidene- $\alpha$ -D-galactopyranose by low concentrations of cupric ion was observed, and studied by computerized measurements of the <sup>13</sup>C linewidths. The application of this broadening to <sup>13</sup>C-spectral assignments of amino sugar derivatives is indicated.

**19671.** VanderHart, D. L., Garroway, A. N., **<sup>13</sup>C NMR rotating frame relaxation in a solid with strongly coupled protons: Polyethylene**, *J. Chem. Phys.* 71, No. 7, 2773-2787 (Oct. 1, 1979).

Key words: C-13; cross-polarization; NMR; polyethylene; relaxation rotating frame.

The validity of interpreting measured rotating frame relaxation times,  $T_{1\rho}^{C*}$ , in terms of molecular motion is investigated for crystalline, oriented, linear polyethylene (PE) as a representative rigid organic solid with reasonably strong dipolar couplings.  $T_{1\rho}^{C*}$  data are presented at three temperatures, -100, 28, and 100 °C and for <sup>13</sup>C rf fields,  $\nu_{1C}$ , in the range  $35 < \nu_{1C} < 90$  kHz, for the orientation where  $B_0$  is parallel to the PE chain axes. With the exception of the  $T_{1\rho}^{C*}$  data taken at  $\nu_{1C} > 80$  kHz and  $T = 100$  °C, all  $T_{1\rho}^{C*}$  data observed were determined not by molecular motion, but rather by spin-spin effects in which the spin-locked carbon system seeks to equilibrate with the proton dipolar system with a characteristic time constant  $T_{CH}^D(\nu_{1C})$ , while at the same time the proton dipolar system is equilibrating with the lattice with a time constant  $T_{1D}$ . The  $T_{CH}^D$  values deduced from  $T_{1\rho}^{C*}$  support existing theory which predicts that  $T_{CH}^D(\nu_{1C}) \propto \exp(2\pi\nu_{1C}\tau_D)$  where  $\tau_D$  is the correlation time for dipolar fluctuations. A calculation of  $\tau_D$  from PE crystal structure agrees very well with the experimentally determined  $\tau_D$  of 24  $\mu$ s. Further experimental proof of the importance of the spin-spin contribution to  $T_{1\rho}^{C*}$  is demonstrated via changes in the carbon rotating frame magnetization,  $M_{SL}(\tau)$ , for



differing states of proton dipolar order. The question of extracting information about molecular motion from  $T_{1\rho}^{C*}$  data is examined under the assumption that the total reduced correlation function for the local proton dipolar field at a carbon nucleus is the product of a Lorentzian reduced correlation function describing dipolar fluctuations and an exponential reduced correlation function describing molecular motion. It is shown for molecular motion in the long correlation time regime and for sufficiently large  $\nu_{1C}$  that contributions to  $T_{1\rho}^{C*}$  from molecular motion and dipolar fluctuations are cleanly separated. Pertinent background material for the interpretation of  $T_{1\rho}^{C*}$  data is also presented; this includes effects of sample spinning, transients in carbon and proton magnetization, and ambiguities which arise when molecular motion is fast enough to cause some averaging of the static dipolar line shape. Criteria are offered whereby one can decide on the validity of interpreting  $T_{1\rho}^{C*}$  data in terms of molecular motion. As an example, the  $T_{1\rho}^{C*}$  data point for  $\nu_{1C} = 87$  kHz and  $T = 100^\circ\text{C}$  is interpreted in terms of molecular motion and the deduced correlation time, assuming a flip-flop motion of the polymer chains, is shown to be qualitatively consistent with published proton  $T_{1\rho}^H$  results. Finally,  $^{13}\text{C}$  longitudinal relaxation time measurements are discussed as a possible alternative to  $T_{1\rho}^{C*}$  for obtaining information about molecular motion.

**19672.** McKenna, G. B., Zapas, L. J., **The normal stress response in nonlinear viscoelastic materials: Some experimental findings**, *J. Rheol.* **24**, No. 4, 367-377 (1980).

Key words: BKZ theory; non-linear viscoelasticity; normal stresses; PIB; PMMA; poly(isobutylene); poly(methyl methacrylate); time dependent behavior.

In a previous paper we presented the interesting theoretical result that in a two-step torsional or simple shearing deformation where the magnitude of the second step is one half the magnitude of the first step, the normal stress response is predicted to be independent of the duration of the first step and equal to the single step response to a deformation of the same magnitude as the second step. Experimental support for this prediction is presented based on tests run on two greatly different polymeric systems—a 19.3% solution of poly(isobutylene) in cetane and glassy poly(methyl methacrylate).

**19673.** Read, D. T., McHenry, H. I., Steinmeyer, P. A., Thomas, R. D., Jr., **Metallurgical factors affecting the toughness of 316L SMA weldments at cryogenic temperatures**, *Weld. J.: Res. Suppl.* **59**, No. 4, 104S-113S (Apr. 1980).

Key words: cryogenic; delta ferrite; ferrite content; fracture; mechanical properties; stainless steel; strength; toughness; welds.

The effects of delta ferrite content, ferrite morphology, carbon content, and sensitization on the fracture toughness and tensile properties of AWS E316L and E316 shielded metal arc (SMA) weldments at 295, 76, and 4 K were investigated. Ten SMA test welds were evaluated, eight made with E316L and two with E316 electrodes. In four of the welds, the delta ferrite content was controlled over the ferrite number range of 0 to 11 through slight variations in the chemical compositions of the electrode coatings. In three of the welds, the ferrite morphology was varied in 8% ferrite welds deposited using the same electrode by varying heat input, preheat, and interpass temperature. One E316 weld with low ferrite content (FN 1.3) and the baseline welding parameters was used to assess the effect of carbon content. The two remaining welds were made with a low cooling rate to study sensitization in the low-ferrite, low (E316L) and regular (E316) carbon welds. Part of the E316 weld was deliberately sensitized at  $675^\circ\text{C}$  ( $357^\circ\text{F}$ ) for 24 hours.

All of the weldments had excellent toughness at room temperature. However, at 76 K only the E316L weld with low ferrite had acceptable (to ASME standards) toughness. Large

decreases in toughness at 76 and 4 K were related to increasing ferrite content. Decreases in Charpy impact energy at 76 K were also related to coarsened ferrite morphology caused by reduced cooling rates, to increased carbon content, and to the sensitization heat treatment. The tensile yield strength increased with ferrite content, especially at 4 K. The effects of ferrite content on the ultimate tensile strength and the ductility were generally minor.

**19674.** Peterlin, A., **Plastic deformation of crystalline polymers**, *Polym. Eng. Sci.* **17**, No. 3, 183-193 (Mar. 1977).

Key words: crystalline polymer; cylindritic structure; fibril; fibrous structure; microfibril; necking; plastic deformation; spherulitic structure; tie molecule.

Under uniaxial tensile load, the plastic deformation of unoriented crystalline polymers first transforms the lamellae into a fibrous structure. Usually the drawing is inhomogeneous with a neck propagating through the sample. The higher the draw ratio, the higher the axial elastic modulus as a consequence of the larger fraction of taut tie molecules in amorphous layers connecting the crystalline blocks of each microfibril. As a consequence of the almost  $1/(1-\alpha)$  times higher strain of amorphous layers under tensile load, the taut tie molecules are much more strained than the chains in crystal blocks. Hence, their contribution to elastic modulus is substantially higher than one would guess from their fraction  $\beta$ . This is more so in polyethylene with higher crystallinity ( $\alpha = 0.8$ ) than in nylon 6 with low crystallinity ( $\alpha = 0.5$ ). Even for the highest modulus polyethylene  $E = 70$  GPa  $\sim 0.3 \times E_c$ , one needs less than 7.5 percent of taut tie molecules. The plastic deformation of the fibrous structure markedly enhances the number of interfibrillar tie molecules in nylon 6 and to a lesser extent in polyethylene and polypropylene. Homogeneous drawing without a neck transforms the whole sample into a fibrous structure rather uniformly so that for a long while one has the lamellar and fibrillar morphology side by side. The end effect on the structure obtained does not differ appreciably from inhomogeneous drawing with neck propagation. The drawing of polymers with a liquid crystal structure yields a highly aligned fibrous structure with very few chain folds and an exceptionally high elastic modulus and strength. But the axial connection of individual highly oriented and ordered domains is affected by a relatively small fraction of tie molecules, and this is responsible for reduction of the elastic modulus below the value of the ideal crystal lattice.

**19675.** Schaefer, A. R., **Reflectance and external quantum efficiency change of a silicon photodiode after surface cleaning**, *Appl. Opt.* **18**, No. 15, 2531 (Aug. 1, 1979).

Key words: cleaning; dirt films; reflectance; silicon photodiodes.

A change in the reflectance of silicon photodiodes was observed and attributed to possible formation of an impurity coating on the detector surface. An experiment was performed to verify this hypothesis and show how the external quantum efficiency of the detector varied with the reflectance in a compensating manner such that the internal quantum efficiency remained constant.

**19676.** Roth, R. S., Negas, T., Parker, H. S., Minor, D. B., Jones, C., **Crystal chemistry of cerium titanates, tantalates and niobates**, *Proc. 12th Rare Earth Research Conf., Vail, CO, July 18-22, 1976*, C. E. Lundin, Ed., II, Session J-T, 605-614 (University of Denver, CO, 1976).

Key words: brannerite; cerium niobate; cerium tantalate; cerium titanate; crystal chemistry; crystallography; fergusonite; scheelite.

Cerium dioxide has been found to react with other oxides at high temperatures in an open air environment with the formation of  $\text{Ce}^{+3}$ ,  $\text{Ce}^{+4}$  or mixed valence phases. The valence of the



cerium ion depends on the temperature and on the relative size and charge of the metal ions in the oxides with which it reacts. With  $\text{TiO}_2$ , only the essentially fully oxidized compound  $\text{Ce}^{+4}\text{Ti}_2\text{O}_6$  is formed. It has the brannerite structure  $a = 9.840$ ,  $b = 3.758$ ,  $c = 6.914\text{\AA}$ ,  $\beta = 119^\circ 8.7'$  and is isostructural with  $\text{ThTi}_2\text{O}_6$ . The addition of sodium or the presence of sodium in the cerium oxide as an impurity leads to the suppression of the brannerite phase and the formation of a black pseudocubic perovskite compound  $\text{NaCe}^{+3}\text{Ta}_2\text{O}_9$ ,  $a = 3.864\text{\AA}$ . With  $\text{Ta}_2\text{O}_5$  a yellow compound is formed at  $\text{Ce}^{+3}\text{Ta}_2\text{O}_9$ . Single crystals grown in a barium vanadium oxide flux reveal that this compound is hexagonal,  $P6_3/mcm$ ,  $a = 6.232$ ,  $c = 19.985\text{\AA}$  rather than the tetragonal cell previously suggested. A perovskite-like phase with  $\text{Ce}^{+3}$  is formed at  $\text{Ce}^{+3}\text{Ta}_2\text{O}_9$ . It is yellow in color with orthorhombic symmetry as previously reported. The compound  $\text{Ce}^{+3}\text{TaO}_4$  is formed at high temperatures with a melting point of  $\sim 1940^\circ\text{C}$ . Single crystals grown by the Czochralski technique in an argon atmosphere are light green and reveal at room temperature a twinned monoclinic phase of the  $\text{LaTaO}_4$ -type,  $P2_1/c$  with  $a = 7.618$ ,  $b = 5.531$ ,  $c = 7.767\text{\AA}$ ,  $\beta = 100^\circ 56.3'$ . However, on oxidizing at low temperature  $\sim 600^\circ\text{C}$ , the crystals turn black and change to monoclinic,  $P2/m$ ,  $a = 7.617$ ,  $b = 5.491$ ,  $c = 3.851\text{\AA}$ ,  $\beta = 102^\circ 30.5'$ , with a corresponding change to  $\sim \text{CeTaO}_{4.174}$ . Another phase which is also light yellow is formed by oxidizing at  $350^\circ\text{C}$  for long periods of time and corresponds to  $\text{CeTaO}_{4.50}$ . The x-ray pattern of this phase is very different from the preceding monoclinic forms and is possibly triclinic although twinned single crystals have not yet revealed the true unit cell. Cerium niobate likewise has a  $\text{Ce}^{+3}$  compound at about a 1:5 ratio (orthorhombic  $Pmnb$ ,  $a = 20.12$ ,  $b = 12.474$ ,  $c = 7.744\text{\AA}$ ) and a yellow perovskite,  $\text{Ce}^{+3}\text{Nb}_3\text{O}_9$ . The 1:1 phase formed in air at high temperature is  $\text{Ce}^{+3}\text{NbO}_4$  with a fergusonite unit cell when quenched to room temperature  $a = 5.544$ ,  $b = 11.434$ ,  $c = 5.177\text{\AA}$ ,  $\beta = 94^\circ 41.8'$ , although it transforms to a scheelite-like structure at about  $600^\circ\text{C}$  in a non-oxidizing environment. On oxidation in air at  $\sim 600^\circ\text{C}$  the cell size is  $a = 5.364$ ,  $b = 11.424$ ,  $c = 5.129\text{\AA}$ ,  $\beta = 93^\circ 22.7'$  at room temperature and corresponds to  $\sim \text{CeNbO}_{4.25}$ . Solid solutions of  $\text{Ce}^{+3}\text{VO}_4$  (zircon structure) in  $\text{Ce}^{+3}\text{NbO}_4$  exist to about 40 mole %  $\text{CeVO}_4$ . At this composition the solid solution has the tetragonal scheelite structure at room temperature  $a = 5.295$ ,  $c = 11.645\text{\AA}$ . This phase can still be oxidized at about  $600^\circ\text{C}$  to a tetragonal scheelite with  $a = 5.276$ ,  $c = 11.630\text{\AA}$ . The crystal chemistry and extent of oxidation of these cerium compounds have been studied as a function of their solid solution formation with corresponding lanthanum, praseodymium and neodymium compounds.

**19677.** Currie, L. A., Noakes, J. E., Breiter, D. N., **Measurement of small radiocarbon samples: Power of alternative methods for tracing atmospheric hydrocarbons**, (Proc. 9th Int. Conf. Radiocarbon Dating, Los Angeles and La Jolla, CA, June 28-July 2, 1976), Paper in *Radiocarbon Dating*, R. Berger and H. E. Suess, Eds., pp. 158-175 (University of California Press, Los Angeles, CA, 1979).

**Key words:** atmospheric pollutants; figure of merit; low-level counting; natural radiocarbon; small gas proportional and liquid scintillation counters.

Measurement problems with very small radiocarbon samples arise whenever such samples have a high specific "cost," that is, are limited in supply or are difficult to collect. One such problem, due to collection difficulties, involves the measurement of carbonaceous species in the atmosphere to determine the relative contributions of man and nature. The characteristics of miniature gas proportional and liquid scintillation counters especially developed for this work have been evaluated and have been judged adequate for the measurement of 10 mg of contemporary carbon. A graphical means of assessing the relative performance of an entire set of small counters has been introduced. It has been used to deduce the equimerit curve for the most

sensitive gas and liquid scintillation counters. Preliminary results on the carbonaceous fraction of an urban dust sample have been compared with the results of earlier research.

**19678.** Marinenko, R. B., Heinrich, K. F. J., Myklebust, R. L., Fiori, C. E., **Crystal efficiency determination for relative line intensity measurements**, (Proc. 15th Annual Conf. Microbeam Analysis Society, Reno, NV, Aug. 4-8, 1980), Paper in *Microbeam Analysis—1980*, D. B. Wittry, Ed., pp. 56-58 (San Francisco Press, San Francisco, CA, 1980).

**Key words:** crystal spectrometer calibration; electron microprobe analysis; energy dispersive spectrometry (EDS); L-series x-ray lines; relative x-ray line intensities; spectrometer efficiency; wavelength dispersive spectrometry (WDS).

Extensive overlap occurs in the x-ray spectra of L-lines; for this reason energy dispersive spectrometry (EDS), where detector efficiency can be calculated, cannot be used to determine accurate relative L-line ratios. The efficiency of a wavelength dispersive spectrometer (WDS), where L-line spectra are better-resolved is difficult to calculate.

A lithium fluoride crystal spectrometer has therefore been calibrated with the help of EDS using  $K\alpha$  and  $K\beta$  x-ray lines. A ratio of the WDS net integral to the corrected EDS net integral is determined. When this ratio is plotted as a function of peak energy for most elements from titanium through arsenic, a smooth curve is obtained. This WDS efficiency curve can then be used to correct L-line integrals for more accurate relative L-line ratios.

**19679.** Small, J. A., Newbury, D. E., Myklebust, R. L., **Instrumental effects on the generation of continuum from pure element targets**, (Proc. 15th Annual Conf. Microbeam Analysis Society, Reno, NV, Aug. 4-8, 1980), Paper in *Microbeam Analysis—1980*, D. B. Wittry, Ed., pp. 53-55 (San Francisco Press, San Francisco, CA, 1980).

**Key words:** continuum intensity; electron probe; microanalysis; particle analysis x-ray; quantitative analysis.

In this paper we discuss a comparison of the continuum intensities from pure element targets measured on three different electron beam instruments at two different accelerating voltages. The results indicate: (1) One expression can be used to describe the dependence of the continuum for the different experimental setups over the range of accelerating voltages 17-25 keV. (2) The energy dependence of the continuum is not the same for the different experimental setups. Investigation of the existing correction procedures is necessary before an expression for the energy dependence of the continuum can be derived.

**19680.** Bass, A. M., Herbert P. Broida, **The Washington Years**, (Proc. 14th Int. Symp. Free Radicals, Sanda, Hyogo-ken, Japan, Sept. 3-7, 1979), Paper in *Free Radicals*, Y. Morino, I. Tanaka, E. Hirota, K. Obi, and S. Saito, Eds., pp. 3-21 (Kwansei Gakuin University, Sanda, Japan, 1979).

**Key words:** Broida; combustion; flames; free radicals; medical physics; spectroscopy.

The professional career of Herbert P. Broida in the period 1949 to 1963 is reviewed. This represents the period of his association with NBS in Washington, D.C. His activities in combustion and flame spectroscopy and medical physics are described. His direction of the Free Radicals Research Program is discussed.

**19681.** Zapas, L. J., Crissman, J. M., **An instability leading to failure of polyethylene in uniaxial creep**, *Polym. Eng. Sci.* 19, No. 2, 104-107 (Feb. 1979).

**Key words:** continuum model; critical strain; instability point; molecular weight distribution; necking; polyethylene; stress relaxation; uniaxial creep.



Based on a continuum model, a point of instability is predicted for the uniaxial creep of high density polyethylene. From dead load experiments it has been found that the instability occurs for linear polyethylene at around 10-12 percent strain, depending upon molecular weight and molecular weight distribution. It is shown that in the range of applied stresses for which the specimens neck during uniaxial creep, the time required to reach the critical point is related by a constant factor to the time at which the neck appears. A synopsis of theoretical considerations, as well as experimental work in support of this idea, is given.

**19682.** Straty, G. C., (*p, V, T*) of compressed fluid ethene, *J. Chem. Thermodyn.* **13**, 709-716 (1980).

Key words: compressibility; density; ethylene; melting pressures; PVT; vapor pressure.

New measurements of the melting line and (*p, V, T*) of fluid ethene are reported. (*p, V, T*) determinations have been made in the amount-of-substance density range from about 13 mol dm<sup>-3</sup> to greater than 23 mol dm<sup>-3</sup> at pressures to 33 MPa. About 250 (*p, V, T*) points have been determined. Melting pressures to 21 MPa are reported.

**19683.** Schrack, R. A., Bowman, C. D., Calculation and measurement of fission and delayed neutron yields in U<sub>3</sub>O<sub>8</sub> and UO<sub>2</sub>, *Nucl. Sci. Eng. Tech.* **75**, 275-277 (1980).

Key words: chemical state; delayed neutron; fission; phonon distribution; U<sub>3</sub>O<sub>8</sub>; UO<sub>2</sub>.

Theoretical calculations and experimental measurements have been made to look for reported chemical dependence in the yield of delayed neutrons from thermal-neutron-induced fission in <sup>235</sup>U. Using an Einstein model of the lattice phonon distribution, calculations have been made that indicate no significant dependence of the fission cross section on the lattice phonon distribution. Two types of experimental measurements were made. The fission fragment yield was compared for thermal-neutron-induced fission in U<sub>3</sub>O<sub>8</sub> and UO<sub>2</sub>. The delayed neutron yields from U<sub>3</sub>O<sub>8</sub> and UO<sub>2</sub> were also compared. In neither measurement was there a significant difference in yield for the two chemical states of uranium.

**19684.** Pletka, B. J., Fuller, E. R., Jr., Koepke, B. G., An evaluation of double-torsion testing—Experimental, *Proc. 11th Natl. Symp. Fracture Mechanics*, Blacksburg, VA, June 12-14, 1978, pp. 19-37 (American Society for Testing and Materials, Philadelphia, PA, June 1978).

Key words: compliance analysis; curved crack profile; double-torsion testing; fracture (materials); fracture toughness; side grooves; three-dimensional crack; torsional beam.

Recently, the double torsion (DT) technique has been widely used for fracture mechanics studies of brittle materials. There are a number of reasons for the popularity of the technique. First, the compliance analysis of a precracked DT specimen indicates the applied stress intensity factor, *K<sub>I</sub>*, is independent of crack length. This allows tests to be conveniently run on opaque samples and in hostile environments. In addition, specimen and loading geometries are simple and easily adapted to most testing machines. Furthermore, specimens are generally easily precracked and slow crack growth data can be obtained using simple load relaxation tests. As in most testing techniques, however, experimental conditions may arise under which the validity of the data may be in question. For instance, the independence of *K<sub>I</sub>* on crack length in a DT specimen occurs over only a limited range of crack lengths. The crack propagation characteristics have also been shown to be dependent on the specimen dimensions. Finally irreproducibility of slow crack growth data occurs under certain testing conditions.

In this paper these and other experimental aspects of the DT test are critically examined with the objective of defining the

conditions under which the data are valid. Among the topics discussed are specimen and loading geometry, precracking techniques, data reproducibility, slow crack growth measurements and comparisons of DT data with other techniques.

**19685.** Soulen, R. J., Jr., Marshak, H., The establishment of a temperature scale from 0.01 K to 0.05 K using noise and <sup>60</sup>Co γ-ray anisotropy thermometers, *Cryogenics* **22**, No. 7, 408-412 (July 1980).

Key words: cryogenic temperature scale; Josephson junction; noise thermometry; nuclear orientation; thermometry; <sup>60</sup>CoCo γ-ray anisotropy thermometry.

We report here on our latest intercomparison of the Josephson junction noise thermometer and <sup>60</sup>Co γ-ray anisotropy thermometer from 0.01 K to 0.05 K. These results show both thermometers are in agreement to better than 0.5%. This is an improvement over our previous data and is due mainly to better temperature control and advances in instrumentation.

**19686.** VanderHart, D. L., Annealing-induced changes in orientation and mobility in the noncrystalline region of drawn linear polyethylene: A <sup>13</sup>C NMR study, *Macromolecules* **12**, No. 6, 1232-1235 (Nov.-Dec. 1979).

Key words: annealing; drawn; NMR; noncrystalline; orientation; polyethylene; <sup>13</sup>C.

A cold drawn linear polyethylene (LPE) sample was subsequently annealed at consecutively higher temperatures between 120 °C and the melt. A definition based on differences of <sup>13</sup>C NMR relaxation times was adopted in order to separate signals from the crystalline component (CC) and noncrystalline component (NCC). Changes in crystallinity and mobility were noted as a function of the average orientation of chain segments. Annealing reduces the NCC from 0.33 to 0.19 with most of the NCC intensity change appearing in the spectral region of those NCC chain segments which are strongly oriented in the drawing direction.

**19687.** Piermarini, G. J., Mauer, F. A., Block, S., Jayaraman, A., Geballe, T. H., Hull, G. W., Jr., Optical microscopic, x-ray diffraction, and electrical resistance studies of CuCl at high pressure, *Solid State Commun.* **32**, 275-289 (1979).

Key words: cuprous chloride; diamond cell; optical microscopy; phase transition; resistivity; x-ray diffraction.

Electrical resistance and x-ray diffraction measurements and also optical observations under a polarizing microscope were made on CuCl to pressures in excess of 12.5 GPa at room temperature using a diamond anvil cell. Resistance measurements were also performed in a piston-cylinder apparatus to pressures of approximately 5.5 GPa at room temperature. Three samples of CuCl prepared by different methods were examined. No anomalous pressure dependence in electrical resistance was found in the pressure range studied, and no dramatic changes in optical transmission were observed up to pressures of approximately 10.0 GPa. Optical observations and x-ray diffraction measurements indicate the existence of four phases in the pressure range studied, including a nonconducting black opaque phase which grows with time when CuCl is left for several days at the highest pressures.

**19688.** Peterlin, A., Drawing and annealing of fibrous material, *J. Appl. Phys.* **48**, No. 10, 4099-4108 (Oct. 1977).

Key words: annealing; drawing; fibril; fibrous structure; high elastic modulus material; microfibril; microfibrillar; tie molecules.

The more-than-linear increase of elastic modulus with draw ratio, the gradual disappearance of meridional SAXS maximum, the drastic drop of elastic modulus after annealing and its recovery upon standing at room temperature if the sample was an-



nealed with fixed ends so that it did not shrink, and the shape stability of such polyethylene samples and of superdrawn material (polyethylene, polypropylene, polyoxymethylene) during new annealing can be easily explained by the microfibrillar model of fibrous structure which was developed some years ago on the basis of electron microscopy and x-ray and in investigation of plastically deformed linear polyethylene and isotactic polypropylene.

- 19689.** McKenna, G. B., Bradley, G. W., Dunn, H. K., Statton, W. O., **Degradation resistance of some candidate composite biomaterials**, *J. Biomed. Mater. Res.* **13**, 783-798 (1979).

Key words: aromatic polyamide fiber; autoclave stability; biomaterial; composites; degradation resistance; fiberglass/epoxy; fiber reinforced composites; graphite/polysulfone; orthopedic materials; PECF; polymer matrix; polypropylene; polysulfone.

The degradation resistance of matrix, fiber and composite systems which we have been studying as candidate orthopedic materials has been examined in two appropriate environments. Both resistance to steam sterilization in an autoclave environment and resistance to a simulated physiologic solution have been studied. In the autoclave study, samples were placed in a pressure cooker at 123 °C for differing amounts of time and tested for retention of mechanical properties. Results indicate that most of the materials tested could be autoclaved several times, as long as autoclave times did not exceed 1 hr. Longer autoclave times result in an accelerated degradation and loss of strength of all materials except the polypropylene. Polysulfone degrades after even the shortest autoclave duration. Resistance to the simulated physiologic environment was tested by measuring retention of mechanical properties after immersion times in pseudo-extracellular fluid (PECF) at 37 °C for as long as three years. None of the materials showed any significant changes in properties after immersion in the PECF.

- 19690.** McKenna, G. B., Penn, R. W., **Time-dependent failure in poly(methyl methacrylate) and polyethylene**, *Polymer* **21**, 213-220 (Feb. 1980).

Key words: additivity of damage; Bailey criterion; damage accumulation; failure; fatigue; mechanical properties; PMMA; polyethylene; poly(methyl methacrylate); time-dependent behavior.

Time-dependent failure of PMMA and polyethylene are characterized within the framework of a cumulative damage model for failure. It is found that the mean failure times in constant rate of stress experiments can be successfully predicted from the model using a time to fail function determined from constant stress experiments. For zero-tension sinusoidal fatigue tests, differences of up to an order of magnitude are observed between predicted and experimental failure times. PMMA and polyethylene data deviate from the predictions in different ways. In PMMA, the distribution of failure times in constant stress tests is moderately broad, as measured by the coefficient of variation, and symmetric about the mean, while in the fatigue tests the distribution is considerably broader, has a high positive skewness and shows evidence of being bimodal. For polyethylene, the distribution changes from being moderately broad and positively skewed in constant stress tests to a moderately broad, symmetric distribution in the fatigue tests. The model also predicts the total lifetime in sinusoidal fatigue tests to be independent of test frequency. Experimental results show that the lifetime of PMMA decreases with increasing frequency, although less rapidly than if the fatigue process were cycle dependent. The lifetime of polyethylene increases with increasing test frequency.

- 19691.** Maruyama, X. K., Kline, F. J., Lightbody, J. W., Jr., Penner, S., Briscoe, W. J., Lunnon, M., Crannell, H., **Elec-**

**troexcitation of  $^{22}\text{Ne}$  below  $E_\alpha = 8.6$  MeV**, *Phys. Rev. C* **19**, No. 5, 1624-1636 (May 1979).

Key words: deduced  $J, \pi, B(CL)$ ; enriched  $^{22}\text{Ne}$  target;  $E = 60$  to 110 MeV; measured  $\sigma(E)$  at 110° and 128° up to 8.6 MeV in excitation energy; nuclear reactions;  $^{22}\text{Ne}(e, e')$ .

The states of  $^{22}\text{Ne}$  below 8.6 MeV excitation energy have been studied using the technique of inelastic electron scattering. Ratios of inelastic to elastic scattering cross sections were measured with incident electron energies between 60 and 110 MeV and scattering angles of 110° and 128°. Form factors for 14 inelastic transitions were measured for the momentum transfer range 0.4 to 1.0 fm<sup>-1</sup>. Reduced transition probabilities for these states have been deduced and assignments of spin and parity have been made.

- 19692.** Mazur, J., Fanconi, B., **Raman spectra of  $n$ -alkanes. I. Raman intensities of longitudinal acoustic modes**, *J. Chem. Phys.* **71**, No. 12, 5069-5080 (Dec. 15, 1979).

Key words: bond polarizabilities; calculated frequencies; Fermi resonance; longitudinal acoustic modes;  $n$ -alkanes; Raman intensities; structural defects; transverse acoustic modes.

Raman intensities are calculated for longitudinal acoustic modes of  $n$ -alkanes which couple through methyl interactions with transverse acoustical modes. Calculated intensities from normal mode analysis and perturbation theory compare favorably with observed intensities. The results lend support to the method of calculating intensities of longitudinal acoustic modes of chains with structural defects in which the intensity is proportional to the square of the dot product of the atomic displacements of the LAM of the all *trans* conformation chain and the displacement of modes calculated for defect conformations.

- 19693.** Fuller, E. R., Jr., **An evaluation of double-torsion testing—Analysis**, *Proc. 11th Natl. Symp. Fracture Mechanics, Blacksburg, VA, June 12-14, 1978*, pp. 3-18 (American Society for Testing and Materials, Philadelphia, PA, June 1978).

Key words: compliance analysis; curved crack profile; double-torsion testing; fracture (materials); fracture toughness; side grooves; three-dimensional crack; torsional beam.

The double-torsion test configuration has many advantages over conventional fracture mechanics configurations for the evaluation of subcritical crack growth parameters and critical fracture toughness. These advantages—such as crack-length independence, compressive loading, simple specimen, geometry, and ease of precracking—have been responsible for the increased use of the double-torsion configuration in recent years. However, before double-torsion testing can be adopted as a standard configuration, a number of unresolved questions need to be answered about the double-torsion specimen and about the experimental techniques involved in its use.

The purpose of this paper is to address some of these questions and to indicate where further effort is needed to establish the validity of double-torsion testing. Assumptions of a compliance analysis for the double-torsion configuration are examined with particular attention given to the influence on experimental results that the violation of any of these assumptions may have. An analytical expression is derived for the compliance of a finite-thickness beam in torsion and is compared to the empirical compliance. Again the emphasis is on the assumption of the derivation and how some of these restrictions might be relaxed.

- 19694.** Ditchek, B., Penn, R. W., **Random strain amplitude cycling of copper single crystals**, *Scr. Metall.* **13**, 877-880 (1979).

Key words: copper crystal; fatigue; persistent slip band; plastic strain; random cycling; single crystal copper.



The similarity in extent and appearance of PSBs on random and conventionally cycled copper single crystals suggests that the saturation behavior is determined by the maximum allowable strain amplitude in a test and not the average. At saturation, enough PSBs are nucleated to permit the maximum enforced elongation. PSBs are not nucleated according to the average enforced strain amplitude. Apparently, there is a maximum strain that a PSB can sustain, but there is no minimum.

In addition, PSBs are more difficult to nucleate in crystals randomly cycled than those cycled between constant plastic strain limits. This is evidenced by the overshooting of the saturation stress for crystals cycled randomly under large maximum plastic strain limits. A conventionally tested crystals cycled under the same maximum plastic strain limits does not require a stress in excess of the saturation stress to nucleate PSBs.

**19695.** Bright, D. S., Fletcher, R. A., Chabay, I., **Particle Doppler shift spectrometry. Accurate size determinations of 5-15- $\mu$ m aerosol**, *J. Phys. Chem.* **84**, No. 12, 1607-1611 (June 12, 1980).

Key words: aerosol; light scattering; Lorenz-Mie light scattering calculation; particle sizing; Stoke's velocity.

We have improved the particle Doppler shift spectrometer (PDSS) to determine the diameter of 5-15- $\mu$ m droplets to high accuracy ( $\pm 0.05 \mu$ m). The diameter is calculated from Stokes law and the gravitational settling velocity which is obtained by measuring the Doppler shift of laser light scattered at a single angle. This scattered light also shows intensity variations with diameter as predicted by Lorenz-Mie light scattering theory. Characteristic features of the plot of scattered light intensity vs. droplet diameter are used as size calibration markers. The features are a function of only the index of refraction of the aerosol material and the wavelength of the light. Our results show better agreement with Stokes law without the slip correction than with the correction.

**19696.** Ledbetter, H. M., **Sound velocities and elastic-constant averaging for polycrystalline copper**, *J. Phys. D: Appl. Phys.* **13**, 1879-1884 (1980).

Key words: copper; Debye temperature; elastic constants; polycrystals; sound velocities; tensor-property averaging.

This study deals with the tensor-averaging problem, with the relationship between single-crystal and polycrystalline elastic constants. For polycrystalline copper, sound velocities were measured within a 0.1% inaccuracy at  $T = 295$  K. Comparison with average values from twelve previous studies shows agreement within 0.2% in  $v_t$ , 0.1% in  $v_e$ , and 0.1% in  $v_l$ . Among eight elastic-constant averaging methods, the Hershey-Kröner-Eshelby method works best for copper. This averaging method predicts that copper's polycrystalline and single-crystalline Debye temperatures differ by about 9 K.

**19697.** Stenbakken, G. N., Eliason, L. K., Researcher, Editor, **Metallic window foil for intrusion alarm systems**, *NIJ Standard-0319.00*, 11 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Aug. 1980).

Key words: alarm; burglar alarm; detector; intrusion alarm; standard; test method; window foil.

This standard establishes performance requirements and methods of test for window foil used in intrusion alarm systems as a sensor to detect the breakage of glass. The standard applies only to metallic foil for use on glazing materials consisting solely of glass.

**19698.** Stroik, J. S., Reichard, T., Washington, D., Eliason, L. K., Researchers, Editor, **Physical security of window units**, *NIJ Standard-0316.00*, 19 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Aug. 1980).

Key words: burglary resistance; frames; hardware; hinges; locks; performance standard; test methods; window; window assemblies; window components.

This document establishes performance requirements and methods of test for the resistance to forced entry of window units intended for use in residences and some small businesses. This standard addresses the capability of window units to frustrate the "opportunity" crimes committed by unskilled and semi-skilled burglars. The skilled or rarely used methods of gaining entry through window units are not addressed.

This standard is compatible with the NIJ standards for the physical security of single-swing entry doors and sliding glass door units.

**19699.** Currie, L. A., Kropschot, R., **Hydrogen: A workshop on societal aspects of energy systems**, *Foresight—Volume I. Societal Aspects of Hydrogen Energy Systems, Part A*, 9-161 (U.S. House of Representatives, Ninety-Fifth Congress, Second Session, Committee on Science and Technology, Washington, DC, Dec. 1978).

Key words: barrier/incentives; hydrogen energy systems; impacts of hydrogen fuel; policy options; societal aspects; workshop.

A workshop to outline the important Societal Aspects of Hydrogen Energy Systems was arranged by the National Bureau of Standards at the request of the Honorable Olin E. Teague, Chairman, Committee on Science and Technology, U.S. House of Representatives. The objectives were to study the conditions under which hydrogen can emerge as a major (negligible) fuel of the future, identify barriers/incentives to implementation, make comparisons with alternate fuels and outline policy changes which would speed or deter hydrogen use. About seventy invited participants met in Reston, Virginia, June 4-7, 1978, and with the input from six parallel interdisciplinary working groups have provided the basis for a response to the U.S. Congress.

**19700.** Calvano, N. J., Gorden, R., Jr., Researcher, Editor, **Riot helmets and face shields**, *NIJ Standard-0104.01*, 18 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Aug. 1980).

Key words: face shield; headgear; helmet; impact; protective equipment; riot helmet.

This standard establishes performance criteria and test methods for helmets and face shields intended for use by law enforcement officers.

Helmet tests include requirements for impact attenuation, penetration resistance, and chin strap/retention system integrity.

Face shield requirements include impact attenuation and optical properties.

**19701.** Nelson, R. E., Jickling, R. M., Jones, R. N., Treado, M. J., Researchers, Editor, **Microphone cable assemblies for mobile FM transceivers**, *NIJ Standard-0217.00*, 10 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Aug. 1980).

Key words: communications equipment standard; compatibility; interchangeability; law enforcement; microphone cable; microphone connector; mobile FM transceiver.

The document is a voluntary performance standard, developed by the Law Enforcement Standards Laboratory, to identify characteristics, establish minimum performance requirements, and describe test methods for measuring the electrical characteristics of microphone cable and connector assemblies used in law enforcement mobile transceivers. The standard addresses the microphone plug, the mating panel receptacle, and the multiconductor cable used to connect the microphone to the control head of a mobile FM transceiver. The use of this standard is



intended to achieve interchangeability and compatibility among microphone connector and cable assemblies used with law enforcement mobile transceivers and microphones, regardless of the manufacturer or model.

19702. Reichard, T. W., Eliason, L. K., Researcher, Editor, **Physical security of sliding glass door units**, *NIJ Standard-0318.00*, 14 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, Aug. 1980).

Key words: burglary resistance; forced entry; patio door; performance criteria; performance standard; sliding glass door; test methods.

This document is a voluntary performance standard developed by the Law Enforcement Standards Laboratory. This standard establishes performance requirements and methods of test for the resistance to forced entry of sliding glass door units intended for use in residences. The capability of sliding glass door units to frustrate the "opportunity" crimes committed by unskilled and semi-skilled burglars is addressed. The rarely used methods of gaining entry through sliding glass door units, and those used only by skilled burglars, are not addressed.

19703. Albers, J., **Comparison of spreading resistance correction factor algorithms using model data**, *Solid-State Electron.* **23**, 1197-1205 (1980).

Key words: correction factor; depth profiling; Laplace's equation; local slope analysis; multilayer analysis; resistivity; sheet resistance; spreading resistance.

Model spreading resistance data generated from the Schumann-Gardner multilayer solution of Laplace's equation are employed to compare two recently published spreading resistance correction factor algorithms. Specifically, depth-dependent resistivities corresponding to diffusions and implants are used to generate the appropriate depth-dependent model spreading resistance data. These data are then analyzed according to the two algorithms and the resulting interpreted resistivities are compared with the original input resistivities. The resistivities interpreted by the multilayer algorithm of D'Avanzo *et al.*, agree with the original resistivities to within one percent on the average while the resistivities interpreted by the  $K_1K_2$  form of Dickey's local slope algorithm agree with the original resistivities to within 10-25% on the average.

19704. Anderson, P. C., Kurylo, M. J., **Rate constant measurements for the reaction  $\text{Cl} + \text{CH}_2\text{O} \rightarrow \text{HCl} + \text{CHO}$ . Implications regarding the removal of stratospheric chlorine**, *J. Phys. Chem.* **83**, No. 16, 2055-2057 (Aug. 9, 1979).

Key words: Cl atoms; formaldehyde; kinetics; ozone; resonance fluorescence; stratosphere.

The flash photolysis resonance fluorescence technique was employed to investigate the rate constant for the reaction  $\text{Cl} + \text{CH}_2\text{O} \rightarrow \text{HCl} + \text{CHO}$  from 223 to 323 K. An Arrhenius fit of the data gives  $k_1 = (1.09 \pm 0.40) \times 10^{-10} \exp[-(131 \pm 98)/T]$  in units of  $\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ . The results are compared to two very recent kinetic studies and are assessed in view of the reaction's role in disrupting the Cl-CIO stratospheric ozone depletion chain.

19705. Baloga, S. M., Hakkila, E. A., **Measurement trends for future safeguards systems**, (Proc. Institute of Nuclear Materials Management 21st Annual Meeting, Palm Beach, FL, June 30-July 2, 1980), *LA-UR-80-1817*, IX, 773-794 (INMM Secretariat, 11704 Bowman Green Drive, Reston, VA 22090, 1980).

Key words: accuracy; bulk measurements; material control and accounting; nondestructive assay; nuclear material measurements; precision; research and development; safeguards.

Safeguards for future commercial-scale nuclear facilities may employ three materials control and accounting concepts: classical accounting, dynamic materials balancing, and independent verification of inventories and materials balances. Typical measurement needs associated with the implementation of these concepts at high-throughput facilities are discussed. Promising measurement methods for meeting these needs are described and recent experience is cited. General directions and considerations for meeting advanced safeguards systems needs through measurement technology development over the next decade are presented.

19706. Welch, M. J., **Developing definitive methods for human serum constituents—A progress report from the CAP NBS Research Associate**, *Pathology XXXIII*, No. 12, 673-676 (Dec. 1979).

Key words: cholesterol; College of American Pathologists; definitive methods; glucose; human serum; isotope dilution; mass spectrometry; research associate; urea; uric acid.

This paper is a report to be published in *Pathologist*, the monthly journal of the College of American Pathologists (CAP). The report covers the principal activities of Michael Welch, who is a Research Associate at NBS, sponsored by the CAP. These activities are part of the effort of the Organic Analytical Research Division to develop definitive methods for organic constituents of human serum. Isotope dilution mass spectrometry (IDMS) is the analytical technique chosen for these methods. Definitive methods and IDMS are described in the report. Work has been completed on a definitive method for cholesterol; a brief description of the method and a table listing representative results are included. The progress of work on glucose, uric acid, urea, and creatinine is also described.

19707. McKenna, G. B., Zapas, L. J., **Nonlinear viscoelastic behavior of poly(methyl methacrylate) in torsion**, *J. Rheol.* **23**, No. 2, 151-166 (1979).

Key words: BKZ theory; mechanical conditioning; nonlinear viscoelasticity; normal stresses; poly(methyl methacrylate); shear stresses.

A modified form of the BKZ elastic fluid is presented. The specific form chosen is used to describe the normal stress and shear responses of PMMA in two-step torsion strain histories. Our results show that the modified form of the BKZ theory does not account for mechanical aging effects in PMMA. However, the response of mechanically conditioned PMMA to the strain histories tested is described by the modified theory. An interesting result is that the normal stress response to a two-step strain history in which the second step strain is half the first step is predicted to be independent of the duration of the first step and identical to the response to a single-step history at the strain level of the second step. This response is observed experimentally.

19708. Blau, P. J., **The role of metallurgical structure in the integrity of sliding solid contacts**, (Proc. Solid Contact and Lubrication Conf., Chicago, IL, Nov. 17-18, 1980), Paper in *Solid Contact and Lubrication AMD*, H. S. Cheng and L. M. Keer, Eds., **39**, 185-191 (The American Society of Mechanical Engineers, New York, NY 10017, 1980).

Key words: copper; copper alloys; friction; microstructure; solid contact; wear.

When solid contact occurs during metal sliding, changes on and below the sliding surfaces occur. These microstructural changes will depend on both the sliding conditions and on the intrinsic properties of the contacting materials. The nature of the materials response can affect the rates and modes of eventual surface degradation. Metallurgical studies of several steels and Cu alloys have been undertaken to examine the characteristics of plastically strained regions produced by sliding. Alloy com-



position is seen to affect the depth of deformation below the contact zone under similar test conditions. Microhardness measurements on polished cross-sections provided information on the unique properties of subsurface regions. Environmental effects as well as other competing wear processes must be taken into account before attempting to analytically model the deterioration of wearing surfaces.

- 19709.** Jennings, D. A., Petersen, F. R., Evenson, K. M., **Direct frequency measurement of the 260 THz (1.15  $\mu\text{m}$ )  $^{20}\text{Ne}$  laser: And beyond,** (Proc. Fourth Int. Conf. on Laser Spectroscopy, Rottach-Egern, Fed. Rep. of Germany, June 11-15, 1979), Paper in *Laser Spectroscopy*, H. Walther and K. W. Rothe, Eds., IV, 41-48 (Springer-Verlag, New York, NY, 1979).

Key words: frequency; He-Ne laser; nonlinear optics; visible frequencies; 1.15  $\mu\text{m}$ .

Absolute frequency measurement has been extended to the visible spectrum with the measurement of the strong 1.15  $\mu\text{m}$  laser line in  $^{20}\text{Ne}$  at 260 THz and lines in iodine at twice this frequency. The 260 THz frequency was synthesized in nonlinear crystals of  $\text{CdGeAs}_2$  and  $\text{AgAsS}_3$  from stabilized  $\text{CO}_2$  lasers and the 1.5  $\mu\text{m}$  laser line in  $^{20}\text{Ne}$ . The visible frequencies were synthesized by generating the second harmonic of the 260 THz radiation with a  $\text{LiNbO}_3$  crystal. The absolute frequencies of ten hyperfine components of  $^{127}\text{I}_2$  near 520 THz were measured.

- 19710.** Cooper, J., Ballagh, R. J., Smith, E. W., **Collisional redistribution of radiation in the non-impact region of spectral lines,** *Acta Phys. Pol. A54*, No. 6, 729-733 (1978).

Key words: absorption; collisional redistribution; emission; line shape; radiative damping.

The theory for collisional redistribution of scattered radiation is outlined starting from its origins in early line shape theories for emission and absorption. Recent developments are discussed including redistribution from the impact region to the far line wings, the effect of  $m$ -degeneracy, the influence of a strong driving field, and a consistent treatment of radiative damping.

- 19711.** King, D. S., Wheeler, J. C., Cox, J. P., Cox, A. N., Hodson, S. W., **Pulsation of high luminosity helium stars,** *Proc. Nonradial and Nonlinear Stellar Pulsation Workshop, University of Arizona, Tucson, AR, Dec. 12-16, 1979*, H. A. Hill and W. A. Dziembowski, Eds., pp. 161-168 (Springer-Verlag, New York, NY, 1980).

Key words: helium stars; R CrB Stars; stellar evolution; stellar pulsation.

A discussion of the long period R Coronae Borealis stars is presented. The constraints on theoretical models imposed by their age, kinematics and distribution led to difficulties in formulating an evolutionary sequence to the formation of this type of star. Several types of models are investigated and the results given.

- 19712.** Katriel, J., **Generalized Hiller-Sucher-Feinberg identity,** *Phys. Rev. A 21*, No. 3, 1067-1068 (Mar. 1980).

Key words: delta function; hypervirial theorems.

The identity recently derived by Hiller, Sucher, and Feinberg between a  $\delta$ -function expectation value and the expectation value of a smoothly varying operator is generalized. A discussion of the relative accuracy of the two expressions for approximate wave functions follows.

- 19713.** Fanconi, B., **Molecular vibrations of polymers,** *Ann. Rev. Phys. Chem. 31*, 265-291 (1980).

Key words: conformationally irregular polymers; Green's functions; molecular vibrations; normal mode calculations; numerical methods; polymer review; Raman and infrared spectroscopy.

Recent developments in theoretical and experimental techniques applied to molecular vibrations of polymers are reviewed. Methods for calculating the normal vibrations of polymers in both the isolated chain and lattice models are given.

Calculations of approximate vibrational frequencies of conformationally irregular chains are reviewed in the context of the coupled oscillator method, the Green's function approach, and various numerical methods.

- 19714.** Green, R. E., Jr., **Electro-optical detectors and flash x-ray generators for dynamic x-ray diffraction investigation of materials,** *Proc. Workshop on X-ray Instrumentation for Synchrotron Radiation, Stanford University, Stanford, CT, Apr. 3-5, 1978*, 165 pages (1978).

Key words: electro-optical detectors; flash x-ray generators; synchrotron x-radiation; x-ray diffraction.

The desirability of obtaining x-ray diffraction photographs with extremely short exposure times in order to study rapid materials alterations has long been realized. An optimum dynamic x-ray diffraction system must consist of both a high-intensity generator and a high-sensitivity detector which operate in the wavelength regime appropriate for diffraction. This paper gives a brief overview of previous work in rapid imaging of x-ray diffraction patterns using conventional x-ray generators, flash x-ray generators, and electro-optical detectors.

- 19715.** Buffington, J. D., Kirchhoff, W. H., **Developing recommendations to improve quality assurance for Federal monitoring programs,** *Proc. Natl. Conf. on Quality Assurance of Environmental Measurements, Denver, CO, Nov. 27-29, 1978*, pp. 1-6 (1979).

Key words: data; environment; Federal programs; laboratory accreditation; monitoring; quality assurance; standard methods.

Most scientists who manage monitoring programs strive to improve accuracy and efficiency through technical design, careful sampling and measurement, internal quality control, and good data management. But the users of environmental data frequently find that many of the measurements available cover the wrong factors, were collected at the wrong place and time, are of questionable accuracy, are located in inaccessible files, or are difficult to correlate among sources or media. The problems are documented in several articles and reports of studies, such as the review of EPA programs by the National Academy of Sciences. Many of the problems are not technical, but are rooted in management and policy.

Responding to a Presidential directive, the Council on Environmental Quality (CEQ) is heading an Interagency Task Force to review Federal programs for environmental data and management and to recommend paths of action that can be taken to improve the effectiveness and efficiency of such programs. The Task Force has been at work for nearly a year and has involved nearly 200 people from more than 20 agencies. Reports and recommendations are not complete, but several common elements appear in the first draft reports: (1) Agencies generally need to have control of their own programs, including the elements of data management and quality assurance; (2) There is need for oversight to make sure there is adequate coordination among agency programs and adequate quality assurance; (3) Agencies are reluctant to accept oversight placed in another agency.

- 19716.** Brown, R. L., **A measurement of the rate of the reaction of  $\text{N} + \text{H} + \text{M} \rightarrow \text{NH} + \text{M}$ ,** *Int. J. Chem. Kinet. V*, 663-667 (1973).

Key words: combination reaction; discharge; hydrogen atoms; nitrogen atoms.

The combination reaction between N and H atoms has been studied in a flow system by mixing H atoms produced by



thermal dissociation of  $H_2$  with active nitrogen produced by a microwave discharge. Relative N atom concentrations were determined from the intensity of the yellow nitrogen afterglow. Absolute N and H atom concentrations were measured by EPR absorption spectroscopy. Absolute N atom concentrations were also determined by titration with NO. Upper and lower limits of  $6.4 \pm 1.5 \times 10^{-32}$  and  $3.1 \pm 1.0 \times 10^{-32}$  cm<sup>6</sup> molecule<sup>-2</sup> sec<sup>-1</sup> were determined for the rate constant.

**19717.** Gilden, D. L., Wheeler, J. C., **Time-dependent, optically thick accretion onto a black hole**, *Astrophys. J.* **239**, 705-711 (July 15, 1980).

Key words: accretion; black holes; general relativity; hydrodynamics; magnetic field reconnection.

We have used a fully relativistic hydrodynamics code which incorporates diffusive radiation transport to study time-dependent, spherically symmetric, optically thick accretion onto a black hole. We find that matter free-falls into the hole regardless of whether the diffusion time scale is longer or shorter than the dynamical time. We have included nonadiabatic heating due to magnetic field reconnection. The internal energy thus generated affects the flow in a purely relativistic way, again ensuring free-fall collapse of the inflowing matter. Any matter enveloping a black hole will thus be swallowed on a dynamical time scale with relatively small net release of energy. The inclusion of angular momentum will not necessarily affect this conclusion.

**19718.** Kirby, R. K., **Thermal expansion**, Article in *Encyclopedia of Physics*, R. G. Lerner and G. L. Trigg, Eds., pp. 1023-1024 (Addison-Wesley Publ. Co., Inc., Advanced Book Program, Reading, MA, Nov. 1980).

Key words: thermal expansion.

This is a short article (~600 words) on thermal expansion that will be published in the AIP Encyclopedia of Physics; Rita G. Lerner and George L. Trigg, Editors; Dowden, Hutchinson and Ross, Inc., Pennsylvania.

A descriptive study and comparison of the thermal expansion of gases, liquids and solids. Examples are given in the text and 3 tables. The bibliography includes references to theory, measurement techniques and data compilations.

**19719.** Petersen, F. R., Evenson, K. M., Jennings, D. A., Scalabrin, A., **New frequency measurements and laser lines of optically pumped  $^{12}CH_3OH$** , *IEEE J. Quantum Elec.* **QE-16**, No. 3, 319-323 (Mar. 1980).

Key words: carbon dioxide laser; laser frequency measurements; new  $^{12}CH_3OH$  laser lines; optically pumped FIR lasers; relative power output of  $CH_3OH$  laser lines.

The frequencies of 70 optically pumped CW FIR  $^{12}CH_3OH$  laser lines have been measured relative to stabilized  $CO_2$  lasers. Fifteen new laser lines together with the relative output powers and polarizations for most of the 104 known lines pumped by laser lines in the normal 9 and 10  $\mu m$  bands of  $^{12}C^{16}O_2$  are also reported.

**19720.** Mucha, J. A., Evenson, K. M., Jennings, D. A., Ellison, G. B., Howard, C. J., **Laser magnetic resonance detection of rotational transitions in  $CH_2$** , *Chem. Phys. Lett.* **66**, No. 2, 244-247 (Oct. 1, 1979).

Key words:  $CH_2$ ; laser; magnetic resonance; rotational transitions.

Laser magnetic resonance spectra observed at 163.0  $\mu m$  have been identified as pure rotational transitions in the ground electronic state ( $^3B_1$ ) of the methylene radical. The identification was based on the observation of hyperfine spin triplets and by isotopic substitutions involving deuterium and  $^{13}C$  as well as other chemical and spectroscopic evidence. A low-pressure flame produced by reacting discharged fluorine with methane

was found to be an excellent new spectroscopic source of ground-state  $CH_2$  radicals.

**19721.** Smith, E. W., Giraud, M., **Pressure broadening of the  $O_2$  microwave spectrum**, *J. Chem. Phys.* **71**, No. 11, 4209-4217 (Dec. 1, 1979).

Key words: low pressures; noble gas broadening;  $O_2$  microwave spectrum; pressure broadening; self broadening; theoretical and experimental comparisons.

The pressure broadened half-widths of the 60 GHz microwave spectrum in  $O_2$  have been calculated for low pressures where the lines do not overlap. Both self-broadening and foreign gas broadening by noble gases have been calculated using various semiempirical potential surface. Agreement with experimental results is quite good. Differences with various other theoretical calculations are discussed.

**19722.** Martinez, R. I., Huie, R. E., Herron, J. T., Braun, W., **Infrared-laser photolysis/mass spectrometry. A technique for the real-time study of free-radical kinetics, and its application to the reaction  $2CF_2 \rightarrow C_2F_4$** , *J. Chem. Phys.* **84**, No. 19, 2344-2347 (1980).

Key words:  $CF_2$ ;  $C_2F_4$ ; kinetics; laser; mass spectrometry; photolysis.

Infrared-laser photolysis/mass spectrometry has great potential as a powerful general method for the production of selected free radicals and for the study of their reaction kinetics and mechanisms in real time. Radicals are produced by the multiphoton, infrared-laser photolysis of suitable substrate molecules inside a reaction cell coupled directly to a mass spectrometer. The method was evaluated with reference to the infrared-laser photolysis of  $CF_2HCl$  and the subsequent recombination reaction of  $CF_2$ :  $CF_2HCl + nh\nu \rightarrow CF_2 + HCl$  and  $CF_2 + CF_2 \rightarrow C_2F_4$ . Sampling distortions which were observed in this work were attributed to the finite rates at which gas enters and exits the enclosed ion-source chamber. Taking this effect into account, computer modeling calculations lead to a value for  $k_2$  of  $2.2 \times 10^{10}$  cm<sup>3</sup> mol<sup>-1</sup> s<sup>-1</sup> (to within a factor of 2), in good agreement with literature values.

**19723.** Davidson, K., **Additional upper limits on a Lyman- $\alpha$  halo around PHL 957**, *Astronom. Soc. Pac.* **91**, No. 544, 817-823 (Dec. 1979).

Key words:  $La$  radiation; quasars.

The Kitt Peak video camera and 2.1-m telescope have been used to look for a possible  $La$  halo around the quasar PHL 957, especially within the annular region 2 arc sec  $\leq r \leq 10$  arc sec. No halo was detected; this has implications regarding some of the absorption-line systems. Either there is a severe limit to the amount of absorbing material at distances between 25 and 100 kpc from the quasar (which would be evidence against some forms of the "intrinsic" hypothesis for the origin of the absorption systems), or else the quasar's ionizing radiation fluctuates drastically on time scales of  $10^2$  to  $10^5$  years. Further work in the same manner, applied to other quasars, can be very sensitive and useful.

**19724.** Myers, D. R., Roitman, P., Mayo, S., Horowitz, D., **Electronic properties of ion-implanted silicon annealed with microsecond dye-laser pulses**, *Proc. Symp. of the Materials Research Society on Laser and Electron Beam Pulses*, Cambridge, MA, Nov. 27-30, 1979, pp. 285-290 (Academic Press Inc., New York, NY, 1980).

Key words: capacitance-voltage profiling; damage effects; electrical activation of implanted impurities; ion implantation; laser annealing; silicon.

The effects of laser irradiation in annealing ion-implanted silicon are examined for the case of a flashlamp-excited, tunable



dye laser operating at a wavelength near 600 nm with a baseline-to-baseline pulse duration of 1  $\mu$ s. The implanted layers were prepared by low dose ( $10^{12}$  cm $^{-2}$ ) boron implantation either into initially single crystal silicon substrates or into a silicon substrate amorphized by high dose ( $10^{15}$  cm $^{-2}$ ) silicon implantation. The range of annealing conditions needed to produce dopant activation or apparent dopant redistribution to the sample surface was further characterized by computer-automated, 1-MHz capacitance-voltage profiling and correlated to damage effects evidenced by surface morphology changes.

**19725.** Powell, F. J., **Aspects of a national program plan for industrial/commercial insulation for mechanical systems applications**, *ASHRAE J.* 22, No. 10, 58-59 (Oct. 1980).

**Key words:** industrial/commercial thermal insulation; insulation program plan; mechanical insulation.

The need for and nature of a national program plan for industrial/commercial thermal insulation in mechanical systems such as piping, ducts, vessels, tanks, and equipment is presented for the temperature range  $-300^{\circ}\text{F}$  to  $+2800^{\circ}\text{F}$ . Problems relating to new system designs, as well as retrofit are considered with applications limited to the use of commercially available materials. The justification for such a plan is given and the contents of such a plan are suggested.

**19726.** Lowney, J. R., Larrabee, R. D., **The use of Fick's Law in modeling diffusion processes**, *IEEE Trans. Electron Devices* ED-27, No. 9, 1795-1798 (Sept. 1980).

**Key words:** Brownian motion; diffusion; Fick's Law; Fokker-Planck equation; process modeling; semiconductors; silicon; vacancies.

Fick's Law treats the diffusion coefficient as the factor of proportionality between the flux and the spatial gradient of a diffusing species. A recent model for impurity diffusion in semiconductors computes the flux in a different way by taking the spatial gradient of the product of the diffusion coefficient and the density of diffusing species. The results of these two approaches are different for spatially dependent diffusion coefficients. The nature and significance of this difference are explored in terms of the random walk and thermodynamic derivations of the diffusion equation. It is concluded that Fick's Law is the more fundamental and straightforward way to model diffusion processes.

**19727.** Armstrong, R. W., Boettinger, W. J., Kuriyama, M., **Crystal subgrain misorientations observed by x-ray topography in reflection**, *J. Appl. Cryst.* 13, 417-424 (1980).

**Key words:** Bragg diffraction; double crystal diffraction; nickel single crystal; process of crystal growth; subgrain misorientation; surface reflection; x-ray topography.

Based on the principles of conservation of momentum and energy for x-ray diffraction, a vector description is obtained for the displacement of adjacent subgrain images in reflection topographs. The analysis includes, in addition to those crystal parameters defining the misorientation at a subgrain boundary, the combined effects of (horizontal and vertical) divergence in the incident x-ray beam and of the position where the x-ray images are recorded. The vector description is matched with a stereographic projection method of analysis for describing the subgrain misorientations. These total considerations are applied to the characterization of subgrain boundaries grown into a nickel single crystal solidified along [010], including specification of the dislocation structure within the boundaries.

**19728.** Freiman, S. W., Wiederhorn, S. M., **Fracture mechanics applied to structural ceramics**, (Proc. Conf. on Fracture and Fatigue Mechanics, Blacksburg, VA, June 1978), Paper in *Fracture Mechanics*, N. Perrone, H. Liebowitz, D. Mulville,

and W. Pilkey, Eds., pp. 299-316 (The University Press of Virginia, Charlottesville, VA, 1978).

**Key words:** ceramic strength; crack propagation; erosion; fracture mechanics; thermal fracture.

Applications of fracture mechanics techniques to ceramic materials is discussed. These techniques are compared with more standard strength techniques and their relevance to failure prediction is analyzed.

**19729.** Greenberg, J., **The solar demonstration program: Technical issues and constraints**, *ASHRAE J.* 22, No. 8, 30-31 (Aug. 1980).

**Key words:** building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy.

This paper is based on a report prepared jointly for the Department of Housing and Urban Development (HUD) and the Department of Energy (DoE) under activities carried out by the National Bureau of Standards (NBS) relative to the Solar Heating and Cooling Demonstration Program. Regulatory information was abstracted from HUD contractor-developed questionnaires and analyzed to determine perceived regulatory constraints which might inhibit, impede, or otherwise adversely affect the installation and use of solar hot water and space and/or cooling systems. The paper documents and analyzes building regulatory information gathered by HUD Contractor personnel during the course of the Solar Residential Demonstration Program—from inception of the program (late 1975) through September 30, 1978. The paper concludes that existing codes do not present a barrier to the installation and acceptance of solar systems; however, code officials need additional training and better back-up material to properly evaluate solar systems.

**19730.** Lashmore, D. S., **Immersion coatings on aluminum**, *Plating Surf. Finish.* 67, Pt. 1, 37-42 (Jan. 1980).

**Key words:** aluminum; coatings; electrodeposition; epitaxy; tin aluminum; zinc.

During a study of the morphologies of zinc and tin immersion deposits on aluminum and its alloys, zinc was found to form epitaxial deposits on alloys, as was previously observed on pure aluminum. Similarities are shown to exist between the zincate and stannate processes; in particular, studies of deposits on single-crystal spheres show that the same crystallographic orientations are active in both systems. Comparisons between zinc deposits produced from solutions containing ferric chloride and Rochelle salts and deposits from the same solution without these additions indicate that ferric chloride plays a fundamental role in the deposition process.

**19731.** Lawn, B. R., Hockey, B. J., Wiederhorn, S. M., **Automically sharp cracks in brittle solids: An electron microscopy study**, *J. Mater. Sci.* 15, 1207-1223 (1980).

**Key words:** aluminumoxide; brittle fracture; dislocations; electron microscopy; erosion; germanium; hardness measurements; plastic deformation; silicon; silicon carbide.

The issue of bond rupture versus microplasticity as an essential mechanism of crack propagation in brittle solids is addressed. A detailed survey of existing theoretical and experimental evidence relating to this issue highlights the need for direct observations of events within the crack-tip "process zone," at a level approaching 10 nm. Transmission electron microscopy is accordingly used to study arrested cracks about sharp-contact (Vickers indentation and particle impact) sites in Si, Ge, SiC and  $\text{Al}_2\text{O}_3$ . The nature of the deformation which accommodates the irreversible contact impression is first investigated, in the light of Marsh's proposal of an "equivalence" between indentation and crack-tip zone processes. Interfacial and tip regions of



the surrounding cracks are then examined for any trace of a plasticity-controlled fracture process. Dislocation-like images are indeed evident at the crack planes, but these are shown to be totally inconsistent with any conventional slip mechanism. The close connection between the dislocation patterns and moiré fringe systems along the cracks points to "lattice mismatch" contrast in association with a partial closure and healing operation at the interface. Analysis of all other details in the crack patterns, e.g., the presence of a crack-front contrast band indicative of a residual strain field and the disposition of interfacial fracture steps relative to the dislocation/ moiré system, reinforces this interpretation. It is concluded that the concept of an atomically sharp crack provides a sound basis for the theory of fracture of brittle solids.

**19732.** Small, J. A., Heinrich, K. F. J., Fiori, C. E., Myklebust, R. L., Newbury, D. E., Dilmore, M. F., **The production and characterization of glass fibers and spheres for microanalysis**, (Proc. 11th Annual Conf. SEM/1978, Los Angeles, CA, Apr. 17-21, 1978), Paper in *Scanning Electron Microscopy* 1, 445-453 (SEM Inc., AMF O'Hare, IL 60666, 1978).

Key words: analytical standards; electron probe microanalysis; fiber; glass; microsphere; Monte Carlo; particulate; quantitative analysis.

Microscopic fibers and spheres have been fabricated from bulk glasses of known composition. The fibers, which have diameters from 6 to 100  $\mu\text{m}$ , are drawn directly from the glass melt by means of a rotating drum. The microspheres, which have diameters from 0.25 to 200  $\mu\text{m}$ , are manufactured by heating an air suspension of powdered glass in an electric furnace. Electron and ion probe microanalysis has confirmed that the fibers and spheres have the same composition as the parent glass.

The fibers and microspheres are also being used to study the quantitative electron probe analysis of single particles. This study includes the effects of continuum fluorescence on particle analysis and the use of peak to background ratios to estimate particle mass. In addition the characteristic x-ray intensity ratios between the microspheres and bulk glass are being measured as a function of microsphere diameter. These experimental ratios are compared to theoretical values obtained from the National Bureau of Standards' Monte Carlo program. The experimental results agree with the theoretical curves within the uncertainties of the Monte Carlo routine and single-particle analysis techniques.

**19733.** Yagi, K., Roth, R. S., **Electron-microscopy study of the crystal structures of mixed oxides in the systems  $\text{Rb}_2\text{O-Ta}_2\text{O}_5$ ,  $\text{Rb}_2\text{O-Nb}_2\text{O}_5$  and  $\text{K}_2\text{O-Ta}_2\text{O}_5$  with composition ratios near 1:3. I. Stacking characteristics of  $\text{MO}_6$  layers**, *Acta Cryst.* A34, 765-773 (1978).

Key words: crystal structure; electron microscope; lattice images; mixed oxides; niobates and tantalates; rubidium and potassium oxides.

The crystal structures of phases, previously designated as 11L, 9L and 16L, which were commonly found in the title systems are suggested from their high-resolution two-dimensional electron-microscope images. Two types of blocks are found which are composed of five and six layers of pentavalent-metal oxide octahedra and are closely related to the pyrochlore structure. The 11L structure is of rhombohedral ABCABC stacking of the former type of block, and the 9L structure is of hexagonal  $\text{BoAo}'\text{BoAo}'$  stacking of the latter type of block. The 16L structure is found to be an alternate stacking of the two types of blocks. The method of stacking of the blocks is the same for the three structures and is found to be favorable from the point of view of local charge balance.

**19734.** Broadhurst, M. G., Davis, G. T., **Piezo- and pyroelectric properties**, Chapter 5 in *Topics in Applied Physics*, G. M. Sessler, 33, 285-319 (Springer-Verlag, Berlin, Germany, 1979).

Key words: crystal relaxations; electrets; ferroelectricity; piezoelectric polymers; polarization; poly(vinyl chloride); poly(vinyl fluoride); poly(vinylidene fluoride); pyroelectric polymers; space charge.

Some polymers can be made both piezo- and pyroelectric by suitable application of a large electric field. This effect is true piezo- and pyroelectricity rather than electrostriction, conduction, electromechanical effects, or the motion of conductors in the field of space charges. Two distinct types of polymers can be piezoelectric. Amorphous polymers are piezo- and pyroelectric by virtue of a nonequilibrium but kinetically stable net dipole orientation in the amorphous phase of the polymer. The semicrystalline polymers are piezoelectric due to alignment of polar, ferroelectric crystals dispersed in the amorphous phase. In both types of polymers, magnitudes of the piezo- and pyroelectric effects are in accord with the expected temperature and pressure dependence of the dipole model. Polarization changes primarily because of dimensional changes of the sample. Space charges embedded in the polymer normally will not produce large piezoelectric and pyroelectric currents. Those embedded near the crystal-liquid interfaces tend to reduce the piezo- and pyroelectricity. Improved orientation of dipoles and reduction of ionic impurities should increase  $p_y$  and  $d_p$  for PVDF by a factor of two above typical values presently reported. The sensitivity of amorphous and semicrystalline polymers is limited mainly by dipole moment per unit volume and breakdown strength.

Some of the models presented here were developed along with the writing and were used as a framework for the presentation in order to make the chapter more coherent. It is hoped that these ideas, some largely untested, will provide direction and stimulation for further work in this field.

**19735.** Dodge, W. R., Hayward, E., Leicht, R. G., Patrick, B. H., Starr, R.,  **$E_2$  strength in  $^{12}\text{C}$  determined by elastic photon scattering**, *Phys. Rev. Lett.* 44, No. 16, 1040-1043 (Apr. 21, 1980).

Key words: dispersion relation; giant quadrupole resonance; photon scattering;  $^{12}\text{C}$ .

The elastic-photon-scattering cross section for  $^{12}\text{C}$  has been measured at  $90^\circ$  and  $135^\circ$  in the energy range from 23.5 to 39 MeV. These data disagree with the predicted scattering, derived from the measured photonuclear absorption cross section, if only  $E1$  transitions are assumed. To explain the difference in these cross sections, a large component of electric quadrupole absorption between 24 and 40 MeV is inferred.

**19736.** Smith, J. H., **Operating experiences with Incoloy 800 in coal-conversion process plants**, *Proc. Int. Conf. Alloy 800, Petten, Netherlands, Mar. 14-16, 1978*, W. Betteridge, R. Krefeld, H. Kröckel, S. J. Lloyd, M. Van de voorde, and C. Vivante, Eds., pp. 231-233 (North-Holland Publ. Co., Amsterdam, NY, 1978).

Key words: alloy 800; coal conversion; failure analysis; Incoloy 800.

Selected examples of the use of Incoloy 800 in coal conversion of Incoloy in coal conversion plants that has resulted in degradation of the material and failure of key components are described. Most failures of components constructed of Incoloy 800 are extremely complex and the exact cause of the failure cannot be determined without extensive diagnostic failure analyses. The component failures that have been observed are generally the result of some combination of complex chemical environment, unexpected operating conditions, and incorrect methods used to fabricate the component.



Although extensive quantities of the Incoloy 800 are being used in advanced coal conversion process plants in the U.S., relatively few failures of components constructed of this alloy, even in the extreme environments existing in these plants, have been reported. In nearly all cases, components constructed of Incoloy failed because of improper fabrication causing degradation of the normal properties of this alloy or operational malfunctions which allowed the environment to deviate widely from the expected operating conditions.

19737. Crawford, M. L., Workman, J. L., **Spherical dipole for radiating standard fields**, (Proc. Conf. on Precision Electromagnetic Measurements, Braunschweig, Federal Republic of Germany, June 23-27, 1980), *IEEE Cat. No. 80CH1497-71M*, pp. 424-429 (Institute of Electrical and Electronics Engineers, New York, NY, 1980).

Key words: dipole radiator for EMI measurements; electromagnetic field measurement; spherical dipole; standard field radiator; 30 MHz to 180 MHz.

This paper describes a 10 cm diameter, self-contained, spherical dipole that radiates a constant, standard field at discrete frequencies between 30 MHz and 180 MHz. Results are presented using the dipole to compare radiated emission measurements performed in shielded enclosures, in transverse electromagnetic (TEM) cells, and on an open-field test site.

19738. Geist, J., **Silicon photodiode front region collection efficiency models**, *J. Appl. Phys.* **51**, No. 7, 3993-3995 (July 1980).

Key words: collection efficiency; quantum efficiency; silicon photodiode; surface recombination.

The minority-carrier transport equations are solved numerically for a realistic model of the front region of a UV-enhanced silicon photodiode. Surface recombination is shown to be the dominant quantum efficiency reducing mechanism. Auger recombination is shown to be almost negligible for the type of diode under investigation.

19739. Antoniewicz, P. R., Cavanagh, R. R., Yates, J. T., Jr., **Temperature effects on the infrared spectrum of chemisorbed CO**, *J. Chem. Phys.* **73**, No. 7, 3456-3459 (Oct. 1, 1980).

Key words: carbon monoxide; chemisorption; electrodynamic; infrared spectra; rhodium.

The temperature dependence of the infrared spectrum of CO chemisorbed on Rh supported by  $\text{Al}_2\text{O}_3$  has been measured. A shift in the CO stretching mode of  $1.4 \times 10^{-2} \text{ cm}^{-1} \text{ K}^{-1}$  to higher wave number is observed on cooling. An electrodynamic model of the surface interactions is presented. The model accounts for both the magnitude and direction of the observed shift.

19740. Baer, T., Kowalski, F. V., Hall, J. L., **Frequency stabilization of a 0.633- $\mu\text{m}$  He-Ne longitudinal Zeeman laser**, *Appl. Opt.* **19**, No. 18, 3173-3177 (Sept. 15, 1980).

Key words: stabilized laser; wavelength standards; Zeeman laser.

A new method of stabilizing the output frequency of a He-Ne laser in a longitudinal magnetic field has been developed. With simple modifications to a standard He-Ne laser tube we obtain a frequency stability of  $< 1 \text{ MHz}$  ( $< 10^{-9}$ ) for an averaging time of 1 sec and a long term (5 months) frequency reproducibility of  $\sim \pm 1 \text{ MHz}$ .

19741. Barlow, M. J., Blades, J. C., Hummer, D. G., **Optical observations of the ultrahigh-excitation Wolf-Rayet star Sanduleak 3**, *Astrophys. J.* **241**, L27-31 (Oct. 1, 1980).

Key words: O VI stars; Sanduleak 3; Wolf-Rayet stars.

We have identified recombination lines of O VII, O VIII, and C V in the optical spectrum of an O VI Wolf-Rayet star, representing the first non-x-ray detection of these ions in astronomical spectra and implying excitation energies in excess of 800 eV. Rapid variations on a time scale of about 150 s have been observed in the profile of one of the O VII lines.

19742. Bender, P. L., Goad, C. C., **Probable LAGEOS contributions to a worldwide geodynamics control network**, *Proc. Symp. on the Use of Artificial Satellites for Geodesy and Geodynamics and Laser Workshop, Lagonissi, Greece, May 1978*, G. Veis and E. Livieratos, Eds., II, 145-161 (National Technical University, Athens, Greece, 1979).

Key words: artificial satellites; distance measurements; geodesy; geodynamics; lasers; station positions.

The need to establish a worldwide reference system for use in geodynamics is clear. We have carried out simulations on the contributions which laser range measurements to LAGEOS can make in establishing such a system. A distribution of ten fixed ranging stations was assumed for most of our calculations, with the stations located in the U.S., S. America, W. Europe, Australia and Japan. A single 7-day arc was used and measurements were assumed to be made only every 10 min., in order to avoid artificial reductions in the uncertainties due to oversampling. As is well known, the gravity field model will be the main contributor to the station coordinate uncertainties initially. However, if some of the harmonic coefficients are adjusted using the LAGEOS data, the gravity field model effects can be substantially reduced. Simulations in which we solved for all of the tesseral harmonic coefficients through degree 5 plus 20 additional terms have shown that a rms station coordinate uncertainty of 4 to 5 cm can be achieved for random range measurement errors and range biases of between 0.7 and 2 cm. The scaled GEM-10 standard deviations were used both as *a priori* uncertainties for the adjusted coefficients and in calculating the effects of the remaining unadjusted coefficients. When further improvements in the gravity field models have been made, it seems likely that retrospective analyses of the LAGEOS ranging data obtained in the next couple of years will be limited mainly by the atmospheric correction uncertainty and the range measurement biases, even, if the bias uncertainty is only 0.7 cm. Some comments also are made on possible procedures for maintaining a worldwide geodynamics reference system.

19743. Brillet, W. L., Gallagher, A., **Inert-gas collisional broadening and shifts of Rb Rydberg states**, *Phys. Rev. A* **33**, No. 3, 1012-1017 (Sept. 1980).

Key words: line broadening; rubidium.

The broadening and shift of several Rb  $3S-nS$  and  $3S-nD$  transitions perturbed by inert gases have been measured by Doppler-free two-photon absorption and fluorescence detection. The measured shifts are in reasonable agreement with the theoretical predictions, whereas the measured broadening rates are found to be much larger.

19744. Capps, W., Schaeffer, H. A., Cronin, D. J., **The effect of striae on the strength of glass**, *J. Am. Ceram. Soc.* **63**, No. 9-10, 570-573 (Sept.-Oct. 1980).

Key words: electron microprobe; glass; interferometry; ion-exchange; refractive index; strength; striae.

Severe striations caused by compositional inhomogeneity had no significant effect on the strength of either annealed glass disks or those strengthened by an ion-exchange surface compression technique. Electron microprobe and interferometric measurements revealed that the striae were caused by variations in the  $\text{SiO}_2/\text{Al}_2\text{O}_3$  ratio rather than by variations in alkali concentration and therefore did not adversely influence the ion-exchange process.



**19745.** Cezairliyan, A., Müller, A. P., **A transient (subsecond) technique for measuring heat of fusion of metals**, *Int. J. Thermophys.* **1**, No. 2, 195-215 (1980).

Key words: dynamic techniques; heat of fusion; high temperatures; melting; niobium.

A transient technique is described for measuring the heats of fusion of metals with melting temperatures above 1500 K. The specimen configuration consists of a strip of the metal under study "sandwiched" between two strips of another metal with a higher melting temperature. The basic method consists of rapidly heating the composite specimen by passing a subsecond-duration electrical current pulse through it and simultaneously measuring the radiance temperature of the containment metal surface, as well as the current through and voltage drop across the specimen. The melting of the metal under study is manifested by a plateau in the temperature versus time function for the containing metal surface. The time integral of the power absorbed by the specimen during melting yields the heat of fusion. Measurements on several tantalum-niobium-tantalum specimens yield a value of  $31.5 \text{ kJ}\cdot\text{mol}^{-1}$  for the heat of fusion of niobium, with an estimated maximum inaccuracy of  $\pm 5\%$ .

**19746.** Coleman, B. D., Zapas, L. J., **Theory of the instability and failure of viscoelastic materials in tension**, *J. Polymer Sci.: Polymer Phys. Ed.* **17**, 2215-2224 (1979).

Key words: instability; necking; nonlinear; simple materials; tensile test; viscoelastic bars.

In a tensile test of a bar or fiber formed from a transversely isotropic viscoelastic material, the initial motion in regions away from the clamps is a homogeneous uniaxial extension. If the applied tensile load is "tame" in the sense that it is given by a piecewise smooth function of time, then during the early stages of loading, the homogeneous extension of the specimen is also tame. It is, however, often the case that at a time  $t_c$ , previous to the instant of fracture, the motion departs from a tame homogeneous extension. The critical time  $t_c$  is the "failure time" of the specimen, i.e., the time at which the motion first changes character;  $t_c$  precedes, often by a constant factor, the time at which neck-down is easily visible. The problem of calculating  $t_c$  for a given loading program is here treated within the framework of the general theory of nonlinear simple materials with fading memory. For such materials the instantaneous tensile modulus, i.e., the derivative of the immediate change in tensile stress with respect to a sudden change in tensile strain, depends upon the previous history of the strain. Reasons are presented here for identifying  $t_c$  with the earliest time  $t_0$  at which the instantaneous tensile modulus becomes zero. It is shown that at a time at which the instantaneous modulus vanishes one *cannot* arbitrarily assign the rate of change of tensile stress and have the motion remain in the class of tame homogeneous extensions.

**19747.** Collins, L. A., Robb, W. D., Norcross, D. W., **Low-energy collisions of electrons with highly polar molecules: Orthogonalization and model exchange potentials**, *Phys. Rev. A* **20**, No. 5, 1838-1840 (Nov. 1979).

Key words: collisions; electron-molecule; exchange potentials; model potential.

The importance of imposing orthogonality constraints on the continuum wave functions calculated from model exchange potentials for electron collisions with the highly polar systems LiH and LiF is demonstrated. The  $\Sigma$  and  $\Pi$  resonance features in e-LiF collisions, found in earlier model-exchange calculations, disappear upon imposing orthogonality; no evidence for these features is observed in the exact static-exchange calculations.

**19748.** Coriell, S. R., Sekerka, R. F., **Interface stability during rapid solidification**, *Proc. Second Int. Conf. on Rapid Solidification Processing: Principles and Technologies*, Reston, VA, Mar.

23-26, 1980, pp. 35-49 (Claitor's Publ. Div., Baton Rouge, LA, Nov. 1980).

Key words: alloy; constitutional supercooling; local equilibrium; perturbation; solidification; solid-liquid interface; stability.

The phenomenon of solid-liquid interface stability during directional solidification of a binary alloy is reexamined with special emphasis on very rapid solidification rates. For ordinary solidification rates, the predictions of the perturbation theory of morphological stability lead to results that are similar to those implied by constitutional supercooling; however, at very rapid solidification rates, the perturbation theory predicts a vast increase in stabilization in comparison to constitutional supercooling. There appear to be two dominant effects. The first effect can occur even if there is local equilibrium at the solid-liquid interface; it is known as absolute stability and arises because only short wavelength perturbations are important at high velocities and these are stabilized by surface energy. Numerical calculations for aluminum with various concentrations of copper and a liquid temperature gradient of  $2(10^9) \text{ K/m}$  show that absolute stability is important for solidification velocities above about  $0.01 \text{ m/s}$ ; in fact, for copper concentrations less than  $6 \times 10^{-3} \text{ wt. \%}$ , the interface is stable at any solidification rate. The second effect is caused by departure from local equilibrium at the solid-liquid interface. Although the exact forms of such departures, let alone their magnitude, is not well known, the perturbation theory can be modified to include their salient features. Most departures from local equilibrium lead to increased stability. For example, all constitutional effects will vanish as the distribution coefficient approaches unity. Finally, other factors are examined with an aim toward the identification of a realm where experimental test of the theory would be meaningful.

**19749.** Dyer, C. S., Trombka, J. I., Seltzer, S. M., Evans, L. G., **Calculation of radioactivity induced in gamma-ray spectrometers during spaceflight**, *Nucl. Instrum. Methods* **173**, 585-601 (1980).

Key words: calculations; gamma-ray spectrometers; germanium; induced radioactivity; sodium-iodide; spaceflight.

Radioactivity induced in detector materials by cosmic rays, trapped protons and secondary neutrons is a major source of background in gamma-ray astronomy and remote sensing spectroscopy of the moon and the planets. A calculation scheme for assessing this component has been developed based on semi-empirical cross-sections and stochastic calculations of energy-loss spectra of radioactive nuclides. In addition, predictive methods are available based on experimental data obtained from monoenergetic proton beam irradiations of scintillators at energies of 155, 600, 800 MeV and 6 GeV. Application of these methods to in-flight results from scintillator detectors carried on lightweight OSO spacecraft, for which trapped protons of 20-200 MeV dominate, shows that the induced radioactivity at lower photon energies can be well explained by spallation interactions of primary protons in the central crystal detector elements. The contributions to the induced activity due to collimators, materials surrounding the detector, and the spacecraft become increasingly important at higher proton energies. For such detectors carried on the Apollo missions, the more energetic ( $> 300 \text{ MeV}$ ) cosmic-ray flux dominates. The library of isotopes presently used can predict only about half the induced radioactivity, and corrections for missing radionuclides must be based on the experimental irradiation results. Results from crystals returned to Earth from Apollo 17 and Apollo-Soyuz show that, for heavy spacecraft, secondary neutrons can significantly enhance the background. Preliminary estimates have been made of the important gamma-ray line features to be expected from cosmic-ray and trapped proton induced spallation products in germanium detectors.



19750. Faller, J. E., Rinker, R. L., Zumberge, M. A., **Absolute gravity as a reconnaissance tool for vertical height changes and for studying density changes**, *Proc. Second Int. Symp. on Problems Related to the Redefinition of North American Vertical Geodetic Networks, Ottawa, Canada, May 26-30, 1980*, pp. 919-931 (Canadian Institute of Surveying, Ottawa, Canada, 1980).

Key words: absolute gravimeter; geophysics; gravity; tectonic processes.

A major effort is under way to develop a highly portable absolute gravimeter having an accuracy of 3  $\mu\text{gal}$  or better, an accuracy which translates into a height sensitivity of about 1 cm. Significant progress toward this end has been made. The instrument uses the method of free fall and consists basically of four parts: a drag free dropping chamber, a long period isolation device, a stabilized laser, and the necessary timing electronics. The size and weight of these units is such that the apparatus can be easily handled and assembled by a single person. The expected measurement time required at any given site is about one hour. Since the instrument's gravity measurements are based on secondary length and time standards it is inherently drift free and we believe field use of it will significantly advance the study of tectonic processes including vertical height changes.

19751. Fine, J., Hardy, S. C., Andreadis, T. D., **The generation of clean liquid gallium surfaces by ion bombardment**, (*Proc. SPIG-80, Dubrovnik, Yugoslavia, Aug. 25-29, 1980*), Paper in *The Physics of Ionized Gases*, B. Cobic, Ed., pp. 294-297 (Boris Kidric Institute of Nuclear Sciences, Beograd, Yugoslavia, 1980).

Key words: ion bombardment; liquid surfaces; surface mass transport.

Ion beam bombardment has been used to prepare clean surfaces on bulk liquid gallium in vacuum. Observations are reported of a new type of phenomenon produced by ion bombardment: the rapid flow of impurity aggregates on a liquid metal surface.

19752. Flynn, J. H., **Degradation kinetics applied to lifetime predictions of polymers**, *Polym. Eng. Sci.* 20, No. 10, 675-677 (July 1980).

Key words: accelerated aging; complex reactions; decomposition; degradation; durability; heating rates; initial rates; kinetics; lifetime prediction; polystyrene; polyurethane; pyrolysis; stability; thermal analysis; thermogravimetry.

The prediction of the lifetime of a polymer by extrapolation from weight-loss data requires a thorough analysis of degradation kinetics over a wide temperature range. Techniques are described in which entire kinetic spectra are compared among experiments performed at heating rates from 6 deg/min to 9 deg/day. These comparisons permit diagnosing shifts in reaction mechanism, uncoupling of competing processes and more reliably predicting the rate-limiting process at service conditions. These techniques and a method for obtaining initial kinetic parameters are illustrated for several polymers.

19753. Galloway, K. F., **Radiation damage estimates and control in ion-beam lithography**, *J. Electrochem. Soc.* 127, No. 8, 1862-1864 (Aug. 1980).

Key words: device processing; electron devices; integrated circuit fabrication; ion-beam lithography; lithography; oxide layers; radiation absorbed dose; radiation damage.

Estimates of the radiation dose absorbed in critical device dielectric layers during the application of ion-beam lithography are given. For typical device and beam parameters, the radiation absorbed dose can be 200 Mrad ( $\text{SiO}_2$ ). Proper adjustment of the ion-beam parameters can significantly reduce or eliminate this radiation damage.

19754. Glass, R. A., Kaetzel, L. J., Smith, G. R., **A computer data base system for indexing research papers**, *Behav. Res. Methods Instrum. Lett.* 12, No. 5, 547-548 (1980).

Key words: data base; information retrieval; interactive processing.

The KGS data base system allows the indexing and retrieval of scientific research papers through the use of a minicomputer system in an interactive mode. Criteria are entered through the user's computer terminal which produces subsets of the data base in a report format as well as statistical summaries of data base elements.

19755. Girvin, S. M., Jonson, M., **Dynamical electron-phonon interaction and conductivity in strongly disordered metal alloys**, *Phys. Rev. B* 22, No. 8, 3583-3597 (Oct. 15, 1980).

Key words: conductivity; disordered alloy; localization; phonon; strong scattering; transport anomalies.

A theory of transport in random metal alloys is presented which focuses on certain model-independent features of the electron-phonon dynamics which have been previously neglected. It is found that in the low-resistivity limit the adiabatic-phonon approximation is valid and the disorder associated with phonons increases the resistivity. In the high-resistivity limit where the weak-scattering approximation breaks down due to incipient Anderson localization, the adiabatic-phonon assumption also fails, and phonons actually assist the mobility, producing an anomalous negative temperature coefficient of resistivity. Model analytical and numerical calculations suggest that this mechanism could be the source of the Mooij correlation between the resistivity and its temperature coefficient. The connection between these results and recent scaling theories of localization is discussed.

19756. Guillot, B., Bratos, S., Birnbaum, G., **Theoretical study of spectra of depolarized light scattered from dense rare-gas fluids**, *Phys. Rev. A* 22, No. 5, 2230-2237 (Nov. 1980).

Key words: depolarized light scattering; lattice-gas; Lorentzian shape; oscillatory; parameters; polarizability; rare-gas; Zwanzig-Mori theory.

A theory is presented to study the depolarized light scattered by dense rare-gas fluids. This theory is based on the Zwanzig-Mori theory of Brownian motion; the transport matrix is estimated by a lattice-gas model. Two modes are theoretically predicted, a dissipative mode due to the translational diffusion of rare-gas atoms and an oscillatory mode associated with their oscillations around a given site in the fluid. The resulting profile has a Lorentzian shape at low frequencies and non-Lorentzian wings at high frequencies. The electron-overlap effect modifies the integrated intensity of the scattered light but has only a minor influence on its spectral density.

19757. Hardman, K., James, W. J., Yelon, W. B., **Preferential ordering of Mn and Fe atoms in  $\text{Y}_6(\text{Fe}_{1-x}\text{Mn}_x)_{23}$** , *J. Phys. Chem. Solids* 41, 1105-1109 (1980).

Key words: atomic ordering; iron-manganese compounds; nearest neighbor distances; neutron scattering; profile refinement; rare-earth compounds.

Neutron diffraction studies of the nonmagnetic compositional range of the  $\text{Y}_6(\text{Fe}_{1-x}\text{Mn}_x)_{23}$  system reveal the presence of preferential ordering of Fe and Mn atoms on the four transition metal crystallographic sites. Throughout the entire compositional range of the ternary system, Mn atoms prefer to occupy the  $f_2$  site and Fe atoms the  $f_1$  site. Refinements of the data were carried out using the Rietveld profile method.

19758. Holys, A., Fuhr, J. R., **Absolute transition probabilities of neutral titanium lines**, *Astron. Astrophys.* 90, 14-17 (1980).



**Key words:** atomic transition probabilities; titanium; wall-stabilized arc.

Transition probabilities for 21 lines of TiI have been measured in emission with a wall-stabilized arc. These lines cover a wavelength range of 3600-6300 Å and originate from either the  $y^3G^o$  or the  $y^5G^o$  upper level. Weak as well as strong lines were measured, and the resulting relative  $A$ -values were converted to the absolute scale of Bell et al. (1975). The uncertainties of the absolute transition probabilities are estimated to be within 20-30%. Comparisons of this work with other recent experiments show excellent agreement.

**19759.** Huie, R. E., Herron, J. T., Braun, W., Tsang, W., Chlorine isotope enrichment in CO<sub>2</sub> TEA laser photolysis of CF<sub>2</sub>Cl<sub>2</sub>, *Chem. Phys. Lett.* 56, No. 1, 193-196 (May 15, 1978).

**Key words:** chlorine isotopes; isotope separation; laser chemistry.

A number of lines from a CO<sub>2</sub> TEA laser were used to photolyze CF<sub>2</sub>Cl<sub>2</sub>. Enrichment of the <sup>35</sup>Cl and <sup>37</sup>Cl isotopes in the molecular chlorine formed during the photolysis was observed using a mass spectrometer. Maximum enrichment was about 1.8. The dependence of enrichment on wavelength, reactant concentration, inert gas pressure, and the presence of SiF<sub>4</sub> is reported. Of particular interest is the persistence of significant enrichment at pressures up to several hundred torr ( $\approx 10^5$  Pa). Aside from the practical significance of this enrichment at high pressures, it suggests that there are important contributions from isotopically specific interactions after the laser pulse.

**19760.** Jacox, M. E., Matrix isolation study of the reaction of fluorine atoms with the trifluoromethyl halides. Infrared spectroscopic evidence for the CF<sub>3</sub>X<sup>•</sup> free radicals, *Chem. Phys.* 5, 69-76 (1980).

**Key words:** CF<sub>3</sub>Br; CF<sub>3</sub>I; CF<sub>3</sub>Cl; CF<sub>3</sub>F; CF<sub>3</sub>Br; CF<sub>3</sub>I; F-atom reactions; infrared spectrum; matrix isolation; photodecomposition.

When F atoms produced by a microwave discharge through NF<sub>3</sub> in argon carrier gas were codeposited with CF<sub>3</sub>Cl, CF<sub>3</sub>Br, or CF<sub>3</sub>I in an argon matrix at 14 K, prominent infrared absorptions, assigned to the CF<sub>3</sub>X<sup>•</sup> reaction intermediate, resulted. The splitting of the degenerate CF<sub>3</sub> stretching fundamental absorption requires that the C—X—F chain be nonlinear, consistent with the results of recent ab initio calculations of the structure of the closely related species ClF<sub>2</sub>. Lower frequency absorptions may be assigned to the X—F stretching vibrations and to CF<sub>3</sub> deformation modes. On exposure of the deposit to the radiation of a medium-pressure mercury arc, the CF<sub>3</sub>X<sup>•</sup> absorptions disappeared, and very strong absorptions of CF<sub>4</sub> appeared. The photodissociation threshold varies from a wavelength longer than 490 nm, for CF<sub>3</sub>IF, to a wavelength shorter than 300 nm, for CF<sub>3</sub>ClF. The possible reaction of CF<sub>3</sub> with XF trapped in an adjacent site prevents a definitive determination of the photodissociation mechanism. It is suggested that CF<sub>3</sub>ClF may be relatively stable.

**19761.** Jones, M. C., Cool-down of superconducting power transmission lines with single phase helium, *Cryogenics* 20, No. 3, 139-145 (Mar. 1980).

**Key words:** conservation equations; cool-down; numerical solutions; superconducting transmission lines.

Numerical solutions of the one-dimensional conservation equations of fluid flow are given for the problem of the cool-down of superconducting power transmission cables. By including the continuity and momentum conservation equations, both time dependent and spatially dependent mass flow may be treated. The equations are applied to specific designs in which one stream of helium fills the bore of a cable while a second fills the space between the outside of the cable and an enclosing pipe.

Both co-current flow and counter flow are treated with a variety of boundary conditions. Temperature profiles as a function of time, and total cool-down times are given.

**19762.** Kasen, M. B., Mikesell, R. P., Interim report on the significance of blunt flaws in pipeline girth welds, *Proc. Int. Conf. on Pipeline and Energy Plant Piping, Calgary, Alberta, Canada, Nov. 10-13, 1980*, 8 pages (1980).

**Key words:** arc strikes; blunt flaws; fracture mechanics; hydrogen-assisted cracking; low-cycle fatigue; porosity; preparing flawed weldments; slag; three-dimensional flaws.

Experiments are being performed to determine if slag, porosity or arc strikes are significant contributors to brittle fracture of pipeline girth welds. API 1104-qualified manual and automatic welds and deliberately flawed welds were produced in 101.6 cm (40-inch) diameter API 5LX65 pipe. Procedures were developed to test large transverse-weld specimens under low-cycle, fully reversed, strain-controlled fatigue at  $-2^\circ\text{C}$  and at strain levels up to twice net section yield while maintaining pipe curvature. Flaw significance is being assessed by determining the number of cycles to crack initiation as defined by a 10% drop in the load required to maintain the desired strain range. Initial test results are presented and discussed.

**19763.** Kline, F. J., Hayward, E., Electrodissintegration of <sup>12</sup>C, *Phys. Rev. C* 17, No. 5, 1531-1534 (May 1978).

**Key words:** absolute measurement; activation; electric dipole; electroexcitation; giant resonance; <sup>12</sup>C.

The cross section for the production of the <sup>11</sup>C activity by bombarding <sup>12</sup>C with 30 MeV electrons has been measured absolutely. The result,  $11.9 \pm 0.2 \mu\text{b}$ , has a smaller absolute error than any previous measurement. This value corresponds to a ( $\gamma, n$ ) cross section integrated to 30 MeV of  $41.0 \pm 0.6 \text{ MeV mb}$ , based on a distorted-wave Born-approximation electric dipole virtual photon spectrum.

**19764.** Larrabee, R. D., Blackburn, D. L., Theory and application of a nondestructive photovoltaic technique for the measurement of resistivity variations in circular semiconductor slices, *Solid State Electron.* 23, No. 10, 1059-1068 (1980).

**Key words:** photoconductivity variations; photovoltaic technique; resistivity gradients; resistivity variations; wafer scanning.

A nondestructive photovoltaic technique for measuring resistivity variations in high-resistivity semiconductor slices is described. The underlying theory of this measurement is reviewed, and the necessary expressions for its implementation are derived for a case of a small light spot scanned over a diameter of a large circular slice. The reduction of these theoretical results to practice is discussed and their validity demonstrated by comparing the results obtained with the photovoltaic technique to resistivity profiles of the same slice diameter measured by four-probe techniques.

**19765.** Linsky, J. L., Stellar chromospheres, *Proc. Stellar Turbulence, IAU Colloq. 51, University of Western Ontario, London, Canada, Aug. 27-30, 1979*, D. F. Gray and J. L. Linsky, Eds., pp. 248-277 (Springer-Verlag, New York, NY, 1980).

**Key words:** late-type stars; stellar chromospheres; ultraviolet spectra

This is an in-depth review of the rapidly emerging field of chromospheres in cool stars. Specific topics covered include trends emerging from semiempirical models of single stars, theoretical models, the Wilson-Bappu relation and systematic flow patterns in stellar chromospheres. The review contains extensive references.



19766. Livio, M., Regev, O., Shaviv, G., **Kelvin-Helmholtz instability in clusters of galaxies**, *Astrophys. J. Lett.* **240**, No. 2, L83-L86 (Sept. 1, 1980).

Key words: clusters; instability; Kelvin-Helmholtz; galaxies.

The motion of galaxies through the hot intracluster gas is examined. It is found that a Kelvin-Helmholtz instability develops at the interface between the moving galaxy and the gas. Its effect is gas stripping from the moving galaxy: the rate of stripping is estimated. The role of viscosity in this process is discussed.

19767. Malewski, R., Anderson, W. E., Moore, W. J. M., **Interlaboratory comparison of EHV shunt reactor loss measurements**, *IEEE Trans. Power Appar. Syst.* **PAS-99**, No. 4, 1634-1641 (July/Aug. 1980).

Key words: bridges; calibration; current comparator; dissipation factor; electrical measurements; energy loss; shunt reactors.

A comparison of loss measurements on a 0.002 power factor, 110 MVA, 735 kV shunt reactor at the Hydro-Quebec Institute of Research using four different bridges from three independent laboratories, is described. The special features of the bridges, which were all basically of the three-winding transformer (current comparator) type, are discussed and their estimated uncertainties are given. In the region where all bridges were judged to be operable, the measured values lie within  $\pm 3\%$  of the mean. For the two bridges which were specifically adapted for shunt reactor loss measurements, the measured values are within  $\pm 1\%$  of the mean. The test conditions, results, and some of the problems encountered are discussed and recommendations for future comparisons are made.

19768. McNesby, J. R., **Effects of photochemical oxidants on materials**, Chapter 13 in *Ozone and Other Photochemical Oxidants*, pp. 643-671 (National Academy of Sciences, Washington, DC, 1977).

Key words: economic; elastomers; materials; ozone; paint; photochemical oxidants; reaction mechanisms; textile dyes.

In the context of this review, the term "photochemical oxidants" is considered to be synonymous with "ozone." In test chambers that have external ozone generators and that operate at or near atmospheric pressure, ozone is the only likely oxidizing species. In ambient air, however, ground-state atomic oxygen, hydroxyl radicals, and especially hydroperoxy radicals can compete with ozone in attacking materials, such as rubber, that contain olefinic bonds. The most economically important materials with respect to ozone damage are paint, elastomers (rubber), and textile fiber-dye systems. Damage to polyethylene by ozone is considered to be negligible. The ozone-specific damage in 1970 to materials has been assessed in economic terms and is approximately as follows: paint, \$540 million; elastomers, \$569 million; and textile fibers and dyes, \$84 million. Total material damage attributable to ozone is, therefore, \$1.22 billion. This is to be compared with Waddell's estimate of total air pollutant material damage of \$2.2 billion. It is clear that ozone is a very important molecule in pollutant damage to materials.

19769. Melmed, A. J., Smit, J., **Field-ion transmission microscopy**, *J. Phys. E: Sci. Instrum.* **12**, 355-356 (1979).

Key words: field-ion microscopy; ion microscopy; microscopy.

The main construction features and salient operating characteristics of a lensless high-magnification high-resolution positive-ion transmission microscope are described. Evidence relating to resolution and transmission using positive hydrogen ions is given. Spatial resolution of 1-2 nm at 180 000 $\times$  direct magnification has been achieved for opaque metal specimen edges.

19770. Müller, A. P., Cezairliyan, A., **Heat capacity and electrical resistivity of palladium in the range 1400 to 1800 K by a pulse heating method**, *Int. J. Thermophys.* **1**, No. 2, 217-223 (1980).

Key words: electrical resistivity; heat capacity; high temperature; palladium; pulse method; thermodynamics.

Measurements of heat capacity and electrical resistivity of palladium in the temperature range 1400-1800 K by a subsecond duration pulse heating technique are described. The results are expressed by the relations:  $C_p = 32.19 - 5.966 \times 10^{-3}T + 4.440 \times 10^{-6}T^2$ ,  $\rho = 15.42 + 1.840 \times 10^{-2}T$  where  $C_p$  is in J-mol $^{-1}$ K $^{-1}$ ,  $\rho$  in  $\mu\Omega$ -cm, and  $T$  in K. Estimated maximum inaccuracies of the measured properties are: 3% for heat capacity and 1% for electrical resistivity.

19771. Misra, D. N., **Monomolecular adsorption isotherms**, *J. Colloid Interface Sci.* **77**, No. 2, 543-547 (Oct. 1980).

Key words: adsorption isotherms; energy distribution functions; Jovanovich equation; Langmuir equation; monomolecular adsorption; nonlinear regression analysis.

There is a mathematical similarity between Jovanovich and Langmuir isotherms. They can be derived from integration of the differential equation.  $(d\theta/dp) = c(1-\theta)^k$ , when  $k = 1$  and  $k = 2$ , respectively. Other isotherms which satisfy certain theoretical conditions of monomolecular adsorption may also be derived from the differential equation when  $k \geq 1$ . The general isotherm, to a first approximation, may be reduced to the Langmuir equation. Nonlinear regression analyses show that the other equations fit as well as Jovanovich's and Langmuir's to a set of experimental data.

19772. Mountain, R. D., **Equations of state**, Article in *Encyclopedia of Physics*, R. G. Lerner and G. L. Trigg, Eds., pp. 290-291 (Addison-Wesley Publ. Co., Inc., Advanced Book Program, Reading, MA, Nov. 1980).

Key words: Debye theory; equation of state; ideal gas; Van der Waals equation; virial coefficient; virial equation.

The concept of an equation of state is introduced and discussed in terms of equations of state for fluids and solids. The need for thermal information, to augment the equation of state when constructing a complete, local thermodynamic description of a system is mentioned.

19773. Olver, F. W. J., **Whittaker functions with both parameters large: Uniform approximations in terms of parabolic cylinder functions**, *Proc. R. Soc. Edinburgh* **86A**, 213-234 (1980).

Key words: asymptotic expansions; confluent hypergeometric functions; error bounds; parabolic cylinder functions; turning points; Whittaker functions.

Asymptotic approximations are derived for the Whittaker functions  $W_{k,\mu}(z)$ ,  $M_{k,\mu}(z)$ ,  $W_{ik,\mu}(iz)$  and  $M_{ik,\mu}(iz)$  for large positive values of the parameter  $\mu$  that are uniform with respect to unrestricted values of the argument  $z$  in the open interval  $(0, \infty)$ , and bounded real values of the ratio  $k/\mu$ . The approximations are in terms of parabolic cylinder functions, and in most instances are accompanied by strict error bounds.

The results are derived by application of a recently-developed asymptotic theory of second-order differential equations having coalescing turning points, and an extension of the general theory of equations of this kind is also included.

19774. Peale, S. J., Cassen, P., Reynolds, R. T., **Tidal dissipation, orbital evolution, and the nature of Saturn's inner satellites**, *ICARUS* **43**, 65-72 (1980).

Key words: constraints on composition; orbital evolution; Saturn's satellites.



Estimates of tidal damping times of the orbital eccentricities of Saturn's inner satellites place constraints on some satellite rigidities and dissipation functions  $Q$ . These constraints favor rock-like rather than ice-like properties for Mimas and probably Dione. Photometric and other observational data are consistent with relatively higher densities for these two satellites, but require lower densities for Tethys, Enceladus, and Rhea. This leads to a nonmonotonic density distribution for Saturn's inner satellites, apparently determined by different mass fractions of rocky materials. In spite of the consequences of tidal dissipation for the orbital eccentricity decay and implications for satellite compositions, tidal heating is not an important contributor to the thermal history of any Saturnian satellite.

**19775.** Pence, W. H., Leone, S. R., **New atomic and molecular lasers and their application to the study of collision physics**, *Proc. Int. Conf. on Physics of Electronic and Atomic Collisions, ICPEAC 1979, Kyoto, Japan, Aug. 29-Sept. 4, 1979*, pp. 773-785 (North Holland Publ. Co., Amsterdam, The Netherlands, 1979).

Key words: calcium; collision physics; dimer lasers; energy transfer; lasers.

New atomic and molecular lasers can be used in a variety of ways to elucidate mechanisms and rates of inelastic collision processes. Examples are given whereby specific energy transfer processes are discovered and studied by laser diagnostic measurements.

**19776.** Pichler, G., Carlsten, J. L., **Self-broadening of the Ti 377.6 nm resonance line**, *J. Phys. B: Atom. Molec. Phys.* **11**, No. 14, L483-L488 (1978).

Key words: Lorentzian type wing; quasistatic wing; self broadening; Van der Waals type wing.

We report preliminary studies on the self-broadening of the 377.6 nm thallium line. In the short wavelength wing we observe asymmetries and a satellite at about 377.1 nm. In the long wavelength quasi-static wing we clearly observe the transition from the Lorentzian to the van der Waals type wing.

**19777.** Risley, A., Jarvis, S., Jr., Vanier, J., **The dependence of frequency upon microwave power of wall-coated and buffer-gas-filled gas cell Rb<sup>87</sup> frequency standards**, *J. Appl. Phys.* **51**, No. 9, 4571-4576 (Sept. 1980).

Key words: cavity pulling; frequency stability; microwave power dependence; optical pumping; Rb frequency standards; wall coating.

Previous studies of a commercial passive gas cell Rb<sup>87</sup> frequency standard showed a strong dependence of the output frequency  $\nu_{Rb}$  upon the microwave power  $P_{ul}$ . A major conclusion of that work was that the dependency of  $\nu_{Rb}$  upon  $P_{ul}$  was due to a line inhomogeneity effect. The line inhomogeneity interpretation suggested that substituting a wall coating for the usual buffer gas would reduce the dependence upon  $P_{ul}$ . As a part of the present work, a wall coating (a form of paraffin) was used and a reduction of this dependence by a factor of 100 was obtained. The present work has led to a more convincing theoretical demonstration of the line inhomogeneity effect. The paper discusses some of the details of the analytical procedure. There are certain major requirements that a wall coating would have to satisfy if it is to be superior to the usual buffer gas, and these are discussed in the text. The advantages demonstrated by the present work indicate that further studies are warranted to determine if an improved standard could be built based on a wall coating.

**19778.** Rosenblatt, J., Chayes, F., Trochimczyk, J., **An algebraic explanation of closure correlation among the coefficients of a principal component**, *Annual Report 1977-78 to The Carnegie*

*Institution of Washington Year Book* **77**, pp. 901-902 (Dec. 1978).

Key words: chemical petrology; closure correlation; principal components analysis; statistics.

In chemical petrology, especially in the study of the distribution of essential constituents, the data matrix is a table of percentages resulting in (well-known) negative covariances among major constituents. Principal components analysis has been used for characterization of such arrays. This note considers a "data" matrix consisting of a set of experimental estimates of the leading principal component obtained from a set of tables of percentages; there will be negative covariances among the elements of the estimates.

**19779.** Roussel, F., Breger, P., Spiess, G., Manus, C., Geltman, S., **Evidence of super-elastic effects in laser-induced ionisation of Na vapour**, *J. Phys. B: Atom. Molec. Phys. Lett. to Ed.* **13**, L631-L636 (1980).

Key words: electron heating; electron seeding; gas breakdown; laser ionization; Na; superelastic.

We report the direct observation of an intense ion yield when Na vapour in the wide range of densities  $10^{12}$ – $10^{15}$  cm<sup>-3</sup> is irradiated by a laser tuned to the  $3S_{1/2}$ – $3P_{3/2}$  resonance and with intensities in the range  $3 \times 10^3$ – $4 \times 10^5$  W cm<sup>-2</sup>. Evidence of superelastic e–Na(3p) collisions is shown above  $10^{13}$  cm<sup>-3</sup>. A critical discussion of possible electron seeding and heating mechanisms and a simple theoretical model for the observed ion yields are given.

**19780.** Unassigned.

**19781.** Simon, T., Linsky, J. L., Schiffer, F. H. III, **IUE spectra of a flare in the RS Canum Venaticorum-type system UX Arietis**, *Astrophys. J.* **239**, No. 3, 911-918 (Aug. 1, 1980).

Key words: binary stars; late-type stars; RS Canum Venaticorum; stellar chromospheres; stellar coronae; ultraviolet spectra.

IUE spectra of UX Ari obtained during the large flare of 1979 January 1 exhibit chromospheric and transition-region emission-line fluxes about 2.5 and 5.5 times brighter than quiescent fluxes, respectively, and up to 1400 times brighter than the quiet Sun. A high-dispersion spectrum of the 2000-3000 Å region exhibits enhanced Fe II emission, which is probably associated mainly with the K0 IV star, and enhanced Mg II emission with asymmetric wings extending to +475 km s<sup>-1</sup>. We interpret these line wings as evidence for mass flow from the K0 IV star to the G5 V star. We propose a speculative scenario of major long-lived RS CVn flares in which the component stars have very large corotating flux tubes, which occasionally interact. Magnetic reconnection results in flux tubes that temporarily connect the two stars. This process and subsequent disruption of the interconnecting field lines, leading to reformation of individual flux tubes, may provide the energy to explain the observed enhanced radio, ultraviolet, and x-ray flux in flares. The observed Mg II wings are emitted by gas streaming along these flux tubes.

**19782.** Straty, G. C., Diller, D. E., McCarty, R. D., **PVTx properties and equation of state for compressed and liquefied nitrogen-methane mixtures**, *Proc. 2d Int. Conf. on Phase Equilibria and Fluid Properties in the Chemical Industry, Berlin, West Germany, Mar. 17-21, 1980*, pp. 18-23 (Deutsche Gesellschaft fuer Chemisches Apparatuswesen e.V., Frankfurt/Main, West Germany, 1980).

Key words: equation of state; extended corresponding states; extended critical region; mathematical model; natural gas components; nitrogen-methane mixtures; PVTx properties measurements.



The PVTx properties of compressed and liquefied nitrogen-methane mixtures have been measured at three fixed compositions ( $X = 0.3, 0.5$  and  $0.7$ ), at temperatures between 80 and 320 K, at densities between 0.8 and 28.5 mol/L, and at pressures to 35 MPa, with an estimated inaccuracy less than 0.2% in density. The measurements were compared with the extended corresponding states model, giving density differences which are generally within experimental error, except in an extended region about the critical point (at temperatures between 0.95 and 1.3  $T_c$  and at densities between 0.5 and 1.5  $\rho_c$ ). The deviations in this region suggest needed improvements in the model.

**19783.** Thurber, W. R., Mattis, R. L., Liu, Y. M., Filliben, J. J., **Resistivity-dopant density relationship for phosphorus-doped silicon**, *J. Electrochem. Soc.* **127**, No. 8, 1807-1812 (Aug. 1980).

Key words: dopant density; electrical measurements; mobility; resistivity; semiconductors; silicon.

New data for the resistivity-dopant density relationship for phosphorus-doped silicon have been obtained for phosphorus densities between  $10^{13}$  and  $10^{20}$  cm $^{-3}$  and temperatures of 296 °K (23 °C) and 300 °K. For dopant densities less than  $10^{18}$  cm $^{-3}$ , results were calculated from resistivity and junction capacitance-voltage measurements on processed wafers. For more heavily doped material, data were obtained from Hall effect and resistivity measurements on specimens cut from bulk silicon slices. The results differ by 5-15% from the commonly used Irvin curve, always in the direction of lower dopant density for a given resistivity. For comparison with the electrical measurements, phosphorus densities were also obtained by neutron activation analysis and the photometric technique. The values from these methods were within 10% of the electrical results. Analytical fits were determined for the resistivity-dopant density product as a function of resistivity and dopant density for temperatures of 23 °C and 300 °K. Similar fits were obtained for the calculated electron mobility as a function of resistivity and electron density.

**19784.** Tsang, W., **Thermal stability of cyclohexane and 1-hexene**, *Int. J. Chem. Kinet.* **X**, 1119-1138 (1978).

Key words: allylic resonance energy; allyl radicals; biradical; cyclohexane; decomposition; decyclization; isomerization; olefins; shock tube; 1-hexene.

The mechanism and initial rates of decomposition of cyclohexane and 1-hexene have been determined from single-pulse shock-tube experiments. The main initial processes involve isomerization of cyclohexane to 1-hexene, followed by decomposition of 1-hexene. From comparative rate experiments the following rate expressions have been derived:  $k(\text{cyclohexane} \rightarrow 1\text{-hexene}) = 10^{16.7} \exp(-44,400/T) \text{ sec}^{-1}$ ;  $k_B(1\text{-hexene} \rightarrow \text{C}_3\text{H}_5 + n\text{C}_3\text{H}_7) = 10^{15.9} \exp(-35,600/T) \text{ sec}^{-1}$ ;  $k_M(1\text{-hexene} \rightarrow 2\text{C}_3\text{H}_6) = 10^{12.6} \exp(-28,900/T) \text{ sec}^{-1}$ .

The 1-hexene bond-breaking reaction leads to an allylic resonance energy of 42.7 kJ and a heat of formation of allyl radicals of 176.6 kJ (300 °K). There appear to be general relations relating the rate expressions for the decomposition of alkynes, alkanes, and alkenes. Studies on the induced decomposition of cyclohexane have also been carried out.

**19785.** Van Brunt, R. J., Hilten, J. S., Silver, D. P., **Partial-discharge pulse height distributions and frequencies for positive and negative dc corona in SF<sub>6</sub> and SF<sub>6</sub>-N<sub>2</sub> mixtures**, (Proc. Second Int. Symp. on Gaseous Dielectrics, Knoxville, TN, Mar. 9-13, 1980), Paper in *Gaseous Dielectrics II*, 303-311 (Pergamon Press, Inc., Elmsford, NY, 1980).

Key words: corona; partial-discharge; point-plane electrodes; pulse height distributions; SF<sub>6</sub>; SF<sub>6</sub>-N<sub>2</sub> mixtures.

The voltage and pressure dependence of partial-discharge pulse height distributions and pulse repetition rates have been investigated for compressed SF<sub>6</sub> and SF<sub>6</sub>-N<sub>2</sub> mixtures using a

fast multichannel analyzer. Positive and negative dc corona were generated using a point-plane stainless steel electrode geometry with a gap spacing of 1.24 cm and a tip radius of 0.07 mm. For SF<sub>6</sub> the positive corona pulses are typically an order of magnitude larger in amplitude than negative corona pulses although their repetition rate is lower. The tendency for SF<sub>6</sub> positive corona pulses to develop as bursts with a burst length that increases with increasing voltage and decreasing pressure is clearly exhibited by the pulse height spectra. The negative corona in SF<sub>6</sub> tends to begin as large pulses which eventually give way to a near glow condition as voltage is increased, although a steady glow, such as occurs in pure N<sub>2</sub>, was never observed. The observed pulse height spectra appear to be sensitive to gas composition as is evident from measurements made with gases containing varying relative concentrations of SF<sub>6</sub> and N<sub>2</sub>. Attempts are underway to correlate observed changes in pulse height spectra with corona-induced chemical changes in the gas using a gas chromatograph-mass spectrometer system.

**19786.** Van Brunt, R. J., Misakian, M., **Comparison of dc and 60 Hz ac positive and negative partial discharge inceptions in SF<sub>6</sub>**, *Proc. Conf. on Electrical Insulation and Dielectric Phenomena, 1980 Annual Report, Boston, MA, Oct. 26-29*, pp. 461-469 (National Academy Press, 2101 Constitution Ave., N.W., Washington, DC 20418, 1980).

Key words: compressed gas; corona; electron avalanche; inception voltage; ionization; ion mobilities; partial discharge; photodetachment; space charge; sulfur hexafluoride (SF<sub>6</sub>); uv radiation; 60 Hz ac and dc.

Measurements have been performed on inception of positive and negative partial discharge (corona) inception for dc and 60 Hz voltages in gaseous SF<sub>6</sub> for absolute pressures in the range of 50 to 500 kPa using polished stainless steel point-plane electrodes with gap spacings between 1.25 and 2.28 cm. Onsets were measured by counting partial discharge pulses corresponding to electron avalanches or streamers above the level of 0.02 pC as a function of applied voltage. For 60 Hz conditions a phase selective detection method was used to distinguish positive and negative corona. Below gas pressures of about 150 kPa there appears to be little difference between inceptions of ac and dc corona. As gas pressure is increased above this value the negative inceptions remain nearly the same, but the dc positive inception occurs at increasingly higher voltages than the ac inception. This difference is explained in terms of residual space charge from negative corona on one half cycle affecting the development of positive corona on the next half cycle, and is shown to be consistent with expected mobilities of negative ion conglomerates which can be formed in a discharge at these gas pressures.

**19787.** Van Zyl, B., Dunn, G. H., Chamberlain, G., Heddle, D. W. O., **Benchmark cross sections for electron-impact excitation of *n* 1S levels of He**, *Phys. Rev. A* **22**, No. 5, 1916-1929 (Nov. 1980).

Key words: benchmark cross sections; electron impact; He excitation; *n* 1S levels of He.

Absolute total emission cross sections have been measured for electron-impact excitation of He giving radiation from the 6<sup>1</sup>S-2<sup>1</sup>P, 5<sup>1</sup>S-2<sup>1</sup>P, 4<sup>1</sup>S-2<sup>1</sup>P, and 3<sup>1</sup>S-2<sup>1</sup>P transitions. Electron energies were 50, 100, 500, 1000, and 2000 eV. Particular care was taken to make the measurements accurate and to make knowledgeable assessments of uncertainties, so that the results serve as reliable benchmarks for calibration of other excitation apparatus as well as for comparison with theory. The most accurate results are for 500-eV electron energy, where the mean uncertainty is only 3.5% high confidence level. The measured emission cross sections are modified to account for branching and cascade to give level-excitation cross sections, and results are compared with other experimental data and theoretical predictions. At 2000 eV,



the measurements average 2.5% below Born-approximation calculations.

**19788.** Walker, J. A., Tsang, W., **Characterization of lubricating oils by differential scanning calorimetry**, (Proc. Conf. Fuels and Lubricants, Baltimore, MD, Oct. 20-23, 1980), *SAE Tech. Paper Series 801383*, pp. 1-8 (Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096, 1980).

Key words: differential scanning calorimeter; lubricating oil; metal surface effects; nitrogen dioxide; oxidation; recycled base stocks; thermal analysis; virgin base stocks.

The oxidative stability of formulated lubricating oils, and virgin and re-refined lubricating base stocks, have been determined by high pressure differential scanning calorimetry. At pressures of 0.7-3.4 MPa (100-500 psig) air or O<sub>2</sub> and temperatures near 200 °C, degradation occurs with an appreciable generation of heat. Experiments have been conducted in both temperature programmed and isothermal modes. These data have been compared with multicylinder engine sequence test (III-C) results. Sensitivity to effects caused by a NOX environment, traces of olefinic materials added in the oil and the nature of metal surfaces have been demonstrated. Data on the response of re-refined and virgin base stocks to fixed quantities of an additive have been obtained. They are indicative of the wide diversity of the substances in question. The results of these studies indicate that the induction period measurements yield important information on the response of base stocks to additive treatment which could be used in quality control for formulating lubricating oils. Further studies are, however, needed to obtain more definite conclusions.

**19789.** Weber, A., **Ro-vibronic species, overall allowed species, and nuclear spin statistical weights for symmetric top molecules belonging to the  $D_{nd}$  and  $D_{nh}$  ( $n \leq 6$ ) point-groups**, *J. Chem. Phys.* 73, No. 8, 3952-3972 (Oct. 15, 1980).

Key words: group theory; nuclear spin; ro-vibronic species; statistical weights; symmetric top molecules.

Nuclear spin statistical weight factors have been calculated for the rotational energy levels of symmetric top molecules belonging to the  $D_{nd}$  ( $n = 2, 3, 4, 5, 6$ ) and  $D_{nh}$  ( $n = 3, 4, 5, 6$ ) point-groups. The ro-vibronic species for the levels have been calculated on the basis of Høugen's classification scheme, using the point-group of the molecule. The Longuet-Higgins permutation-inversion-group was used to determine the overall allowed species permitted by the Pauli exclusion principle and the ramifications of inversion symmetry. The ro-vibronic species and the statistical weights are given in a set of easy to use tables. They are presented explicitly for all possible vibrational states of a totally symmetric electronic state. The weights are given in terms of the coefficients  $m_a$  which occur in the expression  $\Gamma_s = \sum m_a \Gamma_g^a$  for the reduction of the nuclear spin representation  $\Gamma_s$  with respect to the irreducible representations  $\Gamma_g^a$  of the point-group G. General formulas for the characters of the nuclear spin representation are derived. These permit the numerical evaluation of the coefficients  $m_a$  for a specific molecule by means of the standard group theoretical reduction formula. The results are general and are applicable to any molecule belonging to one of the symmetric top point-groups  $D_{nd}$  and  $D_{nh}$  with  $n \leq 6$ , having an arbitrary number of atoms of the same or different kind, and for arbitrary values of the nuclear spins. The tables for the ro-vibronic species and for the statistical weights are arranged in such a manner that account can be taken of the splittings of level degeneracies due to rotation-vibration interaction. Extensions of the tables to include cases of nontotally symmetric electronic states are described. A few examples are worked out for molecules of increasing complexity and belonging to different point-groups to illustrate the ease of using the tables.

**19790.** Wells, J. S., Petersen, F. R., Maki, A. G., **Heterodyne frequency measurements with a tunable diode laser-CO<sub>2</sub> laser spectrometer: Spectroscopic reference frequencies in the 9.5- $\mu$ m band of carbonyl sulfide**, *Appl. Opt.* 18, No. 21, 3567-3573 (Nov. 1, 1979).

Key words: carbonyl sulfide; OCS calibration frequencies; OCS reference frequencies; TDL-CO<sub>2</sub> heterodyne measurements; TDL reference frequencies; tunable diode laser.

The frequencies of twelve carbonyl sulfide absorption lines near 9.5  $\mu$ m have been measured by means of a heterodyne frequency measuring technique, which uses a frequency stabilized CO<sub>2</sub> laser and a tunable diode laser. The diode laser was locked to the peak of each OCS absorption line by means of a first derivative frequency lock procedure. In addition to lines in the 02<sup>0</sup>-00<sup>0</sup> band, measurements also include some nearby OCS hot band features as well as lines in isotopically enriched samples of OC<sup>34</sup>S, O<sup>13</sup>CS, and <sup>18</sup>OCS. These measurements are part of an effort to provide frequency standards for the calibration of tunable IR laser devices.

**19791.** Wiederhorn, S. M., Fuller, E. R., Jr., Thomson, R., **Micromechanisms of crack growth in ceramics and glasses in corrosive environments**, *Met. Sci.*, pp. 450-485 (Aug.-Sept. 1980).

Key words: ceramics; fracture; glass; strength; stress-corrosion cracking; sub-critical crack growth.

At normal temperatures and pressures water is known to have a strong influence on the strength of ceramics and glasses. Behaving as a stress corrosion agent, water causes these materials to fail prematurely as a consequence of subcritical crack growth. A basic premise of this paper is that stress corrosion cracking of ceramics is a chemical process which involves a stress-enhanced chemical reaction between the water and the highly stressed ceramic near the crack tip. Plastic deformation is believed to play no role in this fracture process. After a brief survey of chemical reaction rate theory, the basic rate equation from this theory is modified to reflect physical and chemical processes which occur at crack tips. Modification of the rate equation is based on the assumption that the crack tip can be modelled as an elastic continuum, an assumption that is supported by a simple atomistic model of crack growth. When tested against experimental data collected on glass the theory was found to be consistent with measurements of the crack growth dependence on temperature, applied stress intensity factor, and concentration of reactive species in the environment.

**19792.** Wiederhorn, S. M., Tighe, N. J., **Proof-testing of hot-pressed silicon nitride**, *J. Mater. Sci.* 13, 1781-1793 (1978).

Key words: ceramic turbines; failure prediction; fracture; oxidation; silicon nitride; strength.

Proof-testing was investigated as a method for insuring the reliability of hot-pressed silicon nitride in high temperature structural applications. The objective of the study was to determine if the strength distribution of a population of test specimens could be truncated by proof-testing. To achieve this objective the strength of silicon nitride was measured at 25 °C and 1200 °C, both with and without proof-testing. At 25 °C, however, the strength distribution was effectively truncated by proof-testing. At 1200 °C, however, the effectiveness of proof-testing as a means of truncating the strength distribution was determined by the resistance of the silicon nitride to oxidation. Although oxidation removes machining flaws that limit the strength of silicon nitride, long-term exposure to high temperature oxidizing conditions resulted in the formation of surface pits that severely degraded the strength. Provided the effects of high temperature exposure are taken into account, proof-testing is shown to be useful for truncating the strength distribution of hot-pressed silicon nitride at elevated temperatures.



**19793.** Wing, W. H., **Electrostatic trapping of neutral atomic particles**, *Phys. Rev. Lett.* **45**, No. 8, 631-634 (Aug. 25, 1980).

Key words: atoms; electrostatics; hydrogen; molecules; neutral atom traps.

Excited neutral atoms having positive Stark energies may be trapped near magnitude minima of electrostatic fields. At moderate field strengths Rydberg atoms have trap depths comparable to ambient  $kT$  and as much as 100 times those of recently proposed optical-field traps. Polar molecules and metastable hydrogen and positronium atoms also can be trapped. A slow nondegenerate atom in a quadrupole field is harmonically bound. Sustained trapping and cooling should be possible, allowing Doppler-free few-atom spectroscopy and novel collision studies.

**19794.** Younger, S. M., **Electron-impact-ionization cross sections for highly ionized heliumlike atoms**, *Phys. Rev. A* **22**, No. 4, 1425-1428 (Oct. 1980).

Key words: distorted wave method; electron atom scattering; electron impact ionization; helium isoelectronic sequence.

Cross sections for electron-impact ionization from the ground states of four ions in the helium isoelectronic sequence have been calculated in the distorted-wave Born-exchange approximation. The results are in good agreement with available experimental data. Exchange in the scattering matrix element was found to be important in the determination of accurate cross sections. An isoelectronic plot of the scaled cross section permits ready interpolation of the nonrelativistic ionization cross section for any ion in the helium sequence in the incident electron energy range 1.5 times threshold.

**19795.** Zerpa, C. O., Dharmawardhana, P. B., Parrish, W. R., Sloan, E. D., **Solubility of cyclopropane in aqueous solutions of potassium chloride**, *J. Chem. Eng. Data* **24**, No. 1, 26-28 (1979).

Key words: aqueous potassium chloride; gaseous cyclopropane; Henry's constant; solubility.

An experimental apparatus was designed for measuring the solubility of gases in liquids at low pressure and temperatures. Accurate data for the solubility of gaseous cyclopropane in aqueous potassium chloride are reported. The data were taken at 273, 276, and 278 K, at KCl concentrations of 0, 0.5, 1.1, 1.5, and 10 g/L and at pressures up to cyclopropane hydrate formation conditions. Gas solubility followed Henry's law over the entire range of data. Reciprocal Henry's constants were fitted to an empirical relation in temperature and salt content and confidence limits are given for the relation.

**19796.** Albers, J., **Continuum formulation of spreading resistance correction factors**, *J. Electrochem. Soc.* **127**, No. 10, 2259-2263 (Oct. 1980).

Key words: continuum model; correction factor; Laplace's equation; nonlinear differential equations; resistivity; spreading resistance.

A continuum formulation of spreading resistance correction factors is derived from the Choo *et al.*, recursion relation for the kernel of the spreading resistance correction factor integral. Specifically, a differential equation for the kernel of the correction factor integral is derived in the limit as the layer thickness approaches zero. The resulting differential equation is nonlinear and inhomogeneous but can be transformed into a linear second order equation which can be solved analytically in several cases. The continuum form of the correction factor is compared with the correction factor generated from the finite-layer thickness version of the Laplace equation description for the case of an exponentially varying resistivity. Depending upon the number

of layers used, the exponential constant, and the total thickness of the structure, the continuum and discrete forms of the correction factor differ by factors as large as 2.75 thus indicating a limitation in the accuracy of finite layer algorithms for spreading resistance data interpretation.

**19797.** Clark, E. S., Weeks, J. J., Eby, R. K., **Diffraction from nonperiodic structures. The molecular conformation of polytetrafluoroethylene (Phase II)**, Chapter 10 in *ACS Symp. Series No. 141, Fiber Diffraction Methods*, A. D. French and K. H. Gardner, Eds., pp. 183-192 (American Chemical Society, Washington, DC 20036, 1980).

Key words: conformation; crystal; electron; helix; irrational; Phase II; polytetrafluoroethylene; units per turn.

Remarkable electron diffraction patterns of the low temperature form (Phase II) of polytetrafluoroethylene have been obtained which exhibit layer lines sharply resolved to the 26th order. These patterns permit accurate measurements of the layer line heights. Equations are developed to relate the layer line heights to a molecular conformation defined in terms of an incommensurable helix of ratio,  $r = u/t$ , defining a conformation of  $u$  motifs regularly spaced along  $t$  turns of the helix. The helix parameter,  $r$ , is not the ratio of small whole numbers for an incommensurable helix and the repeat period,  $c$ , becomes a crystallographically useless large number. Solution of the equations for the electron diffraction data yields a molecular conformation of  $r = u/t = 2.159$  for Phase II, with the molecule slightly untwisted from the previously assigned conformation of  $r = 13/6 = 2.167$ .

**19798.** Dickens, B., **Thermal degradation and oxidation of polystyrene studied by factor-jump thermogravimetry**, *Polym. Degradation Stability* **2**, 249-268 (1980).

Key words: activation energy; factor-jump thermogravimetry; oxidation; polystyrene; pyrolysis; thermal degradation; thermogravimetry.

Factor-jump thermogravimetry has been used to study the activation energy of polystyrene degrading in a vacuum, in  $N_2$  flowing at 4 mm/s and in  $N_2/O_2$  mixtures. The results show the activation energy to be  $44.9 \pm 0.2$  kcal/mole ( $188 \pm 0.8$  kJ/mole) for degradation above 350 °C in vacuum or in flowing  $N_2$ . This agrees well with work reported in 1949 by Jellinek but with few results reported subsequently.

The apparent activation energy for polystyrene losing weight above 280 °C in an atmosphere of abundant  $O_2$  is  $21.5 \pm 0.2$  kcal/mole ( $90.2 \pm 0.8$  kJ/mole). In all cases where  $O_2$  was deliberately introduced (partial pressures  $> 4$  mm Hg), the sample degraded to a black tar and the activation energy was  $\leq 30$  kcal/mole, depending on the amount of oxygen present and on the thermal history of the sample.

**19799.** Drullinger, R. E., Wineland, D. J., **Laser cooling of ions bound to a Penning trap**, (Proc. Fourth Int. Conf. on Laser Spectroscopy, Rottach-Egern, Fed. Rep. of Germany, June 11-15, 1979), Paper in *Laser Spectroscopy*, H. Walther and K. W. Rothe, Eds., IV, 66-72 (Springer-Verlag, New York, NY, 1979).

Key words: atomic clocks; atomic spectroscopy; Doppler effects; frequency standards; ion storage; laser cooling; laser spectroscopy; radiation pressure.

MgII ions which are confined in a room temperature Penning trap have been cooled to  $\leq 0.5$  K by scattering photons which are nearly resonant with the  $3s^2S_{1/2} \rightarrow 3p^2P_{3/2}$  transition. The magnesium loaded into the trap has a natural isotopic abundance consisting of  $\sim 80\%$   $^{24}\text{Mg}$ , and  $\sim 10\%$  each  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$ . The  $^{24}\text{Mg}$  is radiatively cooled and it subsequently cools the  $^{25,26}\text{Mg}$  by long range Coulomb collisions. This allows the use of a "cooling ion" being used in conjunction with a more complex species of spectroscopic interest.



Experiments using two lasers are reported where one laser is fixed in frequency and provides the cooling source and the other laser is swept in frequency. By monitoring the scattered light from the second laser, an optical spectrum of MgII ions is obtained. Because the Doppler width of the cooled ions is reduced, the three isotopic lines are clearly resolved.

**19800.** Lehwald, S., Yates, J. T., Jr., Ibach, H., **Adsorption and dissociation of nitric oxide on Ni(III)**, (Proc. Fourth Int. Conf. on Solid Surfaces and the Third European Conf. on Surface Science, Cannes, France, Sept. 22-26, 1980), Supplement 1a Revue, *Le Vide, les Couches Minces*, No. 201, II, 221-224 (1980).

Key words: chemisorption; electron energy loss spectroscopy; Ni(111); NO; vibrational spectroscopy.

The adsorption and dissociation of NO on a Ni(111) single crystal surface have been studied by electron energy loss spectroscopy (EELS). LEED and Auger spectroscopy (AES) were used in addition to characterize different adsorption phases. From the vibrational spectra we concluded that at 150 K NO is molecularly adsorbed in twofold bridging sites: at low coverages in a bent configuration, and at higher coverages in a perpendicular one, concomitant with the appearance of a  $c(4 \times 2)$  LEED pattern.

Upon warming to 250-350 K the NO dissociates into adsorbed N and O atoms. These exhibit different LEED patterns and vibrational frequencies depending on coverage.

**19801.** Novotny, D. B., **Experimental photoresist sensitometry and exposure modeling**, (Proc. Society of Photo-Optical Instrumentation Engineers, San Jose, CA, Mar. 17-18, 1980), Paper in *Semiconductor Microconductor Microlithography V* 221, 184-193 (Society of Photo-Optical Instrumentation Engineers, Bellingham, WA 98227, 1980).

Key words: exposure; exposure modeling; photolysis kinetics; photoresist; sensitometry; Van Kreveld's law.

Sensitometric properties were measured for a positive diazo-type photoresist at wavelengths of 365, 405, and 436 nm. It is shown that the exposure data at these three wavelengths may be combined according to Van Kreveld's additivity law to accurately predict both simultaneous and successive exposures made with combinations of these wavelengths. Exposure modeling using Beer's law and first order photolysis kinetics, when combined with the measured sensitometric properties, supports the validity of Van Kreveld's law for simultaneous and successive exposures. The combined modeling and experimental data also support the existence of a critical inhibitor concentration that defines complete exposure and is the same for all wavelengths as well as for monochromatic simultaneous and successive exposures. Applications of characteristic curves of exposure depth as a function of exposure are outlined.

**19802.** Nyyssonen, D., **Calibration of optical systems for linewidth measurements on wafers**, (Proc. Society of Photo-Optical Instrumentation Engineers, San Jose, CA, Mar. 17-18, 1980), Paper in *Semiconductor Microconductor Microlithography V* 221, 119-126 (Society of Photo-Optical Instrumentation Engineers, Bellingham, WA 98227, 1980).

Key words: critical dimensions; linewidth; metrology; micrometrology; microscopy; optical imaging.

In contrast to earlier work with nearly opaque photomasks, optical linewidth measurements on wafers encompass materials with a much wider variation in optical parameters and material profiles. Accurate optical edge detection requires corrections for both the relative reflectance and phase at the line edge because of the partial coherence present in optical microscopes. However, measurement systems which cannot provide the appropriate corrections and cannot detect edge location accurately can be calibrated. Since the correction curve is material depend-

ent, calibrated standards are theoretically required for each step in the wafer fabrication process where linewidths are measured. In the proposed approach for thin layers (less than 200 nm), a small number of etched silicon-dioxide-on-silicon wafers can be used for calibration of a large class of wafer materials. Examples of wafer calibration data for filar, image-splitting and image-scanning systems are given. The problems associated with accurate linewidth measurement and calibration for thick layers are also discussed.

**19803.** Parr, A. C., Jason, A. J., Stockbauer, R., McCulloh, K., **Photoionization and fragmentation study of cyclopropene**, (Proc. 8th Int. Mass Spectrometry Conf., Oslo, Norway, Aug. 12-18, 1979), Paper in *Advances in Mass Spectrometry* 8, 62-70 (1980).

Key words: allene; coincidence; cyclopropene; fragmentation; photoionization; propyne; threshold photoelectron spectroscopy.

The photoionization efficiency curves have been obtained for cyclopropene and its fragments  $C_3H_3^+$ ,  $C_3H_2^+$ , and  $C_3H^+$  from threshold to 20 eV. The threshold photoelectron spectra and breakdown curves are given over the same energy range. The adiabatic ionization potential of the parent molecule and the derived heats of formation of the ionic species were determined. The breakdown curve will be compared to those of allene and propyne which were measured earlier.

**19804.** Santoro, A., Mighell, A. D., Rodgers, J. R., **The determination of the relationship between derivative lattices**, *Acta Cryst.* A36, 796-800 (1980).

Key words: critical evaluation; derivative lattices; indexing; lattice relationships; lattices; single-crystal methods; twinning.

Derivative lattices are related to one another by transformation matrices having rational elements. A simple algorithm for finding these matrices consists in testing if the scalar products of the vectors defining two arbitrary primitive cells of two lattices can be exactly or approximately related by equations with rational coefficients. A rational relationship indicates that two or more lattices have a number of geometrical features in common such as common superlattices, sublattices, etc. The algorithm can, therefore, be applied to a variety of crystallographic problems such as the study of twinning, the indexing of powder patterns, single-crystal diffractometry and the critical evaluation of crystal data. Five examples are discussed in detail.

**19805.** Stockbauer, R., **The formation of high vibrational states of ions by photoionization**, (Proc. 8th Int. Mass Spectrometry Conf., Oslo, Norway, Aug. 12-18, 1979), Paper in *Advances in Mass Spectrometry* 8, 79-89 (1980).

Key words: carbon dioxide; carbon monoxide; hydrogen; nitric oxide; nitrogen; nitrogen dioxide; nitrous oxide; oxygen; photoelectron spectra; photoionization; threshold photoelectron spectra; water.

Threshold photoelectron spectroscopy measures the distribution of ion states formed when photoionization is accompanied by a zero kinetic energy (threshold) electron. Such spectra are presented in this paper for the following molecules:  $H_2$ ,  $D_2$ ,  $N_2$ ,  $O_2$ , NO, CO,  $CO_2$ ,  $N_2O$ ,  $NO_2$ ,  $H_2O$ , and  $D_2O$ . The structure observed in these spectra show that in these molecules, autoionization processes populate vibrational states of the ion not normally accessible by direct ionization. Thus, vibrational states of the ion not visible in HeI photoelectron spectra due to unfavorable Franck-Condon factors are observed in the TPES. In addition, a step is observed in the TPES of  $H_2O$  ( $D_2O$ ) at the  $OH^+$  ( $OD^+$ ) fragment onset. This step is probably due to a change in the competition between ion and neutral fragmentation processes at the onset of this ion fragmentation channel.



19806. Thurber, W. R., Mattis, R. L., Liu, Y. M., Filliben, J. J., **Resistivity-dopant density relationship for boron-doped silicon**, *J. Electrochem. Soc.* 127, No. 10, 2291-2294 (Oct. 1980).

Key words: dopant density; electrical measurements; mobility; resistivity; semiconductors; silicon.

New data for the resistivity-dopant density relationship for boron-doped silicon have been obtained for boron densities between  $10^{14}$  and  $10^{20}$   $\text{cm}^{-3}$  and temperatures of 296 °K (23 °C) and 300 °K. For dopant densities less than  $10^{18}$   $\text{cm}^{-3}$ , results were calculated from resistivity and junction capacitance-voltage measurements on processed wafers. For more heavily doped material, boron densities were obtained from the nuclear track technique and from Hall effect measurements on specimens cut from bulk silicon slices. The Hall factor was assumed to be 0.8 in the calculation of hole density. The results differ significantly from the commonly used Irvin curve for boron densities greater than  $10^{16}$   $\text{cm}^{-3}$  with a maximum deviation of 45% at  $5 \times 10^{17}$   $\text{cm}^{-3}$ . The data are in better agreement with the Wagner curve, but for boron densities less than  $10^{17}$   $\text{cm}^{-3}$ , the measured resistivities were always higher than those predicted by the Wagner expression. Least squares fits to analytical expressions were determined for the resistivity-dopant density product as a function of resistivity and of dopant density for temperatures of 23 °C and 300 °K. Similar fits were obtained for the calculated hole mobility as a function of resistivity and of hole density.

19807. Wiese, W. L., **Energy levels, wavelengths and transition probabilities for the first five spectra of Fe, Co and Ni**, (Workshop on Atomic Physics and Spectroscopy for Supernovae Spectra, La Jolla Institute, La Jolla, CA, Jan. 10-12, 1980), Paper in *AIP Conference Proceedings No. 63, Supernovae Spectra*, R. Meyerott and G. H. Gillespie, Eds., pp. 103-117 (American Institute of Physics, New York, NY, 1980).

Key words: allowed lines; atomic energy levels; cobalt; forbidden lines; iron; nickel; transition probabilities; wavelengths.

Atomic energy level, wavelength and transition probability data for the first five spectra of Fe, Co and Ni are reviewed, and lists of recent comprehensive data tables are presented. The source material for transition probabilities, both for allowed and forbidden lines, is critically discussed, since these data contain large uncertainties.

19808. Wlodawer, A., **Studies of ribonuclease-A by x-ray and neutron diffraction**, *Acta Cryst.* B36, 1826-1831 (1980).

Key words: atomic models; flat-cone geometry; neutron diffraction; protein structure; ribonuclease-A; structure refinement.

The structure of monoclinic bovine ribonuclease-A [ $P2_1$ ,  $a = 30.18(12)$ ,  $b = 38.4(10)$ ,  $c = 53.32(15)$  Å,  $\beta = 105.85(8)^\circ$ ] has been studied by a combination of x-ray and neutron diffraction techniques. A model based on x-ray data to 2.5 Å resolution has been refined by restrained least squares, with a final  $R = 25.2\%$  for 951 nonhydrogen atoms and one phosphate molecule. Partially refined coordinates of ribonuclease-S were initially used. A good fit between the model and difference Fourier maps was obtained. Several maps based on neutron diffraction intensities at 2.8 Å resolution and various phasing schemes were calculated and they are discussed in terms of their usefulness in further refinement of the structure.

19809. Trevino, S. F., Rymes, W. H., **A study of methyl reorientation in solid nitromethane by neutron scattering**, *J. Chem. Phys.* 73, No. 6, 3001-3006 (Sept. 15, 1980).

Key words: methyl group; molecular reorientation; neutron scattering; nitromethane; quantum tunnelling; x-ray scattering.

The geometrical and dynamical properties of the reorientation of the methyl group of nitromethane in the solid state have been studied by inelastic neutron scattering. Quasielastic scattering spectra have been obtained for several values of momentum transfer at five temperatures between 50° and 150 °K. The spectra are shown to be consistent with jumps of 120° about an axis coincident with the C—N bond. The temperature dependence of the residence time yields a barrier of 234 cal/mole. An inelastic neutron spectrum obtained at 4.2 °K suggests a tunnel splitting of the torsional ground state of  $0.045 \pm 0.005$  meV, which is consistent with the derived activation energy. Inelastic neutron scattering has also been used to determine the energy of the tunnel split first excited state which in  $\text{CH}_3\text{NO}_2$  has a mean energy of 7.4 meV above the ground state and is split by 1.8 meV. In the deuterated compound, the first excited state is at 5.3 meV above the ground state and its splitting is less than the instrumental resolution.

19810. Trevino, S. F., Prince, E., Hubbard, C. R., **Refinement of the structure of solid nitromethane**, *J. Chem. Phys.* 73, No. 6, 2996-3000 (Sept. 15, 1980).

Key words: methyl group; molecular reorientation; neutron scattering; nitromethane; quantum tunnelling; x-ray scattering.

The complete determination of the crystal structure of solid nitromethane has been obtained from single crystal x-ray diffraction and neutron powder diffraction data. The structure is orthorhombic, space group  $P2_12_12_1$  with  $a = 5.1832$  Å,  $b = 6.2357$  Å,  $c = 8.5181$  Å at  $T = 4.2$  K, and  $Z = 4$ . Two models were used to describe the thermal motion of the methyl group, one with anisotropic temperature factors for the hydrogen atoms constrained to correspond to a threefold rotation around the C—N bond, and the other treating the group as a rigid body, with a torsional oscillation about the C—N bond axis.

19811. Glinka, C. J., Prask, H. J., Choi, C. S., **Neutron diffraction and small-angle scattering as nondestructive probes of the microstructure of materials**, (Proc. Conf. on Mechanics of Nondestructive Testing, Blacksburg, VA, Sept. 10-12, 1980), Paper in *Mechanics of Nondestructive Testing (1980)*, W. W. Stinchcomb, Ed., pp. 143-164 (Plenum Publ. Corp., New York, NY, 1980).

Key words: materials microstructure; neutron scattering; new instruments and methods; nondestructive testing; residual stress; small-angle; texture determination.

This article gives a brief introduction to small-angle and wide-angle neutron scattering methods as they pertain to the nondestructive evaluation of materials properties. Examples are presented of work done at NBS and elsewhere which illustrate the techniques discussed.

19812. D'Antonio, P., Santoro, A., **Powder neutron diffraction study of chemically prepared  $\beta$ -lead dioxide**, *Acta Cryst.* B36, 2394-2397 (1980).

Key words: isotropic refinement; neutron diffraction; octahedral distortions; powder method; rutile-type compounds;  $\beta$ - $\text{PbO}_2$ .

$\beta$ - $\text{PbO}_2$ , tetragonal,  $P4_2/mnm$ ,  $a = 4.9578$  (2),  $c = 3.3878$  (2) Å,  $Z = 2$ , with the Pb atoms located in positions 2(a) and the O atoms in positions 4(f). The structure was refined with the Rietveld method utilizing powder neutron diffraction data collected with a multiple-channel detector up to  $\sin \theta/\lambda = 0.6$  Å $^{-1}$ . Anisotropic thermal parameters were included in the refinement. The O positional parameter was found to be  $x = 0.3067$  (2). The Pb atoms are coordinated by six O atoms, forming an irregular octahedron in which the four equatorial Pb—O distances are 2.1689 (7) Å and the two axial distances 2.150 (1) Å.



**19813.** Hill, J. E., **Standard procedures for collector performance testing**, Chapter 15 in *Solar Energy Technology Handbook. Part A. Engineering Fundamentals. Energy, Power and Environment* 6, W. C. Dickinson and P. N. Cheremisinoff, Eds., pp. 457-480 (Marcel Dekker, Inc., New York, NY, 1980).

Key words: solar collector; solar heating and cooling; standards; testing.

The use of solar energy for space heating, cooling, and supplying domestic hot water to buildings has received considerable attention over the past several years. As a result, a solar heating and cooling industry has emerged, and with it a need for both performance and testing standards. This paper reviews the basic concepts used in testing solar collectors for thermal performance and then describes in detail the adopted consensus standard test method, ASHRAE Standard 93-77. It presents typical results obtained for flat-plate collectors using the Standard, how the method can be used for concentrating collectors, how to calculate "cooling" performance for a collector using the test results, and some recent developments in the collector testing field.

**19814.** Koch, W. F., **The value of the Faraday via 4-aminopyridine**, (Proc. Atomic Masses and Fundamental Constants, East Lansing, MI, Sept. 18-21, 1979), Paper in *Atomic Masses and Fundamental Constants*, J. A. Nolen, Jr., and W. Beneson, Eds., 6, 157-172 (Plenum Publ. Corp., New York, NY, 1980).

Key words: coulometry; Faraday constant; 4-aminopyridine.

In 1833, Michael Faraday of the Royal Institution in London formulated the laws of electrolysis revealing the relationship between electric current, time, and chemical equivalent weight (mole). Translated into mathematical terms, this relationship can be expressed:  $\text{mole} = (1/F) \int i \, dt$ . The constant of proportionality,  $F$ , has of course been named the Faraday constant and its value is the subject of this presentation.

At the last meeting (AMCO-5), preliminary results were reported on the determination of the Faraday constant by way of coulometric titration of 4-aminopyridine performed at Iowa State University. Additional titrations of the same material have since been conducted at the National Bureau of Standards, taking advantage of improved standards of mass, time, voltage and resistance. A reappraisal of the error analysis has also been undertaken in light of further evidence and is reported herein.

Detailed accounts of experimental procedures, instrumentation and data treatment are well documented and need not be repeated here. However, a brief review of the experiment may prove helpful to the following discussion.

**19815.** Kennish, W., Ahmed, M., McCabe, M., McKinstry, M., **Determination of thermal performance characteristics of modular passive solar storage walls**, *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980*, pp. 975-979 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: finite-difference computer model; passive solar energy; responsive coefficients; solar storage walls; testing procedures; thermal performance.

A conceptual study of testing procedures to determine thermal performance characteristics of Trombe-Wall type passive solar storage wall systems has been performed. In the study, a finite-difference thermal model of a passive solar storage wall in a test facility was used to predict the wall thermal performance in a particular climatic location. The simulated test results were used in a multiple regression analysis to characterize the thermal performance of test wall. These characteristics were then used in a simplified calculation procedure to predict the thermal performance of the solar storage wall in different climatic re-

gions. A comparison of these predictions with detailed computer simulation results for these other climatic regions show that the test procedure and data reduction technique provides a simple method of characterizing the passive solar storage wall and has potential wide scale applications for modular passive components.

**19816.** Fassett, J. D., Kelly, W. R., Machlan, L. A., Moore, L. J., **Mass spectrometric isotope metrology of uranium on resin beads**, (Proc. ORNL Conf. on Analytical Chemistry in Energy Technology, Gatlinburg, TN, Oct. 8-12, 1979), Paper in *Radioelement Analysis Progress and Problems*, W. S. Lyon, pp. 357-364 (Ann Arbor Press, Ann Arbor, MI, 1980).

Key words: errors; isotope ratios; mass spectroscopy; pulse counting; resin beads; thermal ionization; uranium.

The potential for making high-precision, high-accuracy isotope ratio measurements on submicrogram amounts of uranium absorbed on anion-exchange resin beads has been investigated utilizing a single stage thermal ionization mass spectrometer with pulse counting detection. The errors inherent in this measurement process have been evaluated. These errors include isobaric interferences, contamination, ion scattering and baseline correction, mass discrimination, and isotopic fractionation. A mass spectrometric procedure for loading and analyzing beads has been developed. A single bead is loaded onto a rhenium V-filament wetted with cyclohexanone. At 1660 °C a stable  $U^+$  signal of greater than 100,000 counts per second is produced from a nanomole of uranium. Analyses of the NBS SRM's U-100 to U-900 indicate that the mass spectrometric errors can be minimized and fractionation pattern reproduced such that the  $^{235}U/^{238}U$  ratio can be measured to 0.1 percent (95% confidence limit). For minor isotopes the precision is counting statistics limited.

**19817.** Coursey, B. M., Calhoun, J. M., **Liquid scintillation counting of inorganic radiochemicals in high-efficiency scintillators**, (Proc. Int. Conf. on Liquid Scintillation Counting, Recent Applications and Developments, San Francisco, CA, Aug. 21-24, 1979), Paper in *Sample Preparation and Applications II*, 19-29 (Academic Press, Inc., New York, NY, 1980).

Key words: inorganic radiochemical; liquid scintillator; radioactivity; sample preparation; scintillation counting; solgel.

Methods of incorporating inorganic radiochemicals into liquid and solgel scintillators that exhibit high scintillation yield are described. Liquid-scintillation measurements have been made at the National Bureau of Standards on 31 different radionuclides for a variety of application in radionuclide metrology. Sample preparation techniques are described for a number of radionuclides that differ markedly in their chemical behavior as well as in their nuclear-decay characteristics. Particular emphasis is given to radionuclides such as  $^{59}Fe$  and  $^{241}Pu$  which decay by emission of low-energy radiations.

**19818.** Burke, R. W., Mavrodineanu, R., **Assessment of the accuracy of spectrophotometric measurements and methodologies**, *Am. Soc. Test. Mater. Spec. Tech. Publ. 708*, 45-65 (1980).

Key words: absorbance accuracy; instrumental standards; method accuracy; multielement analyses; NBS standard reference materials; spectrophotometry; systematic errors; transmittance accuracy.

Modern day spectrophotometers are used to perform both relative and absolute transmittance or absorbance measurements. In order to discuss these two distinct functions, this paper is divided essentially into two parts. The first part discusses the instrumental parameters that must be verified in order to assure that the measurement is accurate and outlines the several types of National Bureau of Standards (NBS) standard reference materials (SRM) that are currently available, or in process, for per-



forming these verifications. The second part of the paper focuses on analytical method accuracy and describes a number of spectrophotometric procedures that have been widely used at NBS with the belief that they produce accurate results. In instances where sufficient data exist, the accuracy of these procedures is reexamined by comparison of the spectrophotometric values with those obtained by the accepted definitive isotope dilution-mass spectrometric method. The paper concludes with some projections on the possible future use of ultraviolet-visible absorption spectrophotometry as a practical, multielement technique.

**19819.** McKinsty, M., Richtmyer, T., Ducas, W., **Performance evaluation of passive/hybrid solar heating and cooling**, *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980*, pp. 346-350 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: building heat transfer; energy conservation; passive solar heating, cooling, and performance monitoring.

Two levels of passive/hybrid solar heating and cooling performance evaluation are discussed. They have been reviewed and accepted by coordinating committees drawn from government organizations and universities, as technical appendices to the U.S. DoE Program Area Plan, "Performance Evaluation of Passive/Hybrid Solar Heating and Cooling," and will be used in the U.S. DoE passive performance monitoring program. Both levels use a subtractive calculation for passive heating or cooling used by the building, although, with the more detailed method, heat flux to or from primary storage elements is monitored so that an approximate additive calculation can be done.

**19820.** Ducas, W., McCabe, M., DeCorte, K., **Review of thermal performance test procedures for testing passive/hybrid solar components**, *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980*, pp. 970-974 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: passive product types; solar calorimeter tests; solar-optical properties tests; solar simulation; thermal performance test procedures; thermal transmission tests; thin-film resistance heaters.

Existing test methods have been reviewed for their application as thermal performance test procedures for modular passive/hybrid solar components. These methods cover the thermal performance of building envelope assemblies such as walls and windows, and tests developed for thermal storage assemblies.

A classification of passive components is identified, recommendations are made for testing several types of passive components, and recommendations for new test procedures are identified.

**19821.** Ruthberg, S., **A rapid cycle method for gross leak testing with the helium leak detector**, *Proc. 1980 30th Electronic Components Conf., San Francisco, CA, Apr. 28-30, 1980*, pp. 128-134 (Institute of Electrical and Electronics Engineers, New York, NY, 1980).

Key words: back pressurization hermetic test; helium mass spectrometer leak test; hermeticity; hybrid microcircuits; leak testing; semiconductor device packages.

A new noncontaminating dry gas, quantitative test method has been developed that permits gross leak measurements on hermetic packages. It provides rapid testing with a helium leak detector over the leak size range of less than  $1 \times 10^{-5}$  to more than  $1 \text{ atm-cm}^3/\text{s}$  with a test gas of  $\sim 1\%$  helium. The present limitation on dry gas procedures results from the rapid depletion of the test gas from the package interior which prevents detec-

tion of the larger leaks. The rapid cycle method attacks this limitation by employing either a rapid transfer of the test package or a rapid gas cycling technique for extending the upper range of the helium leak detector procedure. Theoretical relationships have been derived based on viscous flow to correlate the leak detector reading to leak size. Experimental apparatus is described, and test results are given for a time of test of about 8 s, a measurement precision of 15 to 35%, and a correlation coefficient between theory and test of better than 0.99. The rapid transfer mode of operation can be implemented readily with any helium leak detector equipped for fast pump down and high helium flow rate.

**19822.** Santoro, R. J., Semerjian, H. G., Emmerman, P. J., Goulard, R., Shabahang, R., **Multangular absorption measurements in a methane diffusion jet**, (Proc. Symp. of the 178th Meeting of the American Chemical Society, Washington, DC, Sept. 9-14, 1979), Chapter 36 in *Laser Probes for Combustion Chemistry*, D. R. Crosley, Ed., ACS Symp. Series 134, pp. 427-433 (American Chemical Society, Washington, DC, 1980).

Key words: absorption measurement; combustion measurements; convolution algorithm; diffusion jet; laser diagnostics; reconstruction algorithm; tomography.

A multangular absorption approach is used to measure the concentration profile of methane across a diffusion jet. The results have been used to assess the applicability of tomography to gas phase species analysis. Comparisons of the center line concentration and jet position have shown excellent agreement with the known experimental values. The effect of the number of angles for which data is obtained has also been addressed and found to agree with previous analytical studies.

**19823.** Sabatiuk, P. A., McCabe, M., **Development of thermal performance criteria for residential passive solar buildings**, *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980*, pp. 621-624 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: depletable energy; HUD Demonstration Program; passive solar buildings; performance criteria; statistical evaluation; thermal analysis.

In support of the development of thermal performance criteria for residential passive solar buildings, thermal design characteristics and anticipated performance for 266 projects in the HUD Passive Residential Design Competition and the HUD Cycle 5 Demonstration Program were analyzed. These passive residences are located in all regions of the United States requiring space heating, and they represent a variety of passive solar system types including direct gain, indirect gain, and solarium (isolated gain) systems. The results of this statistical analysis are being used to develop proposed minimum acceptable levels of thermal performance for passive solar buildings for the residential performance criteria.

A number of performance measures were examined, including net solar contribution, solar fraction, and auxiliary energy use. These and other design and climate-related parameters were statistically correlated using the DATAPLOT computer program and standard statistical analysis techniques.

**19824.** Wiese, W. L., Martin, G. A., **Atomic transition probabilities**, Section E in *CRC Handbook of Chemistry and Physics*, 61st Edition, R. C. Weast and M. J. Astle, Eds., pp. E-349—E-384 (CRC Press, Inc., Boca Raton, FL, 1980).

Key words: atomic oscillator strengths; compact tabulation; critical evaluation; hydrogen through iron; selected transition probabilities.



A table of selected, critically evaluated transition probabilities is presented, which comprises about 4000 prominent lines of the lighter elements from hydrogen through iron. For the sake of convenience, a compact handy format is used which contains only the bare minimum of information.

19825. Wood, H. M., A survey of computer-based password techniques, Chapter 7 in *Advances in Computer Security Management*, T. A. Rullo, Ed., 1, 140-145 (Heyden & Son, Inc., Philadelphia, PA, 1980).

Key words: computer networking; computer security; controlled access; identification; passwords; personal authentication.

This report surveys passwords and their effective application to the problem of controlling access to computer resources. After describing the need for and uses of passwords, password schemes are categorized according to selection technique, lifetime, physical characteristics, and information content. Password protection, both in storage and transmission, is dealt with in the next section, followed by brief sections on current implementations and cost considerations.

19826. Blau, P. J., Sliding wear of metals, *Mater. Eng.* 92, No. 2, 56-57 (Aug. 1980).

Key words: copper alloys; friction; metallic materials; microstructure; sliding wear; wear; wear models.

This paper briefly reviews several recent models for sliding wear of metallic materials. These include a systems approach to wear, the "delamination theory," a fracture mechanics approach, an oxidational wear model and a crystal plasticity model. A lack of clear understanding of the interrelationships among wear and microstructural properties emphasizes the need for further research in this area. Preliminary results on some effects of near surface microstructure on wear and friction of copper alloys exemplifies the potential of the microstructural approach to wear control.

19827. Burstyn, H. C., Esfandiari, P., Sengers, J. V., Stokes-Einstein diffusion of critical fluctuations in a fluid, *Phys. Rev. A* 22, No. 1, 282-284 (July 1980).

Key words: binary liquids; critical fluctuations; diffusion; light scattering; Stokes' law; viscosity.

The diffusion coefficient associated with the order-parameter fluctuations near the critical point of fluids is expected to vanish asymptotically as  $D = RkT/6\pi\eta\xi$ , where  $\eta$  is the viscosity,  $\xi$  the correlation length, and  $R$  a universal constant. Our experiments, using 3-methylpentane-nitroethane, yield  $R = 1.02 \pm 0.06$ , in agreement with the mode-coupling theory of critical fluctuations, but in disagreement with the value  $R/6\pi = 1.2/6\pi \approx 1/5\pi$ , recently suggested by several investigators.

19828. Gadzuk, J. W., Hole recoil, vibrational shakeup, and photoelectron lineshapes, (Proc. Nobel Symp. 46, Many Body Theory of Atomic Systems, Gothenburg, Sweden, June 11-16, 1979), *Phys. Scripta* 21, 570-575 (1980).

Key words: hole dynamics; lineshapes; photoelectron spectroscopy.

The general problem of boson renormalization of a quasi-localised hole state created in a photo-ejection process from a molecule or solid is considered. A quasi-localised hole can hop from the initial site of creation and this introduces the possibility of recoil when the hole interacts with the boson field.

As an illustrative example, the problem of the photoionization spectrum for a molecule adsorbed on a metal surface is considered. Hopping from the ad-molecule hole state into the substrate is the delocalization mechanism and intra-molecular vibrational modes are the bosons. Recoil induced interferences between the

two processes lead to a more narrow lineshape than would be inferred from a straightforward convolution-of-independent-events line.

19829. Boyd, V. L., Zon, G., Himes, V. L., Stalick, J. K., Mighell, A. D., Secor, H. V., Synthesis and antitumor activity of cyclophosphamide analogues. 3. Preparation, molecular structure determination, and anticancer screening of racemic *cis*- and *trans*-4-phenylcyclophosphamide, *J. Med. Chem.* 23, No. 4, 372-375 (1980).

Key words: *cis*-4-phenylcyclophosphamide; cyclophosphamide analogs; *in vivo* anticancer activity; molecular structure determination; single crystal x-ray diffraction; synthesis.

Cyclization of racemic 3-amino-3-phenyl-1-propanol with bis(2-chloroethyl)phosphoramidic dichloride gave a diastereomeric mixture of 4-phenylcyclophosphamide (3), which was chromatographically separated into the faster and slower eluting components. A combination of  $^1\text{H}/^{31}\text{P}$  NMR and IR spectral data indicated that the faster and slower racemates correspond to *cis*-3 (mp 129-130 °C) and *trans*-3 (mp 112-114.5 °C), respectively. The molecular structure of the former compound was determined by x-ray crystallography and thereby unambiguously established the *cis* relationship between equatorially disposed phenyl and P=O substituents in a chair conformation. These results confirm the stereochemical assignments for *cis*- and *trans*-3 which have been independently deduced by Y. E. Shih, J. S. Wang, and C. T. Chen. Anticancer screening tests against L1210 lymphoid leukemia in mice have revealed that, while both diastereomers of 3 afford toxic metabolites, *trans*-3 led to therapeutic activity and *cis*-3 did not. The relevance of these findings to results reported for 4-methylcyclophosphamide and cyclophosphamide is briefly discussed.

19830. Cahn, J. W., Surface stress and the chemical equilibrium of small crystals—I. The case of the isotropic surface, *Acta Metall.* 28, No. 10, 1333-1338 (1980).

Key words: interstitials; melting; small particles; solid solutions; solubility; surfaces; thermodynamics; vapor pressure.

The equilibria of small solid solution crystals with isotropic surfaces in contact with vapor or fluid solutions is considered when the surface stress differs numerically from the surface free energy. The interstitial components of the solid are shown to have a constant chemical potential throughout the system, while the chemical potentials of the substitutional components are not constant unless the magnitude of the surface stress equals the surface free energy. Six examples are given to illustrate various equilibria. Only the surface stress acts on the interstitial component, while the substitutional components are affected by the surface free energy and in most circumstances by the surface stress as well.

19831. Cavanagh, R. R., Yates, J. T., Jr., Infrared spectra of methyl isocyanide chemisorbed on rhodium, *Surf. Sci.* 99, L381-L383 (1980).

Key words: aluminium oxide; chemisorption; infrared spectroscopy; isomerization; methylisocyanide; rhodium.

The chemisorption of  $\text{CH}_3\text{NC}$  on dispersed Rh supported on  $\text{Al}_2\text{O}_3$  has been investigated using transmission infrared spectroscopy. Evidence for the chemisorption of undissociated  $\text{CH}_3\text{NC}$  is presented. It is shown that at 300 K the isomerization of  $\text{CH}_3\text{NC}$  to  $\text{CH}_3\text{CN}$  does not occur on Rh. The spectra obtained for adsorbed  $\text{CH}_3\text{NC}$  suggest an analogous chemistry of the Rh surface sites to that found in organometallic chemistry.

19832. Mighell, A. D., Rodgers, J. R., Lattice symmetry determination, *Acta Cryst.* A36, 321-326 (1980).

Key words: Bravais lattice; classification; crystal data; reduced forms; space group frequency; symmetry.



Transformation matrices required to obtain a conventional cell (Crystal Data cell) from the reduced cell have been applied to 47 000 crystalline compounds in the Crystal Data file. For 97% of the compounds, the calculations from the reduced cells yield conventional cells (lattice parameters, lattice type, and crystal system) that are entirely consistent with those reported in the original literature. In a few instances in which the reduced-cell matrix indicated a higher symmetry, the author has often noted that the crystal was unusual in some way or there was an error in the reported symmetry. Some implications of the results of this survey are: (1) metric symmetry as determined from the reduced cell is usually identical to the crystal-lattice symmetry; (2) determination of precise cell parameters defining any primitive cell of the lattice is valuable because from them one can conveniently determine the crystal system with a high degree of confidence (the results, however, should still be verified by checking equivalent intensities and systematic extinctions); (3) if the metric symmetry obtained from the reduced cell and the symmetry determined by other techniques do not agree, the reason should be sought as there are often important structural implications; (4) the sequence of steps in an automatic procedure for the determination of space groups could be: primitive cell, reduced cell, lattice metric symmetry, crystal-lattice symmetry, extinction conditions.

**19833.** Young, J., Ogburn, F., Ballard, D., **Electroforming a micrometer scale of 50  $\mu\text{m}$  (2 mil) overall length, *Met. Finish.*, pp. 27-29 (Aug. 1980).**

Key words: electroforming; electroplating; micrometer scale; scanning electron microscope.

A procedure is described for constructing an accurate micrometer scale by electroplating methods to form alternate layers of nickel and gold which show good contrast in an electron microscope. The nickel-gold composite is sectioned, mounted and polished using metallographic techniques to reveal thin lines of gold spaced by an accurate thickness of nickel. It is designated as NBS SEM magnification standard SRM 484.

**19834.** Akcasu, A. Z., Benmouna, M., Han, C. C., **Interpretation of dynamic scattering from polymer solutions, *Polymer* 21, 866-890 (Aug. 1980).**

Key words: light scattering; neutron scattering; polymer solutions.

The theoretical results available for the interpretation of the dynamic scattering from polymer solutions have been re-examined. The scattering law  $S(q, t)$  is formulated using the eigenfunction expansion method and the linear response theory. All previously known exact expressions of  $S(q, t)$  for a single unperturbed Gaussian chain have been re-derived using the first method to demonstrate the interrelationships among the various approaches to calculation of  $S(q, t)$ . The results are cast into new forms which, in many cases, are more convenient for both numerical and analytical discussions. The infinite chain results are obtained from the exact closed expression of  $S(q, t)$  for ring polymers as a special case as  $N \rightarrow \infty$ . Questions like the effect of the draining parameter on the shape of  $S(q, t)$ , the positive definiteness of the diffusion tensor, and the possibility of measuring the eigenvalue of the first internal mode through light scattering, have been included in the discussions.

A new method has been proposed for the interpretation of the dynamic scattering experiments in terms of the initial slope,  $\Omega$ , of  $\ln S(q, t)$ . The quantity  $\Omega$  can also be identified as the first cumulant of  $S(q, t)$ . The advantage of this method is that  $\Omega(q)$  can be calculated for all  $q$  values as a function of temperature and concentration by combining the linear response theory and the blob model of chain statistics. Consequently, one is not restricted to the asymptotic small- and intermediate- $q$  regions in order to interpret the scattering experiments. The analytical and numerical results giving  $\Omega(q)$  under various conditions have

been presented. Using infinite chain results it is shown that  $\Omega$  acts as a characteristic frequency in the sense that in both the small- and intermediate- $q$  regions,  $\ln S(q, t)$  can be scaled to a  $q$ -independent shape function when time is expressed as  $\Omega t$ . This property facilitates the measurement of  $\Omega$  from  $S(q, t)$ -data using a known shape function. The feasibility of the method has been demonstrated using light scattering data on polystyrene in toluene in the transition region between small- and intermediate  $q$ -regions.

**19835.** Batts, M. E., Russell, L. R., Simiu, E., **Hurricane wind speeds in the United States, *ASCE J. Structural Div.* 106, No. ST10, 2001-2016 (Oct. 1980).**

Key words: buildings (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology).

A Monte Carlo simulation technique is used to obtain estimates of hurricane wind speeds in the Gulf and East Coasts of the United States. The paper describes the sources of data, the probabilistic models for the climatological characteristics of hurricanes, and the physical models for the hurricane wind speed field used in the estimations. Estimated values of fastest-mile hurricane wind speeds at 10 m above ground in open terrain at the coastline and at 200 km inland are given for various mean recurrence intervals. The estimated hurricane wind speeds were found to be best fitted by Weibull distributions with tail length parameters  $\gamma \geq 4$ . Estimates are given of various errors inherent in the estimated values of the hurricane wind speeds. Owing to uncertainties with respect to the applicability of the physical models used in this work to locations north of Cape Hatteras, estimated hurricane wind speeds given for these locations should be viewed with caution.

**19836.** Ehrlich, D. J., Osgood, R. M., Jr., Turk, G. C., Travis, J. C., **Atomic resonance-line lasers for atomic spectrometry, *Anal. Chem.* 52, No. 8, 1354-1356 (July 1980).**

Key words: atomic resonance laser; atomic resonance-line laser; flame spectrometry; laser enhanced ionization; optical galvanic effect; photodissociation laser.

Atomic resonance-line lasers based on photodissociation of metal-halide molecules have important implications for spectrochemical analysis. Analytical curves of growth and limits of detection have been obtained by laser enhanced ionization (LEI) for two (Ti and Na) of the eight atomic resonance line lasers which have been demonstrated to date. The fixed frequency lasers offer a significant simplicity advantage over tunable dye lasers. In addition, the presence of additional atomic laser lines permits the excitation of high energy electronic levels by means of sequential excitation. Such two-wavelength excitation demonstrated by the Na LEI result reported here, has important implications for both selectivity and sensitivity. Although general applicability will depend on further development of the lasers, they are presently appropriate for many special, dedicated applications.

**19837.** Gadzuk, J. W., Metiu, H., **Theory of electron-hole pair excitations in unimolecular processes at metal surfaces. I. X-ray edge effects, *Phys. Rev. B* 22, No. 6, 2603-2613 (Sept. 15, 1980).**

Key words: electron-hole pairs; molecular processes; surface reactions; x-ray edge.

A theory of the dynamics of molecular processes at solid surfaces must necessarily deal with those aspects of the solid which provide dissipative or irreversible reaction channels, thus giving the particular process a direction in time. While the heat-bath aspects of the solid are often considered from the phonon point of view, there is increasing speculation that the substrate electron-hole pair excitations may be a significant rate-determining factor, at least for metals. This belief is supported by various



conclusions which have emerged from theoretical studies of time-dependent perturbations acting on extended Fermi systems, as physically realized in core-level spectroscopies of solids. We present here one phase of a study of surface reaction dynamics, focusing on the irreversible coupling of nuclear motion of an incident beam of atoms or molecules with the substrate electrons. For the cases in which the incident particle undergoes a substrate-induced diabatic transition in its internal electronic state, a sudden localized perturbation on the electrons is turned on. In analogy with the x-ray edge problem, an infrared divergent spectrum of electron-hole pairs is created which could give rise to irreversibility. Specific examples are considered and the ramifications on such observable quantities as sticking coefficients are detailed.

**19838.** Kayser, R. F., Raveché, H. J., **Emergence of periodic density patterns**, *Phys. Rev. B* **22**, No. 1, 424-435 (July 1, 1980).

**Key words:** BBGKY equation; bifurcation; direct correlation function equation; freezing; periodic crystalline solutions.

Two recent statistical-mechanical theories for the periodic patterns exhibited by the local density  $\rho_1(\vec{r})$  as a uniform fluid crystallizes are analyzed. One theory is based on the direct correlation function, the other on the pair correlation function. In the absence of tractable equations for the angular dependence of these functions in an ordered phase, similar assumptions are made in both theories which lead to similar nonlinear integral equations. The differences between investigating the local stability of the fluid in contrast to the global stability of the predicted ordered phase are considered. Calculations are given for the hard-sphere interaction in one and three dimensions and the global predictions for  $\rho_1(\vec{r})$  and the thermodynamic properties are discussed in terms of the underlying structure of both the exact and the approximate equations. An exact treatment of either theory for an infinite system with no constraints excludes bifurcation. In light of this, the significance of bifurcation in studying phase transitions is discussed.

**19839.** Ausloos, P., Jackson, J. A. A., Lias, S. G., **Reactions of benzyl ions with alkanes, alkenes, and aromatic compounds**, *Int. J. Mass Spectrom. Ion Phys.* **33**, 269-283 (1980).

**Key words:** free radicals; heats of formation; ion cyclotron resonance spectrometer; ion-molecule reactions; ions; rate constants.

Biomolecular chemical reactions of benzyl ions with hydrocarbons and halogenated hydrocarbons have been examined in an ion cyclotron resonance spectrometer. Benzyl ions undergo hydride transfer reactions with linear, branched, and cyclic alkanes. The probability that a collision will lead to reaction is generally low, and is directly dependent on the exothermicity of the reaction. Collision of the benzyl ion with an olefin leads to condensation followed (under the conditions of this study,  $10^{-6}$ – $10^{-5}$  torr) by a dissociation to form a lower olefin. Isotopic labelling experiments demonstrate that extensive rearrangement occurs in the condensation ion prior to dissociation, even when the dissociation regenerates the benzyl ion. Benzyl ions react with alkylbenzenes via "CH<sub>2</sub>-transfer reactions" ( $C_6H_5CH_2^+ + \text{Alkylbenzenes} \rightarrow \text{Alkylbenzyl}^+ + C_6H_6$ ) as well as through hydride transfer reactions involving the side chain; reaction of benzyl ions with halogenated toluenes, however, yields a CH<sub>2</sub>-transfer occasionally at the site of the halogen atom, thereby giving a neutral C<sub>6</sub>H<sub>5</sub>X product.

**19840.** Wolyneć, S., Escalante, E., **Determination of "true" polarization curves for corrosion rate measurements of steel in NaCl stagnant solutions**, *Corrosion-NACE* **36**, No. 7, 327-334 (1980).

**Key words:** carbon steel; chronoamperometry; corrosion rate measurement; polarization.

Determination of corrosion rate for carbon steel in stagnant NaCl solutions was attempted by the linear polarization method, but none of the polarization data obtained by conventional procedures (potentiostatic or potentiodynamic) gave satisfactory results. It was shown that the value of calculated corrosion rate is affected by the direction in which the polarization is undertaken, by the scanning rate for curves determined by potentiodynamic technique, and by the time interval between consecutive steps for curves determined by potentiostatic technique. A new method for obtaining polarization data was derived from chronoamperometric investigations. This method is similar to the potentiostatic one, with two differences: (1) The polarization potential is switched off for some minutes between two consecutive steps so as to allow the corroding system to recover, at least partially, the conditions observed initially, and (2) the current is determined by extrapolating the data of the current decay curves to infinite time. It was observed that in those curves, the current holds an exponential relationship to the inverse of the square root of time. The data generated by this method is in good agreement with weight loss and corrosion potential measurements not only in terms of corrosion rate but also in terms of Tafel slopes.

**19841.** Wise, S. A., Chesler, S. N., Guenther, F. R., Hertz, H. S., Hilpert, L. R., May, W. E., Parris, R. M., **Interlaboratory comparison of determinations of trace level hydrocarbons in mussels**, *Anal. Chem.* **52**, No. 12, 1828-1833 (Oct. 1980).

**Key words:** aliphatic hydrocarbons; aromatic hydrocarbons; gas chromatography; hydrocarbons; interlaboratory comparison; liquid chromatography; mass spectrometry; mussels; polycyclic aromatic hydrocarbons; tissue analyses.

The results of the determination of trace-level hydrocarbons in mussel tissue homogenates from two different sites are compared among eight laboratories. The values for the concentrations of total extractable hydrocarbons, total hydrocarbons in the gas chromatographic elution range, and individual hydrocarbon compounds generally differed by less than a factor of four. Sample inhomogeneity, storage instability over a nine-month period, and analysis uncertainty contributed to an observed intralaboratory precision ( $1\sigma$ ) of  $\pm 40\%$ . The results are discussed with regard to the reliability and comparability of data currently generated in environmental monitoring programs.

**19842.** Waxler, R. M., Feldman, A., **Piezoelectric coefficients of four neodymium-doped laser glasses**, *Appl. Opt.* **19**, No. 15, 2481-2482 (Aug. 1, 1980).

**Key words:** glass; lasers; photoelasticity; piezoelectric; refractive index.

The results of measurements of the piezoelectric coefficients of four new laser glasses, one neodymium-doped phosphate glass and three neodymium-doped fluorophosphate glasses are reported. The measurements were made at 0.6328  $\mu\text{m}$  and 1.15  $\mu\text{m}$ , and, in general, the values are slightly smaller at the longer wavelength. The small values of the coefficients at both wavelengths for certain glasses indicate that these glasses are to be preferred for laser use.

**19843.** Thomson, R., **Theory of chemically assisted fracture. Part 1. General reaction rate theory and thermodynamics**, *J. Mater. Sci.* **15**, 1014-1026 (1980).

**Key words:** environmental fracture; fracture; materials failure; reaction rate theory; slow crack growth; surface energy.

In this first of a two-paper series, we develop a theoretical formulation for chemically assisted fracture in materials. The external environment is assumed to be a diatomic gas, and the chemical attack is at the crack tip. The crack is presumed to be atomically sharp, and the adsorbing chemical species lowers the energy of bond breaking at the crack tip. The formalism is



couched in the language of chemical absolute reaction rate theory, and the results bear a close resemblance to the reaction rate theory of atomic diffusion in solids. Expressions are derived for thermally activated crack growth. The thermodynamic limit is derived, and the connection made to previous macroscopic mechanical treatments. A qualitative discussion is given of more complex forms of fracture chemistry. General conclusions are that atmospherically assisted fracture should be associated with changes in adsorbed surface energy; that details of kinetics will vary widely from one chemical system and material to another; and, that cleavage experiments should be a quantitative tool for surface and interfacial energy measurements. Finally, bridging reactions at the crack tip are shown to lead to possibilities for chemical toughening of the material.

**19844.** Salomone, L. A., *The effect of organization culture on managers, Proc. ASCE Convention and Exposition, Hollywood, FL, Oct. 27-31, 1980*, pp. 1-13 (American Society of Civil Engineers, New York, NY, 1980).

Key words: management theory; managers; organizational development; organization culture; strategic model; theories of behavior.

Systematic examination of management, with few exceptions, is the product of the present century and especially of the past several decades although most students of management would agree that problems of management have existed since the dawn of organized life. Changes in the size, diversity and complexity of projects have reemphasized the need for developing better and more effective techniques in project management. In addition, the unsettled economic environment has reduced the number of new projects, and as a result, has increased the competition in private industry for those projects which are funded. Likewise, in government, similar pressures have been created because of efforts to decrease or hold down government spending.

The management theory which is assisting the National Engineering Laboratory of the National Bureau of Standards in Washington, D.C. and its managers in their search for excellence is presented, and the effect of organization culture on managers is discussed. Using the Managerial Grid developed by Robert R. Blake and Jane S. Mouton, the perceptions of some government employees and corporate managers regarding the soundest organization culture are investigated. Also, results of an experiment in which government employees were asked to rank the alternatives to questions, designed to evaluate organization culture, based on how their organization actually operates are presented.

**19845.** Prialnik, D., Shaviv, G., *The relationship between the envelope composition of a  $6 M_{\odot}$  red-giant model and its future evolution, Astron. Astrophys.* **88**, 127-134 (1980).

Key words: abundances; evolution; planetary nebulae; red giants.

The questions regarding the maximum mass of a main-sequence star that becomes a white-dwarf; the mass of single white dwarfs; the enhanced abundance ratios of N/O and He/H in planetary nebulae and the He<sup>3</sup> abundance in planetaries and in the interstellar medium are shown to be interrelated. We find that a model star of  $6 M_{\odot}$  on the main-sequence develops prior to the double-shell source phase a C—O core of  $0.82 M_{\odot}$  an enrichment of 27% in the He/H ratio and a N/O ratio 5.5 times higher than the solar value. These results indicate that a  $6 M_{\odot}$  star is a plausible planetary-nebula progenitor.

We also show that intermediate mass stars, ejecting most of their mass during the red-giant stage, are important contributors of C and O isotopes and of He<sup>3</sup> to the interstellar medium.

**19846.** Barkigia, K. M., Rajkovic-Blazer, L. M., Pope, M. T., Prince, E., Quicksall, C. O., *Molybdoarsinate heteropoly complexes. Structure of the hydrogen*

*tetramolybdodimethylarsinate(2-) anion by x-ray and neutron diffraction, Inorg. Chem.* **19**, No. 9, 2531-2537 (1980).

Key words: crystal structure; heteropoly complexes; hydrogen bonds; molybdoarsinate; neutron diffraction; x-ray diffraction.

Seven salts of the heteropoly molybdate anions  $R_2AsMo_4O_{15}H^{2-}$  ( $R = CH_3, C_2H_5, C_6H_5$ ) have been synthesized and characterized by spectroscopic measurements. The structure of  $[(CN_3H_6)_2AsMo_4O_{15}H] \cdot H_2O$  ( $P2_1/c$ ,  $a = 8.531$  (2) Å,  $b = 8.527$  (2) Å,  $c = 30.129$  (5) Å,  $\beta = 95.49$  (2)°) has been determined by single-crystal x-ray and neutron diffraction and refined to final consistency indices  $R$  and  $R_w$  of 0.043 and 0.063 for the x-ray data and 0.047 and 0.037 for the neutron data. The anion may be viewed as a ring of face- and edge-shared  $MoO_6$  octahedra capped by the tetrahedral  $(CH_3)_2AsO_2^-$  group. At the base of the anion is an oxygen that is asymmetrically shared by all four Mo atoms ( $Mo-O = 2.360-2.927$  Å). The single anionic proton required by the stoichiometry is located on the basal oxygen, with an O—H bond length of 0.991 (5) Å. The unique hydrogen participates in a hydrogen bond to a water molecule which is 1.779 (5) Å away from the hydrogen.

**19847.** Behrens, J. W., Schrack, R. A., Bowman, C. D., *Nondestructive examination of a defective silver braze using resonance-neutron radiography, Nucl. Technol.* **51**, No. 1, 78-82 (Nov. 1980).

Key words: epithermal neutrons; neutron radiography; non-destructive assay; nondestructive evaluation; position-sensitive proportional counter.

Resonance-neutron radiography is being developed at the National Bureau of Standards (NBS) for use in nondestructive evaluation (NDE) and assay (NDA) applications. To illustrate the method we determined the distribution and thickness of silver between two silver-brazed metal plates. The NBS electron Linac provided a pulsed source of epithermal neutrons. Neutron energy was determined using the time-of-flight technique. Neutrons were detected using a one-dimensional position-sensitive proportional counter containing 4 atm <sup>3</sup>He, 6 atm argon, and 0.5 atm CO<sub>2</sub> and having a spatial resolution of 5 mm. Transmission values, measured over the 5.2-eV resonance in <sup>109</sup>Ag, were used to locate the silver. Simple area analysis of these values yielded the amount of silver that was present.

**19848.** Berman, G. A., *ASTM Committee E-36: Participation in laboratory evaluation and accreditation, Am. Soc. Test. Mater. Stand. News* **8**, No. 12, 8-10 (Dec. 1980).

Key words: evaluation criteria; laboratory accreditation; standards committees.

Laboratory accreditation is widely used for identifying capable testing laboratories. Over 70 formal accreditation systems currently exist in the United States which are sponsored or operated by Federal, State and local governments, trade associations, and professional societies. Some 7000 laboratories are evaluated through these formal systems. It is estimated that up to 8000 private less formal accreditation systems exist which evaluate some 50,000 laboratories to meet contractual requirements of the Department of Defense, National Aeronautics and Space Administration, the Nuclear Regulatory Commission and others.

ASTM Committee E36 on Criteria for the Evaluation of Testing Laboratories and Inspection Agencies was established in 1973 to develop generic standards which could be used by accreditors as a basis for laboratory evaluation. The Committee has prepared a document, E548, "Standard Practice for Use in the Evaluation of Testing and Inspection Agencies" which provides a framework for information disclosure in categories of laboratory organization, management, human and physical resources, operational procedures, and quality assurances prac-



tices. While this standard has done much to provide a basis for information disclosure more work is needed to provide generic information and guidance. To this end the committee is developing criteria for accreditors and accreditation systems.

- 19849.** Blau, P. J., **Use of a two-diagonal measurement method for reducing scatter in Knoop microhardness testing**, *Scr. Metall.* **14**, 719-724 (1980).

Key words: brass; copper; hardness testing; Knoop; microhardness; nondestructive testing.

Knoop indenter microhardness data for Cu and Cu-30 wt%Zn were used to demonstrate the usefulness of a two indentation diagonal measurement method for reducing data scatter. Measuring both major and minor diagonals of the Knoop indentations reduced the variability of the microhardness data more for the large-grained Cu than it did for smaller-grained brass; however, there was a noticeable improvement in numerical reproducibility in both materials. The two-diagonal method may be most useful for cases where large, relatively easy to measure indentations are produced and/or where only a limited sample of material is available and large numbers of microhardness tests cannot easily be performed.

- 19850.** deCandia, F., Russo, R., Vittoria, V., Peterlin, A., **Transport properties of annealed, drawn low-density polyethylene (LDPE)**, *J. Poly. Sci. Polym. Phys. Ed.*, **18**, 2083-2096 (1980).

Key words: annealing; diffusion; drawing; low density polyethylene; sorption.

The specific concentration  $c_a$  of methylene chloride, the zero-concentration diffusion coefficient  $D_0$ , and the concentration coefficient  $\gamma_D$  of the diffusivity in drawn and annealed LDPE were measured. The influence of the drawing rate, of annealing with the ends of the sample free and fixed and the effects of time of standing at room temperature after annealing were investigated. The observed transport properties are in good agreement with the microfibrillar model of fibrous structure, its relaxation during annealing, and the slow crystallization of relaxed tie-molecules upon standing at room temperature.

- 19851.** Cahn, J. W., **Antiphase domain growth in  $\text{Cu}_3\text{Au}$** , *Scr. Metall.* **14**, No. 1, 93-94 (Jan. 1980).

Key words: antiphase domains; copper alloys; diffusion; domain growth; gold alloys; ordered alloys.

Data recently published on domain growth in  $\text{Cu}_3\text{Au}$  fit my published theory better than one the authors try to put forth.

- 19852.** Klose, J. Z., Bridges, J. M., Ott, W. R., **The use of deuterium lamps as radiometric standards between 115 nm and 350 nm, (Extended Abstract)**, (Proc. VI Int. Conf. on Vacuum Ultraviolet Radiation Physics, University of Virginia, Charlottesville, VA, June 2-6, 1980), Paper III-52 in *VUV Lasers, Synchrotron Radiation, Atmospheric & Space, Instrumentation, and Applications III*, 1-3 (U.S. Naval Research Laboratory, Washington, DC, 1980).

Key words: deuterium lamps; radiometry; spectral irradiance; standards; vacuum ultraviolet.

The spectrum of a deuterium lamp has been investigated at wavelengths shorter than 165 nm for use as a radiometric standard. Applications will be discussed.

- 19853.** Egelhoff, W. F., Jr., Tibbetts, G. G., **Photoemission studies of a mixed valent ytterbium aluminum alloy, (Extended Abstract)**, (Proc. VI Int. Conf. on Vacuum Ultraviolet Radiation Physics, University of Virginia, Charlottesville, VA, June 2-6, 1980), Paper I-20 in *VUV Lasers, Synchrotron Radiation, Atmospheric & Space, Instrumentation, and Applications III*, 1-3 (U.S. Naval Research Laboratory, Washington, DC, 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.

- 19854.** Peterlin, A., **Chain folding in lamellar crystals**, *Macromolecules* **13**, No. 4, 777-782 (July-Aug. 1980).

Key words: chain folding in polymers; crystal amorphous complex; lamellar crystallization; lamellar morphology; polymer crystallization.

Small-angle neutron scattering yields a gyration radius and a segment distribution of the linear polyethylene molecule which can be best interpreted by a model based on the original suggestion by Frank and the analysis by Flory of chain folding on the boundary between the crystal core and the amorphous surface layer. In order to provide space for the amorphous chains half the stems in the crystal lattice must be connected by regular loops with adjacent reentry. One third of all the stems must be connected by random loops in order to reproduce the small-angle neutron-scattering data on samples quenched from the melt.

- 19855.** Ellingson, W. A., Berger, H., **Three-dimensional radiographic imaging**, Paper in *Research Techniques in Nondestructive Testing IV*, 1-38 (Academic Press Inc., (London Ltd.), London, England, 1980).

Key words: computerized axial tomography; Fresnel zone; holographic reconstruction; imaging; laminagraphy; nondestructive testing; radiography; three-dimensional radiography; tomography; x-ray laser.

In this chapter, the various three-dimensional imaging methods will be described, with selected examples of NDT applications; also, the limitations of the more developed methods with respect to in-plane and plane-to-plane resolution will be pointed out. Although most of these schemes have been used in a limited way as compared to conventional NDT methods, the availability of new devices, techniques, and knowledge may make any or all of the three-dimensional methods more widely applicable to NDT in the future.

- 19856.** Linsky, J. L., **Stellar chromospheres and coronae**, *Trans. IAU (Report of Commission 36 on Theory of Stellar Atmospheres)*, XVIIA, Pt. 2, 197-203 (1979).

Key words: spectroscopy, ultraviolet; spectroscopy, visible; stars, chromospheres; stars, coronae; stars, emission line; stars, late-type.

Important advances have been made recently in this field due to the development of spectroscopic diagnostics and the growth of ultraviolet and x-ray data from space. These data lead to estimates of physical properties in chromospheres and coronae of individual stars, and to a first generation of models. In some cases crude estimates of radiative losses have been made; these pose tests of theoretical estimates of nonradiative heating rates.

- 19857.** Vreeland, R. G., Levin, B. M., **Psychological aspects of firesetting**, Chapter 3 in *Fires and Human Behaviour*, D. Canter, Ed., pp. 31-46 (John Wiley & Sons Ltd., New York, NY, 1980).

Key words: arson; behavior disorder; fire; firesetters; motives; psychiatry; psychopathic personality; psychopathology.



The purpose of this chapter is to examine some of the psychological factors involved in firesetting and arson. Although arson is a major problem and has been an area of behavioral research for over a century, we still know very little about its etiology and even less about its treatment. This paper summarizes the research literature and discusses: 1) types and motives of firesetters; 2) intellectual and academic performance of firesetters; 3) psychopathology of firesetting; and 4) treatment.

**19858.** Penn, D. R., Mean free paths of very-low-energy electrons: The effects of exchange and correlation, *Phys. Rev. B* **22**, No. 6, 2677-2682 (Sept. 15, 1980).

Key words: exchange and correlation; low energy electrons; mean free path.

The mean free paths of low-energy electrons in a free-electron-like material are calculated using a screened electron-electron interaction which is antisymmetrized for the case of parallel-spin electrons. Calculations are carried out for several different approximations of the screening function: Fermi-Thomas, Lindhard, Singwi, and Kukkonen-Overhauser. The first three yield mean free paths that agree to within 10%, while the Kukkonen-Overhauser screening yields mean free paths that are roughly half those given by the other approximations. The effect of the Pauli principle in all cases is that the scattering between antiparallel-spin electrons is roughly three to ten times stronger than between parallel-spin electrons.

**19859.** Ogburn, F., Ballard, D., Thickness of gold coating measured with a calibrated SEM, *Plating Surf. Finish.* **67**, No. 4, 49-53 (Apr. 1980).

Key words: gold coating cross section; magnification calibration; SEM; thickness measurement; video waveform.

The thickness of gold coatings can be measured in a metallographic cross section by examination with a scanning electron microscope (SEM). The SEM magnification is calibrated with a stage micrometer scale and measurements made on conventional photomicrographs or, for improved accuracy, measurements are made on photos of the SEM video waveform signal. The uncertainty of coating thickness measurements at 10,000 magnification is about 0.06  $\mu\text{m}$  (2.4 microinches).

**19860.** Madey, T. E., The role of steps and defects in electron stimulated desorption: Oxygen on stepped W(110) surfaces, *Surf. Sci.* **94**, 483-506 (1980).

Key words: adsorption; chemisorption; electron stimulated desorption; ion angular distribution; oxygen; stepped surfaces; surface bonding; tungsten.

In order to examine the role of atomic steps and defects on electron stimulated desorption (ESD) phenomena, we have studied the adsorption of oxygen on a polyhedral tungsten crystal containing a W(110) flat and 4 flats having orientations 6° and 10° off the (110) plane with rows of steps parallel to the [100] and [110] directions. Upon adsorption at 300 K, there is little or no ESD O<sup>+</sup> emission from the oxygen-covered (110) plane. In contrast, the stepped surfaces yield intense O<sup>+</sup> emission normal to the terraces and in "downstep" directions, as seen using electron stimulated desorption ion angular distributions (ESDIAD). The presence of atomic steps has a major influence on sticking probability, saturation oxygen coverage and the ESDIAD patterns at all adsorption temperatures in the range 100 K to > 1400 K. Adsorption at low coordination sites appears to be a key factor in producing high ESD ion yields.

**19861.** Lias, S. G., Shold, D. M., Ausloos, P., Proton-transfer reactions involving alkyl ions and alkenes. Rate constants, isomerization processes, and the derivation of thermochemical data, *J. Am. Chem. Soc.* **102**, No. 8, 2540-2548 (Apr. 9, 1980).

Key words: aromatic molecules; benzyl ions; hydride ion transfer; ion cyclotron resonance spectrometer; ion-molecule reactions; rate constant.

Rate constants and mechanisms have been determined for proton transfer reactions of the type  $\text{AH}^+ + \text{M} \rightleftharpoons \text{MH}^+ + \text{A}$ , where A is propylene, isobutene, trans-2-butene, cyclopentene and cyclohexene. In order to avoid competing side effects the  $\text{AH}^+$  reactant ions are generated in alkanes and alkylhalides.

It is observed that the rate constants for exothermic direct proton transfer reactions, from  $\text{AH}^+$  to M or from  $\text{MH}^+$  to A, are equal to the collision rate only when the total rotational, vibrational and electronic entropy change associated with the reaction is positive, and when the exothermicity of the reaction exceeds 2-4 kcal/mole. On the basis of rate constants in the forward and reverse direction for multiple reaction pairs, internally consistent values are obtained for the proton affinities of propylene, isobutene and cyclopentene.

Protonation of tr-2-C<sub>4</sub>H<sub>8</sub> by H<sub>3</sub>O<sup>+</sup> ( $\Delta H_{\text{Rn}} = -10$  kcal/mole) yields sec-C<sub>4</sub>H<sub>9</sub><sup>+</sup> exclusively. However, carbon skeletal rearrangement to the t-C<sub>4</sub>H<sub>9</sub><sup>+</sup> configuration becomes important when the  $\Delta H$  of the proton transfer is < 10 kcal/mole. The experimental evidence indicates that the isomerization occurs before departure of C<sub>4</sub>H<sub>9</sub><sup>+</sup> from the reaction complex. Taking a maximum value  $\Delta H_f(\text{t-C}_4\text{H}_9^+) = 164.2 \pm 1.5$  kcal/mole, the values derived for the heats of formation, in kcal/mole, are: sec-C<sub>4</sub>H<sub>9</sub><sup>+</sup>,  $185.7 \pm 2.1$ ; c-C<sub>5</sub>H<sub>9</sub><sup>+</sup>,  $185.5 \pm 1.9$ ; sec-C<sub>4</sub>H<sub>9</sub><sup>+</sup>,  $178.5 \pm 2.9$ ; c-C<sub>6</sub>H<sub>11</sub><sup>+</sup>,  $171 \pm 3$ ; c-C<sub>5</sub>H<sub>8</sub>CH<sub>3</sub><sup>+</sup>,  $166.3 \pm 1.7$ ; t-C<sub>5</sub>H<sub>11</sub><sup>+</sup>,  $156.7 \pm 2.0$ ; c-C<sub>6</sub>H<sub>10</sub>CH<sub>3</sub><sup>+</sup>,  $154.8 \pm 1.7$ ; t-C<sub>6</sub>H<sub>13</sub><sup>+</sup>,  $150.6 \pm 1.8$  (the last four from an analysis of data from the literature).

**19862.** Kusuda, T., Silberstein, S., McNall, P. E., Jr., Modeling of radon and its daughter concentrations in ventilated spaces, *J. Air Pollut. Control. Assoc.* **30**, No. 11, 1201-1207 (Nov. 1980).

Key words: energy conservation; indoor air quality; radioactivity; radon; ventilation.

In order to predict indoor radiation levels due to radon daughters at low building ventilation and air leakage rates, differential equations governing the decay and venting of radon (Rn-222) and its daughters were used. A computer program based on the equations was written to predict radon and daughter concentrations, total potential alpha energy concentration and equilibrium factor. The program can account for time dependence of ventilation and emanation rates and is readily used by building designers.

Sample calculations using the program showed that potential alpha energy levels in tightened buildings can commonly reach about 0.01 working level (WL), a level more than twice as high as concentrations currently found in most houses.

**19863.** Kuriyama, M., Boettinger, W. J., Burdette, H. E., Basic limits in real-time industrial radiographic systems, (Proc. Symp. on Real-Time Radiologic Imaging, Philadelphia, PA, Sept. 1980), Paper in *Am. Soc. Test. Mater. Spec. Tech. Publ. STP 716*, 113-127 (1980).

Key words: background scattering; collimation; high resolution; image intensifier; image signals; microradiography; monochromatic radiography; real-time radiography; x-ray image magnifier.

Industrial applications of radiography presently demand improvements in resolution when radiographic images are viewed on a real-time basis. Unlike medical applications (radiology), the dosage of incoming X-rays or gamma-rays does not impose serious restrictions in industrial applications. In addition, many advances in the area of computer-assisted intensification of image signals allow us to reexamine the present techniques of radiography from a fresh viewpoint. As a consequence, we may be able to make a major advance in the improvement of resolution in real-time radiography. In this paper, we discuss (1) collimation of primary radiation, including apparent size of



sources, (2) monochromatic radiography to obtain true signals, (3) resolution improvement by a magnification of X-ray images before the radiation reaches the detecting (or viewing) system and, briefly, (4) intensification of signals when crystal collimation is used.

**19864.** Kranbuehl, D. E., Verdier, P. H., Monte Carlo studies of polymer chain dynamics: Lattice dependence, *Polymer Preprints* 21, No. 2, 195-196 (Aug. 1980).

Key words: computer simulation; end-to-end length; entanglement effects; excluded volume effects; lattice-model polymer chains; polymer chain dynamics; random-coil polymer chains; relaxation times; self-entanglement effects.

The effects of excluded volume interactions upon the limiting long-time relaxation behavior of vector end-to-end length have been obtained by direct computer simulation for lattice-model chains on simple cubic, body-centered cubic, and face-centered cubic lattices. Results have been obtained for chains employing single-bead moves, double-bead moves, and a mixture of both types of move. The chain-length dependence of the lengthening of the longest relaxation times by excluded volume appears to be very similar for all three lattices. For models employing only single-bead or only double-bead move rules, the lengthening is proportional to about the 6/5 power of chain length; for models employing a mixture of both types of move, the lengthening is proportional to about the 3/5 power of chain length. At a given chain length, the lengthening of the longest relaxation times by excluded volume decreases with increasing lattice coordination number.

**19865.** Kirkpatrick, D., Horlick, J., Proficiency testing: An essential element of laboratory accreditation, *Am. Soc. Test. Mater. Stand. News* 8, No. 12, 14-17, 48 (Dec. 1980).

Key words: laboratory accreditation; laboratory evaluation; laboratory performance; proficiency testing; thermal insulation.

The National Voluntary Laboratory Accreditation Program (NVLAP) is a laboratory performance evaluation program operated by the Department of Commerce which currently accredits, upon request, laboratories that test thermal insulation materials, carpets, and freshly mixed field concrete. Decisions to accredit laboratories are based on a three part approach to laboratory evaluation which includes questionnaires, on-site examination and proficiency testing. Thus, proficiency testing is an essential element of the NVLAP accreditation process. Although a laboratory may have the facilities, equipment and personnel to meet NVLAP criteria, it is of the utmost importance to the users of a testing laboratory's services that the laboratory consistently provide reliable testing results. The actual ability of a laboratory to produce reliable testing results can only be verified by an analysis of its performance. This analysis is accomplished through proficiency testing.

The first year's proficiency testing program showed that the combination of the laboratories, the test materials, and the standard test methods lead to acceptable, well-behaved statistical results which allowed for the comparison of testing laboratories. It should be noted that due to the limited nature of the testing, the identification of outliers did not necessarily mean that those laboratories would not receive accreditation.

**19866.** Kincaid, J. M., Kayser, R. F., Jr., Kinetic perturbation theory for dilute gases, *Phys. Lett.* 78A, No. 3, 215-216 (Aug. 1980).

Key words: Boltzmann equation; collision integral; dilute gas; kinetic perturbation theory; kinetic theory; nonequilibrium perturbation theory; perturbation theory; soft spheres; transport coefficients.

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 power series in  $\lambda$ .

**19867.** Myklebust, R. L., Newbury, D. E., Small, J. A., Backscatter loss in the x-ray continuum, (Proc. 15th Annual Conf. Microbeam Analysis Society, Reno, NV, Aug. 4-8, 1980), Paper in *Microbeam Analysis—1980*, D. B. Wittry, Ed., pp. 49-50 (San Francisco Press, Inc., CA, 1980).

Key words: backscattered electrons; continuum x-ray loss; electron probe; Monte Carlo method for electron trajectories; particle analysis; quantitative analysis; x-ray continuum.

The continuum x-ray loss due to backscattered electrons,  $R(\text{continuum})$  has been computed for a large number of elements with the NBS Monte Carlo program for predicting electron trajectories in solids. The results compare favorably with other determinations of  $R(\text{continuum})$  appearing in the literature. An empirical expression has been fitted to the  $R(\text{continuum})$  values as a function of atomic number and overvoltage that predicts  $R(\text{continuum})$  with better than 2% accuracy.

**19868.** McCoubrey, A. O., Metric system, Article in *Academic American Encyclopedia* 13, 345-347 (Arete Publ. Co., Inc., Princeton, NJ, Aug. 1980).

Key words: measurements; metric; metrology; SI; standards; units.

The article reviews the historical development of the Metric System of measurements, the basis for its structure and trends for the future.

**19869.** Newbury, D. E., Report on the U.S.-Japan cooperative analysis of glasses by secondary ion mass spectrometry, *Proc. Secondary Ion Mass Spectrometry Seminar, Tokyo, Japan, Oct. 23-27, 1978*, pp. 52-74 (1980).

Key words: glasses; ion microprobe mass analysis; microanalysis; quantitative analysis; secondary ion mass spectrometry; surface analysis.

Measurements of two glasses by secondary ion mass spectrometry (SIMS) have been made by twenty-two laboratories in the United States, Japan, and Europe. Spectral intensities for positive ions normalized to the ion emission for silicon are reported for each laboratory. The normalized secondary ion yields are found to vary by as much as a factor of fifty when the data of all investigators is compared. For a particular type of instrument, the range is reduced to a factor of five. The range in the normalized yields does not arise because of variation in a single parameter such as primary ion energy. The results imply that quantitative analysis schemes in SIMS rely on local measurements of relative sensitivity variations.

**19870.** Overton, R. L., Cassel, D. E., McCabe, M. E., Evaluation of a proposed modification to the f-chart method to include collector array air leakage, *Proc. Winter Annual Meeting Solar Energy Division, American Society of Mechanical Engineers, Chicago, IL, Nov. 16-21, 1980, Paper 80 WA/Sol-12*, pp. 1-10 (American Society of Mechanical Engineers, New York, NY, 1980).

Key words: air leakage; f-chart method; flat-plate solar collectors; solar energy system; TRNSYS computer program.

Field measurements of air leakage reported for a number of residential and commercial solar air heating systems suggests that air leakage occurs in most collector arrays. However, standard analytical techniques to predict solar energy system performance such as the f-chart method do not consider the effects of air leakage on system thermal performance. A proposed method for incorporating collector array leakage consid-



erations into the f-chart method of system evaluation was determined to be effective. Using modified collector parameters accounting for collector array leakage and the FCHART computer program, the annual thermal performance of a solar space heating system in Madison, Wisconsin was compared with detailed TRNSYS computer program results based on explicit modeling of system air leakage. The modified f-chart method produced annual thermal performance predictions that agreed within five percent of the TRNSYS simulation results when air leakage rates were less than 50 percent of the collector design flow rate.

**19871.** Pella, P. A., *The development of potential thin standards for calibration of x-ray fluorescence spectrometry*, Office of Environmental Engineering and Technology Paper EPA-600/7-80-123, 48 pages (Available from the National Technical Information Service, Springfield, VA 22161, 1980).

Key words: calibration standards; focused-ion beam sputtering; thin films; x-ray fluorescence spectrometry.

Thin films containing known concentrations of metals are important for the calibration of x-ray fluorescence spectrometry (XRF), especially for the analysis of collected airborne particulate matter. A focused ion-beam sputtering technique has been investigated as a candidate method for fabricating thin glass films containing known concentrations of metals on polycarbonate substrates. Glass targets were fabricated at NBS for these studies, and parameters such as ion-acceleration voltage and ion-current were systematically varied to determine any changes in film composition. It was found that rather severe changes in instrumental parameters do not affect the elemental composition of the films appreciably. Up to eight substrates were coated at one time and the compositional reproducibility as measured by XRF for Si, Ca, Zn, and Pb for 13 samples was within 5% relative standard deviation at mass loadings of glass from 160-190 mg/cm<sup>2</sup>. Glass films containing phosphorous and sulfur were also prepared to demonstrate the feasibility of preparing glass films containing such elements of low atomic number. Additional studies consisted of the deposition of finely ground synthetic glasses on membrane filters, and the characterization of some selected commercial thin films prepared by thermal evaporation.

**19872.** Reinhold, T. A., Sparks, P. R., *The influence of wind direction on the response of a square-section tall building*, *Proc. Fifth Int. Conf. on Wind Engineering*, Ft. Collins, CO, July 8-14, 1979, I, Sessions I-V, VI-3-1—VI-3-14 (Pergamon Press, Elmsford, NY, 1980).

Key words: aerodynamics; boundary layers; dynamic response; influence of wind-direction; tall buildings; wind loads; wind tunnels.

This paper describes a wind-tunnel study to determine the effect of wind-direction on the response of a square-section tall building with an 8.33 to 1 aspect ratio. Rigid models instrumented with pressure transducers were used to determine the modal forces for the fundamental translational and torsional modes of the building. Using these forces and typical stiffness and damping values, the influence of wind-direction on the response of a 500:1 scale prototype building was estimated. The maximum response was generally found to occur when the wind was blowing onto a face of the building. Comparisons are made between predicted response levels of the prototype building, based on experimental results on the one hand, and on current design procedures on the other hand.

**19873.** Rubin, R. J., *Energy flow and thermal conductivity in one-dimensional, harmonic, isotopically disordered crystals*, Chapter 7 in *Perspectives in Statistical Physics*, H. J. Raveche, Ed., pp. 112-122 (North-Holland Publ. Co., Amsterdam, The Netherlands, Nov. 1980).

Key words: energy current; isotopic disorder; nonequilibrium; one-dimensional harmonic crystal; random matrix products; steady state; thermal conductivity.

Rubin and Greer established that as the number of defect particles increases, the thermal conductivity increases at least as fast as  $N^{1/2}$ . Subsequently, Verheggen established that the limiting dependence is exactly  $N^{1/2}$ . It appears from the Monte Carlo calculations plotted in fig. 2 for the fixed boundary model that the thermal conductivity decreases with increasing  $N$  for  $N > 800$ . However, no well-defined power law dependence on  $N$  is evident in the range  $800 < N < 3200$ —it is definitely not  $N^{-1/2}$ .

A number of interesting questions meriting further work are raised by the results reported here: (1) If, in the fixed boundary model, the limiting power-law dependence is  $N^{-1/2}$ , why is the approach to the limiting law so slow? (2) If a second fixed-boundary spring is added at the other end of the disordered section of particles, is there a significant change in behavior? (3) What is the limiting power-law dependence in the one and two fixed boundary models?

**19874.** Ruff, A. W., *Debris analysis of erosive and abrasive wear*, *Proc. Int. Conf. on the Fundamentals of Tribology*, Massachusetts Institute of Technology, Cambridge, MA, June 19-22, 1978, pp. 877-885 (1980).

Key words: abrasive particles; electron microscopy; erosive wear; impact; steel; wear; wear debris.

Debris particles have been recovered from dry abrasion and erosion studies of AISI 1015 steel specimens. The size and morphology of the debris particles have been related to the worn surface topography. In both cases it appears that the principal wear mechanism involves removal of plastically deformed, exposed material from the lips of impact craters (erosion) or surface grooves (abrasion). Theoretical models that consider cutting processes on flat surfaces do not appear to properly consider the steady state morphology actually involved. The advantage of obtaining information from studies of both worn surfaces and debris particulates has been demonstrated.

**19875.** Tipson, R. S., Parker, F. S., *Infrared spectroscopy*, Chapter V in *The Carbohydrates: Chemistry and Biochemistry*, 2d Edition, W. Pigman and D. Horton, Eds., 1B, 1394-1436 (Academic Press Inc., New York, NY, 1980).

Key words: attenuated total reflection; determination of structure of carbohydrates; infrared spectra of carbohydrates; interpretation of infrared spectra; plane-polarized radiation; Raman spectra.

A survey has been made of the literature on the infrared spectroscopy of carbohydrates, in which all of the important work in this field has been collected and systematized. This was needed because previous articles in the literature were either out of date or not sufficiently comprehensive, and certain statements that had been made were subject to misinterpretation. The present article discusses principles and instrumentation, sampling techniques, comparison of samples, interpretation of spectra, functional groups of carbohydrates and their derivatives, correlations for the fingerprint region and beyond, and conformational studies. In addition, examples are discussed of the use of infrared spectra for quantitative and qualitative purposes and in the determination of structure. Special techniques are briefly described, including use of plane-polarized radiation, the technique of attenuated total reflection, and Raman spectra.

**19876.** Ott, W. R., Bridges, J. M., Klose, J. Z., *The use of gas discharges as ultraviolet radiometric standards*, *Proc. Int. Conf. on Phenomena in Ionized Gases*, Grenoble, France, July 9-13, 1979, *J. Phys.* 40, Suppl. 7, C7-803—C7-804 (July 1979).



Key words: arc; calibrations; irradiance; radiance; sources; ultraviolet.

19877. Koukhar, V. A., Maksimov, A. A., Berger, H., A comparison of NDT standards in the US and USSR, *Proc. Ninth World Conf. on Non-Destructive Testing, Melbourne, Australia, Nov. 18-23, 1979*, 6-3, 9 pages (1979).

Key words: calibration; image quality indicator; nondestructive testing; radiography; sensitivity; standards; ultrasonics.

An initial comparison and analysis is given for several radiographic and ultrasonic standards of the US (ASTM) and the USSR (GOST). This study is part of a joint US/USSR project on automated information systems in standardization. Differences between standards are pointed out.

19878. Bertocci, U., Detection and analysis of electrochemical noise for corrosion studies, *Proc. 7th Int. Conf. on Metallic Corrosion, Rio de Janeiro, Brazil, Oct. 4-11, 1978*, pp. 2010-2020 (ABRACO, Rio de Janeiro, Brazil, 1979).

Key words: aluminum; corrosion; electrochemical noise; instrumentation; iron; nickel; potentiostat.

This paper describes the work done at NBS for the study of the fluctuations in current and potential of electrochemical systems, commonly referred to as electrochemical noise.

In order to keep unwanted noise caused by the testing circuit to a minimum, a battery-operated potentiostat was developed, with a special amplifier for the detection of the current fluctuations. The results of the testing of such an instrument show that the instability of the control voltage generates a signal of the order of  $5 \cdot 10^{-8} \text{ V}/\sqrt{\text{Hz}}$ , while the amplifying system contributes a noise current of  $3 \cdot 10^{-11} \text{ A}/\sqrt{\text{Hz}}$ .

Two different experimental arrangements are described. With one of them, noise lower than that generated by the instrumentation can be measured.

A number of electrochemical reactions was investigated, such as the electrodeposition of nickel. In this case, the noise detected apparently was related to the charge-transfer process.

Two systems of interest to corrosion science have been investigated, iron and aluminum, both in neutral solution. It is shown that anodic polarization above the pitting potential increases the noise generated by a Fe electrode. In the case of Al, addition of small amounts of chlorides was found to enhance the noise current by two orders of magnitude.

19879. Berger, H., National and international standards for NDT: To achieve improved repeatability and measures related to performance, *Proc. Ninth World Conf. on Non-Destructive Testing, Melbourne, Australia, Nov. 18-23, 1979*, 6-3, 12 pages (1979).

Key words: calibration; international; nondestructive testing; radiography; standards and ultrasonics.

Nondestructive testing (NDT) standards provide a practical procedure to bring some measure of reproducibility to NDT measurements. Nevertheless, better standards are needed both to improve reproducibility and to provide quantitative data for performance-related analyses.

19880. Gadzuk, J. W., Metiu, H., Aspects of reaction dynamics at metal surfaces, (Proc. Fourth Int. Conf. on Solid Surfaces and the Third European Conf. on Surface Science, Cannes, France, Sept. 22-26, 1980), Supplement a la Revue, *Le Vide, les Couches Minces*, No. 201, II, 168-171 (1980).

Key words: molecular processes; reaction dynamics; surface reactions.

Key features are presented of a theory of chemical reaction dynamics at metal surfaces which include: i) diabatic electronic transitions between internal states of an incident beam of atoms or molecules; ii) irreversibility and dissipation through substrate

electron-hole pair excitation, iii) quantum modifications to classical trajectories via appropriate Franck-Condon factors.

19881. Schwarz, F. P., Measurement of the solubilities of slightly soluble organic liquids in water by elution chromatography, *Anal. Chem.* 52, 10-15 (1980).

Key words: elution chromatography; liquid chromatography; organic solution.

A simple method based on liquid phase elution chromatography is presented for determining the solubilities of organic liquids in water. An inert solid support in a transparent tube is coated with the organic liquid. As this solute is eluted with water, a solute depleted zone develops which is different in color than that of the remainder of the support. Measurement of the rate of progress of the boundary of this zone, the flow rate of water, and the mass of solute coated on the support are sufficient to determine the solubility. The method has been tested by measuring the solubilities of benzene, cyclohexene, cyclohexane, 2-heptene, toluene, iodopropane, *m*-dichlorobenzene, 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, and dibutylphthalate in water at  $23.5 \pm 1.5^\circ \text{C}$ . These solubility measurements cover a range from 0.296 wt % (1,1,2,2-tetrachloroethane) to 0.00150 wt % (2-heptene) with an accuracy independent of the solubility of the solute.

19882. Bur, A. J., Impregnation and void filling of porous polymer tapes with dielectric oil, (Proc. Conf. on Electrical Insulation and Dielectric Phenomena, Pocono-Hershey, White Haven, PA, Oct. 21-25, 1979), *Proc. 1979 Annual Report*, S. A. Boggs, C. M. Cooke, R. J. Densley, E. Sacher, and J. E. West, Eds., pp. 382-388 (Washington Academy of Sciences, Washington, DC, 1979).

Key words: buoyant force; dielectric insulation; oil permeation; porous polymers; specific volume; void filling; void volume.

Porous polymer tapes are viewed as alternatives to paper tape presently used in the tape-oil insulation system of high-voltage transmission cables. We have recently completed a study which defines the physical property criteria for porous polymer tapes and describes the experimental tests for measuring these properties. One of these tests, the degree of void filling test, was developed in our laboratory for the purpose of measuring the amount of void volume in a tape specimen which remains unfilled by the dielectric oil.

19883. Cunningham, W. C., Etz, E. S., Zoller, W. H., Raman microprobe characterization of South Pole aerosol, (Proc. 14th Annual Conf. of the Microbeam Analysis Society, San Antonio, TX, Aug. 13-17, 1979), Paper in *Microbeam Analysis—1979*, D. E. Newbury, Ed., pp. 148-154 (San Francisco Press, Inc., San Francisco, CA, 1979).

Key words: airborne particles; atmospheric aerosol; atmospheric sulfate environmental pollution; microsampling; molecular microanalysis; particle microanalysis; Raman microprobe; Raman spectra; Raman spectroscopy; South Pole atmosphere.

The NBS laser-Raman microprobe has been applied to the study of the major molecular species present in particulate matter from the South Pole atmosphere. Aerosol samples were collected by ground-based equipment for characterization by optical microscopy, SEM/x-ray microanalysis and micro-Raman spectroscopy. Most of the aerosol is of submicrometer size and shows high concentrations of sulfur. Raman microprobe measurements were made on individual particles ( $> 1 \mu\text{m}$ ) and on microscopic regions (6-20  $\mu\text{m}$  diameter spots) of dense aerosol collections. The Raman spectra of these samples show various crystalline sulfates as dominant constituents, with ammonium sulfate as the major pure component. Other sulfates appear to have a more complex composition. Chemical reactivity of the



aerosol is indicated by its interaction with lithium fluoride substrates used in the impactor-collection of these samples. It is inferred from the spectroscopic results that some fraction of the aerosol also existed in the form of sulfuric acid at the time of sampling. These results are the first direct indication of acid sulfate species in the Antarctic atmospheric aerosol and support the indirect identifications of these compounds made by other workers.

**19884.** Molino, B. B., **Special features of NBS's Omnidata system applicable to the retrieval, analysis, and dissemination of chemical data**, (Division of Chemical Information Symp. on Techniques and Problems in Retrieval of Numerical Data, 178th National Meeting, American Chemical Society, Washington, DC, Sept. 12, 1979), *J. Chem. Inf. Comput. Sci.* **20**, 136-138 (Aug. 1980).

Key words: computer programs; data analysis; data base management; data retrieval; information retrieval; MIS; on-line retrieval.

Omnidata is an interactive, general-purpose system for data retrieval, data analysis, and file maintenance, developed at NBS. The system allows individuals with little background in computers to search and analyze data files and prepare reports. In addition to the "typical" searching, reporting, sorting, and updating, there are roughly 30 modules providing statistical and graphical analysis, data manipulation, and file management. Many are specifically designed and have unique features to aid the chemist in the retrieval, analysis, and dissemination of data. Some of these are discussed and illustrated on files of chemical data.

**19885.** Berger, H., **Nondestructive testing of railroad rail**, *Transportation Res. Record* **744**, 22-26 (1980).

Key words: coupling; magnetic inspection; nondestructive testing; pulsed mode; rail test car; railroad rail; sensitivity; ultrasonic inspection.

Techniques of nondestructive testing (NDT) of railroad rail in service are reviewed with the aim of assessing the state of the art and future needs. The contributions to the industry of the primary NDT methods—ultrasonic and magnetic inspection—are noted, and their limitations are examined. The limitations of ultrasonic inspection include ensuring the coupling of the ultrasonic signal into and out of the rail, setting the sensitivity level of the inspection system reproducibly, and relating the amplitude of the return ultrasonic signal to the size of the defect. Magnetic inspection is generally limited to the railhead. The two systems used together provide the most reliable inspection, the magnetic system providing special assistance with defects located near the edges of the railhead. Recommendations for improving rail NDT include greater use of these two complementary systems (now available on only about 50 percent of U.S. rail test cars), greater attention to operator training and characteristics and to the inspection of new rail before installation, and changes in government regulations that will lead to more effective use of rail test cars. In addition, research is needed to relate defect growth to rail service conditions so that realistic decisions can be made about leaving defective rail in use. Developments leading to improved technology are also discussed.

**19886.** Bernstein, B., Kearsley, E. A., **A theory of the effects of pressure on finite elastic shear**, (Proc. VIII Int. Congress on Rheology, Naples, Italy, Sept. 1-5, 1980), Paper in *Rheology*, G. Astarita, G. Marrucci, and L. Nicolais, Eds., **1**, 305-311 (Plenum Publ. Corp., New York, NY, 1980).

Key words: bulk modulus; compressibility; finite elasticity; modulus; rubber; shear.

Often the theory of finite deformations of an elastic medium is used with the added restriction of incompressibility of the

medium. This restriction makes possible the solution of several classes of problems in terms of an unspecified strain-energy potential, however, it excludes the possibility that the elastic material properties depend on pressure. In this paper, a general theory of materials whose mechanical properties depend on pressure will be derived from the unrestricted theory and the condition for incompressibility of the medium will be added as an approximation.

**19887.** Broadhurst, M. G., Edelman, S., Davis, G. T., **Piezoelectric and pyroelectric applications of plastics**, (Proc. Division of Organic Coatings and Plastics Chemistry, American Chemical Society 179th National Meeting, Houston, TX, Mar. 23-28, 1980), Paper in *Organic Coatings and Plastics Chemistry* **42**, 241-245 (American Chemical Society, Washington, DC, 1980).

Key words: applications; piezoelectric; polymers; pyroelectric transducer.

Synthetic polymeric materials can have large and durable electric dipole polarization. This polarization varies linearly with small applied stresses such as electric fields, mechanical stress and temperature change, and this sensitivity renders them useful as piezoelectric and pyroelectric transducers. That is, they can be used to provide an analog electrical signal to monitor mechanical and thermal signals, and inversely, can provide mechanical motion and changes in heat content in response to applied electric fields.

**19888.** Tilford, C. R., Wood, S. D., Lundquist, A. J., **Survey of altimeter calibration accuracy**, (Proc. 1980 Air Data Systems Conf., U.S. Air Force Academy, Colorado Springs, CO, May 5-8, 1980), *SRDS Tech. Letter Report No. RD-80-6-LR*, 6 pages (U.S. Department of Transportation, Federal Aviation Administration, Systems Research & Development Service, Washington, DC 20590, May 8, 1980).

Key words: altimetry; altimetry accuracy; aviation safety; pressure measurement; pressure transducers.

Limited data exist from which to determine what altimeter accuracies are actually achieved in field use. In order to acquire some information about altimeter accuracy and, in particular, to evaluate whether or not adequate pressure measurement accuracy is available to the aviation community, a limited measurement survey of altimeter repair and calibration shops has been performed.

A commercial transfer-standard quality pressure transducer was modified for field use. It was repeatedly calibrated in the field using a portable calibration unit. This equipment and calibration procedures were able to maintain an uncertainty of .001" Hg + .01% of reading for the transfer standard. Several instrument repair shops were then asked to calibrate the transfer standard in the same manner they would an altimeter. The results of these comparisons and the details and performance of the equipment used are discussed.

**19889.** Wood, S. D., Tilford, C. R., **Survey report—altimeter setting indicators**, (Proc. 1980 Air Data Systems Conf., U.S. Air Force Academy, Colorado Springs, CO, May 5-8, 1980), *SRDS Tech. Letter Report No. RD-80-6-LR*, 17 pages (U.S. Department of Transportation, Federal Aviation Administration, Systems Research & Development Service, Washington, DC 20590, May 8, 1980).

Key words: altimeter setting indicator; aviation instrumentation; aviation safety; barometry; pressure.

The accurate altimetry required for landing approaches and terrain avoidance necessitates that reliable altimeter settings be available to compensate for changes in the local barometric pressure. The procedures and equipment used to provide altimeter settings and maintain their accuracy vary widely. In order to determine the accuracy actually found in the field a limited



survey of altimeter setting indicators and some associated equipment was conducted at several locations. The results of that survey are presented.

**19890.** Menis, O., Mackey, J. A., Garn, P. D., **A study of particulates of environmental interest by differential thermal analysis**, *Proc. Thermal Analysis Symp., Rappersville, Switzerland, Apr. 18-30, 1979*, pp. 321-332 (1979).

Key words: alpha-quartz particulate; chrysotile asbestos particulate; differential thermal analysis; environmental particulates; thermal analytical methods.

In this presentation we describe our current progress using thermoanalytical methods to study particulates of interest in environmental problems. The topics included are: (1) differential thermal analysis (DTA) of current NBS Standard Reference Material (SRM) 1645, River Sediment and NBS SRM 1648, Urban Particulate Matter; (2) studies of a suitable crystalline silica ( $\alpha$ -quartz and cristobalite) as a potential SRM; (3) preparation of mixtures of chrysotile asbestos and quartz in a suitable matrix, and (4) a modified DTA apparatus including a design of a DTA cell for rapid sample changing and operation under regulated steam pressure.

**19891.** Boettinger, W. J., Biancaniello, F. S., Kalonji, G. M., Cahn, J. W., **Eutectic solidification and the formation of metallic glasses**, *Proc. Second Int. Conf. on Rapid Solidification Processing: Principles and Technologies, Reston, VA, Mar. 23-26, 1980*, 6 pages (Claitor's Publ. Div., Baton Rouge, LA, 1980).

Key words: amorphous alloys; coupled growth; eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification.

The relationship between eutectic solidification and the ease of formation of metallic glasses is investigated. For many systems, crystallization, including partitionless crystallization, of alloys into a single phase solid is impossible over a wide range of composition near stable or metastable eutectics. This fact forces alloys to crystallize into two-phase solids. Because of the need for diffusional sorting of the components and creation of solid-solid surfaces, the kinetics of eutectic crystallization are relatively slow and may be closely related to the ease of glass formation of these alloys.

Experiments are reported on the directional solidification of Pd-6 at % Cu-17 at % Si alloys which show the evolution of microstructure as a function of interface velocity. A structure of dendrites and interdendritic eutectic at low velocity ( $\leq 0.25$  mm/s) becomes a fine eutectic-like structure at intermediate velocities ( $\sim 1$  mm/s) and finally the alloy forms glass when crystallization is attempted at velocities greater than 2.5 mm/s.

**19892.** Interrante, C. G., **Needed: A fracture mechanics vocabulary**, *Am. Soc. Test. Mater. Stand. News* 7, No. 4, 22-24 (1979).

Key words: definitions; fracture testing; nomenclature; symbols; terminology; terms.

Words, after all, are the single most important tool for ASTM activities, and the importance of precisely defined and clearly understood technical terminology cannot be overrated. In this article, the chairman of E-24's terminology subcommittee details the group's history, present activities, and future plans; lingering over some of the more interesting battles that have developed in fracture mechanics terminology.

**19893.** Rabolt, J. F., Block, S., Piermarini, G. J., **The characterization of polymers under high pressure using Raman spectroscopy**, (Proc. Sixth AIRAPT Conf., University of Colorado, Boulder, CO, July 25-29, 1977), Paper in *High-Pressure Science and Technology, Vol. 1, Physical Properties and Material Synthesis*, K. D. Timmerhaus and M. S. Barber, Eds., pp. 478-481 (Plenum Press, New York, NY, 1979).

Key words: diamond anvil cell; high pressure physics; perfluoro n-alkanes; phase transition; polytetrafluoroethylene; Raman spectroscopy.

The high pressure phase of  $nC_{20}F_{42}$ , polytetrafluoroethylene (PTFE) and a random copolymer of tetrafluoroethylene and hexafluoropropylene (TFE-HFP) has been investigated using Raman spectroscopy. All of these materials transform to the planar zig zag form (as evidenced by the appearance of the  $625\text{ cm}^{-1}$  band) in the 7-9 Kbar range. It was observed that the peak intensity ratio (PIR) of the  $285$  to  $395\text{ cm}^{-1}$  bands, taken as a qualitative measure of pressure induced deformation, increased significantly in PTFE in the 15-30 Kbar range. This behavior of the PIR with pressure was markedly different from that observed in  $nC_{20}F_{42}$  and the TFE-HFP copolymer. This variation in PIR in PTFE has been correlated with a change in sample crystallinity. Morphological differences between the three materials studied suggest that the deformation mechanism at high pressures which results in an increase in PTFE crystallinity could be one of pressure induced nucleation or pressure driven crystal thickening.

**19894.** Hastings, J. R., Sengers, J. M. H. L., Balfour, F. W., **The critical-region equation of state of ethene and the effect of small impurities**, *J. Chem. Thermodyn.* 12, No. 11, 1009-1045 (Nov. 1980).

Key words: Burnett method; coexistence curve; critical exponents; critical isochore; critical parameters; equation of state; ethylene; impurities; isochores; scaling laws.

Accurate measurements are reported of the equation of state of ethene on 16 isochores within  $\pm 40$  per cent of the critical density and at temperatures from 220 to 303 K. Two samples, one of 99.993 and one of 99.999 moles per cent  $C_2H_4$ , have been used. The principal source of experimental error is found to be impurity. A model for predicting the effect of known small impurities is developed and used to explain qualitatively the observed differences between the results for our two samples as well as those between our own and other recently-reported accurate measurements. A scaled fundamental equation, incorporating Ising-like asymptotic behavior, revisions of and corrections to scaling, has been fitted to the results for the 99.993 moles per cent pure sample. The equation, with nine adjustable parameters, represents the measured values to within an estimated uncertainty of  $5 \times 10^{-4}$  K in temperature,  $5 \times 10^{-5}$  MPa in pressure, and  $0.003\text{ mol dm}^{-3}$  in amount-of-substance density. The critical-point parameters resulting from the fit are presented. Comparisons are made with two other sets of measurements recently published. The agreement is generally satisfactory.

**19895.** Rabolt, J. F., Fanconi, B., **Longitudinal acoustic mode in helical polymers: Poly(oxyethylene) and isotactic polypropylene**, *Polymer Lett.* 15, 121-127 (1977).

Key words: longitudinal acoustic mode; polyoxyethylene; polypropylene; Raman spectroscopy; Young's modulus.

A longitudinal acoustic mode (LAM) characteristic of polymer crystalline lamellae has been observed in the low frequency Raman spectra of melt crystallized polyoxyethylene and isotactic polypropylene. The shift in peak frequency of the LAM is correlated with an increase in lamella thickness resulting from annealing. Assuming the applicability of the uniform elastic rod model to helical polymers, values of the elastic modulus are derived and found to be much larger than those obtained from x-ray measurements. The possible origins of this discrepancy are discussed.

**19896.** Polvani, R. S., Christ, B. W., **Microcreep of instrument grade beryllium**, *SAMPE Quart.* 10, No. 4, 37-41 (July 1979).

Key words: beryllium; creep; dimensional instability; inertial guidance; microcreep; optical mirrors.



Inertial guidance system gyroscopes and optical mirrors are designed to be dimensionally stable to better than 1 microinch over long times. New gyroscope designs require still better stability, 0.01 microinch. Uniaxial microcreep experiments at elevated temperature show instrument grade beryllium deforms in excess of both design limitations. However, a microstrain hardening process was observed that seems a possibility for improving microcreep strength. Performing these experiments required development of a test system with better than 0.1 microinch resolution, less than 0.01 microinch thermal noise in the signal at 144 °F, and typically, sample misalignment of about  $10^{-5}$  radians.

- 19897.** Choi, C. S., Prask, H. J., Prince, E., **Phase transitions in ammonium nitrate**, *J. Appl. Cryst.* **13**, 403-409 (1980).

Key words: ammonium nitrate; crystal structure; hydrogen bonding; neutron diffraction; phase transitions; x-ray diffraction.

The phases of ammonium nitrate,  $\text{NH}_4\text{NO}_3$ , doped with small amounts of NiO or CuO have been studied by x-ray and neutron diffraction at various temperatures from 80 to 423 K.  $\text{NH}_4\text{NO}_3$  with metal-oxide additives, which are believed to form complexes, exists as a solid solution. Phase IV is stable down to 140 K in the NiO-doped samples and 210 K in the CuO-doped sample. The thermal expansion of this phase is extremely anisotropic, with the *b* axis expanding rapidly with increasing temperature while the *a* axis contracts slightly. At higher temperatures the doped samples transform directly from phase IV to phase II, bypassing phase III, starting at about 328 K. The structure of phase II, which is disordered, was refined in the space group  $P4/mbm$ . The structure of phase III contains hydrogen-bonded chains parallel to the *b* axis.

- 19898.** Deslattes, R. D., **The Avogadro constant**, *Ann. Rev. Phys. Chem.* **31**, 435-461 (1980).

Key words: atomic masses; fundamental constants; mole; precision measurement.

This review of the Avogadro Constant is prepared in response to an invitation from the Editor of the Annual Reviews of Physical Chemistry. It attempts to deal with some aspects of the history in this field of certain conceptual problems and the present state of experimental measurement.

- 19899.** Cohen, A., Hertz, H. S., Schaffer, R., Sniegowski, L. T., Sun, T., White, E., **The accurate determination of cholesterol in serum by isotope dilution gas chromatography/mass spectrometry**, (Extended Abstract), *Proc. 26th Conf. on Mass Spectrometry and Applied Optics*, St. Louis, MO, May 28-June 2, 1978, pp. 298-300 (American Society for Mass Spectrometry, Bethesda, MD, 1978).

Key words: cholesterol; gas chromatography/mass spectrometry; isotope dilution; serum.

A method for the accurate measurement of total cholesterol in serum has been developed to give values against which the accuracy of clinically appropriate reference methods can be judged. Labelled cholesterol (25,26,26,27,27,27- $\text{d}_7$ ) was added to serum and the mixture subjected to alkaline hydrolysis. Cholesterol was isolated by extraction and converted to the TMS ether. An observed ratio of labelled to unlabelled cholesterol was obtained for each sample by summing over the GC peak the signal generated by selected ion monitoring (SIM) of the molecular ions utilizing magnetic beam switching coupled with continuous viewing of the *m/e* peaks. The observed ratio for each sample was converted to a weight ratio by linear interpolation between standard mixtures which bracketed each sample in both time and in ratio. The eight measurements obtained on five different serum pools (1.3 to 3.4 mg cholesterol per ml serum) had an overall relative standard deviation of 0.33%.

**19900.** Unassigned.

- 19901.** Peterlin, A., **Molecular model of fracture of fibrous polymeric material**, (Proc. 4th Int. Conf. on Fracture, Waterloo, Canada, June 19-24, 1977), *Fracture* **1**, No. ICF4, 471-485 (1977).

Key words: crystalline polymer; elastic modulus; fibrils; fibrous structure; fracture; load-elongation curve; microfibrils; point defects of microfibrillar structure; ruptured chains; strength; tie molecules.

The fibrillar model of fibrous structure assumes a dense packing of long and narrow microfibrils into spindle shaped slightly skewed fibrils. The ends of microfibrils located mainly on the outer boundary of the fibrils represent an interruption of the massive axial connection by taut tie molecules. They are prime candidates for microcrack formation upon tensile loading which deforms the sample by shear displacement of adjacent fibrils and microfibrils. The axial and radial growth of microcracks ruptures the tie molecules in its path. The sample fails as soon as one of cracks reaches critical dimensions. The rest of the sample in a new loading run exhibits a lower load-elongation curve but practically the same or even higher strength because the reopening of old microcracks is easier than their initial formation while the growth of microcracks beyond the limits of the first run requires an increased load.

- 19902.** Madey, T. E., Goodman, D. W., Fisher, G. B., Yates, J. T., Jr., **Structure and kinetics of surface species**, *Proc. Fourth Symp. on Fluid/Solid Surface Interactions*, National Bureau of Standards, Gaithersburg, MD, Oct. 18-20, 1978, pp. 239-243 (Commanding Officer, Naval Research Laboratory, Code 6170, Washington, DC 20375, 1980).

Key words: catalysis; catalytic methanation; electron stimulated desorption; surface kinetics; surface structure.

The ONR-supported research in the Surface Science Division at the National Bureau of Standards has been concentrated in two areas: (a) the characterization of the structure of adsorbed species using the Electron Stimulated Desorption Ion Angular Distribution (ESDIAD) method, and (b) kinetic and spectroscopic studies of surface species, with particular emphasis on molecular species of catalytic interest. Examples from each of these efforts will be discussed.

- 19903.** Peterlin, A., **Mechanical properties of fibrous structure**, (Proc. Mechanical Structure Ultrahigh Modulus Polymers Symp., Santa Margherita Ligure, Italy, May 23-27, 1977), Chapter 10 in *Ultra-High Modulus Polymers*, A. Ciferri and I. M. Ward, Eds., pp. 279-320 (Applied Science Publ. Ltd., Essex, England, 1979).

Key words: annealing; crystallization; elastic modulus; fibrils; fibrous structure; microfibrils; superdrawing; Taut tie molecules.

The drawing of a more or less isotropic semicrystalline polymer solid usually produces a fibrous material with high anisotropy of physical properties, e.g., elastic modulus *E*, strength ( $\sigma_y$  = stress-to-*y*ield,  $\sigma_b$  = stress-to-*b*reak,  $\epsilon_b$  = strain-to-*b*reak), diffusivity (diffusion coefficient). This anisotropy is closely connected with the orientation of chains in crystalline and amorphous regions and with the direction in which the two regions alternate. The former effect shows up in wide-angle x-ray scattering (WAXS) and infrared dichroism, the latter in small-angle x-ray scattering (SAXS). At small draw ratios already, the chains in the crystal lattice are almost completely oriented in the draw (or fibre or axial) direction. The orientation only slightly increases with further drawing. In amorphous regions, the chain orientation is much less perfect but increases steadily over the whole range. The crystalline regions, separated by amorphous layers, are oriented more or less perpendicular to the fibre direction. It is worth while to mention that the long



period  $L$  of the crystalline-amorphous alternation is a unique function of the temperature of drawing with a slight influence of drawing rate, but completely independent of the long period of the isotropic starting material.

**19904.** Peterlin, A., *Crystallization phenomena*, (Proc. Symp. on Flow-Induced Crystallization, Midland Macromolecular Institute, Midland, MI, Aug. 22-26, 1977), *Int. J. Polym. Mater.* **7**, 1-28 (1979).

Key words: crystallization temperature; melting temperature; row nucleation; stirred solution; strained melt.

The minimum requirement of the free enthalpy increase for the formation of any type of critical size nucleus determines the probability for the nucleation from supercooled melt or solution and for the subsequent crystal growth. The minimum demand decreases as the inverse square of the supercooling. This yields a rapid increase of the nucleation and growth rate with decreasing temperature. On the other hand, the viscous resistance of the melt or solution to the chain transfer from the liquid to the crystalline phase increases with the temperature approaching that of the glass transition. Both effects together yield a maximum of the nucleation and growth rates at a finite supercooling with a subsequent drastic drop at a higher supercooling. The extension and alignment of the polymer chains in the liquid by applied mechanical forces lowers the entropy and to some extent also the enthalpy of the liquid state, thus raising the equilibrium melting temperature of the system and increasing the effective supercooling. As a consequence the rate of nucleation and crystal growth is drastically increased. Moreover, the shape of the primary nuclei becomes substantially linear with orientation in the main strain direction. Since these linear elements carry most of the applied load or stress, the rest of the liquid can relax to such an extent that by epitaxial overgrowth the macromolecules are able to be deposited in more or less conventional lamellae perpendicular to the stress. This yields the shish-kebab structure in the stirred or sonicated solutions and the cylindritic structure in hard elastomers solidified from the extruded melt.

**19905.** Berger, P. W., Tucker, J. C., *Standards and guidelines for data*, Chapter 8 in *Data Handling for Science and Technology*, S. A. Rossmassler and D. G. Watson, Eds., pp. 93-113 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1980).

Key words: engineering standards; information interchange; measurement systems; product standards; standard reference data; standard reference materials.

Measurements are made to establish hypotheses, control industrial processes, aid health care, and set standards. These measurements must be precise and must also be compatible. Standard reference data systems provide critically evaluated numerical values of physical and chemical properties. Standard reference materials with accurately assessed properties provide means for comparison of instruments and methods. Engineering and product standards are written by national and international organizations to assure quality and compatibility of industrial output. Finally, major international attention has been focused on standardization of information processing. In addition to describing these levels of standardization, the chapter describes some of the standards organizations in various countries and gives an extensive bibliography.

**19906.** Zupancic, I., Lahajnar, G., Blinc, R., Reneker, D. H., Peterlin, A., *NMR study of diffusion of butane in linear polyethylene*, *J. Polymer. Sci. Polymer Phys. Ed.* **16**, 1399-1407 (1978).

Key words: butane; diffusion; experimental methods; migration; molecular transport; nuclear magnetic resonance; polymers.

The diffusion coefficient of butane in linear polyethylene at room temperature as a function of the vapor pressure of butane was measured by the spin-echo method with a pulsed magnetic field gradient. For the special morphology of randomly oriented stacks of parallel lamellas the detour factor is 1/3. As long as the blocking factor and migration through the lamellas can be neglected, the local diffusion coefficient  $D_a$  of the small molecules through the amorphous layers in the direction parallel to the lamellas is three times the apparent diffusion coefficient  $D$  derived from the decay of the amplitude of the spin echo under the assumption of an infinitely extended homogeneous medium. The diffusion coefficient and the spin-spin relaxation time both increase exponentially with increasing pressure, i.e., butane concentration in the polymer, while the spin-lattice relaxation time is pressure independent and seems to be determined by interactions with the amorphous polyethylene matrix.

**19907.** Ziff, R. M., Kincaid, J. M., *The virial series of the ideal Bose gas*, *J. Math. Phys.* **21**, No. 1, 161-165 (Jan. 1980).

Key words: Bose gas; fugacity expansion; Padé approximants; phase transitions; virial coefficients; virial series.

The radius of convergence  $\rho_R$  of the virial series of the  $d$ -dimensional ideal Bose gas is estimated by the method of Padé approximants, using at least thirty virial coefficients, which were numerically determined. A finite  $\rho_R$  is found for  $d = 1$  and 2, even though no phase transition occurs for these  $d$ . For  $d = 3$ ,  $\rho_R$  is consistent with Fuchs' analytical bounds, and for  $d = 4, 5$ , and 6,  $\rho_R$  is equal to the critical density  $\rho_c$ . These findings are supported by some analytic results for the equation of state.

**19908.** Zalewski, E. F., *Preliminary results of the interlaboratory comparison of detector spectral response transfer capabilities*, *Proc. Electro-Optics/Laser 79 Conf. & Exposition, Anaheim, CA, Oct. 23-25, 1979*, pp. 414-419 (1979).

Key words: absolute spectral response; detector intercomparison; optical radiation measurements; photodetector; photometry; radiometry.

As part of the NBS detector spectral response calibration program, participating laboratories were asked to report the results of several diagnostic and response transfer simulation experiments. The diagnostic tests probed for wavelength inaccuracies and stray light problems. In the response transfer simulation experiments the participants measured, on the basis of the absolute spectral responsivity supplied with the detector, alternative spectral response functions generated by absorbing glass filters placed in front of the detector. The results of these measurements are an assessment of the state of the art of detector spectral response calibrations among the laboratories participating in this program. This paper describes the results of the diagnostic and intercomparison measurements in the visible spectral region.

**19909.** Zalewski, E. F., Geist, J., Willson, R. C., *Cavity radiometer reflectance*, (Proc. 23d Annual Int. Tech. Symp. of the SPIE, San Diego, CA, Aug. 27-30, 1979), Paper in *Measurements of Optical Radiations*, H. P. Field, E. F. Zalewski, and F. Zweibaum, Eds., 196, 152-158 (Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, 1979).

Key words: absolute radiometry; cavity absorptance; cavity reflectance; electrically calibrated radiometer; pyroheliometry; solar constant.

The evolution of absorbing surfaces for electrically calibrated radiometers, and techniques for measuring their absorptance (reflectance) are described. A new reflectometer for cavity reflectance measurements, which is based on a ring-shaped silicon photodiode, is described. The results of reflectance measurements on a series of cavities which represent the evolution of



cavity technology are presented, and the significance of the results for future research are discussed.

- 19910.** Yates, J. T., Jr., Duncan, T. M., Vaughan, R. W., **Infrared spectroscopic study of activated surface processes: CO chemisorption on supported Rh**, *J. Chem. Phys.* **71**, No. 10, 3908-3915 (Nov. 15, 1979).

**Key words:** carbon monoxide; chemisorption; infrared spectroscopy; isotopic exchange; rhodium.

The infrared spectrum of CO chemisorbed on alumina-supported Rh surfaces has been studied following chemisorption at cryogenic temperatures. Major differences are observed in the distribution and spectroscopic character of chemisorbed CO species produced at low temperatures (110-170 K) compared to chemisorbed CO species produced on Rh at 295 K. It has been found that the species  $\text{Rh}(\text{CO})_2$ , formed on isolated Rh sites, is produced rapidly via an activated chemisorption process above  $\sim 200$  K. On more "crystalline"  $\text{Rh}_x$  sites, containing chemisorbed CO, an activated CO adsorbate-conversion process has been detected in which  $\nu_{\text{CO}}$  decreases by  $\sim 50 \text{ cm}^{-1}$  on warming the adsorbed layer above  $\sim 265$  K. Isotopic exchange between  $^{13}\text{CO}(\text{g})$  and  $^{12}\text{CO}(\text{ads})$  has been shown to occur rapidly at low temperature ( $\sim 200$  K) for  $\text{Rh}(\text{CO})_2$  species, whereas  $\text{Rh}_x(\text{CO})$  species exchange rapidly only at higher temperatures ( $\geq 250$  K). These results, taken together, serve to confirm a model in which isolated Rh sites coexist on the alumina support with crystalline  $\text{Rh}_x$  sites; the two kinds of sites are separable on the basis of the spectroscopic character of the chemisorbed CO species they adsorb as well as by means of their chemical properties.

- 19911.** Yagi, K., Roth, R. S., **Electron-microscope study of crystal structures of mixed oxides in the systems  $\text{Rb}_2\text{O}-\text{Ta}_2\text{O}_5$ ,  $\text{Rb}_2\text{O}-\text{Nb}_2\text{O}_5$  and  $\text{K}_2\text{O}-\text{Ta}_2\text{O}_5$  with composition ratios near 1:3. II. Various intergrowth phases and two-dimensional ordering of pentavalent ions**, *Acta Cryst.* **A34**, 773-781 (1978).

**Key words:** crystal structure; electron microscope; lattice images; niobates and tantalates; rubidium and potassium oxides; two-dimensional ordering.

In part I, the preceding paper, structural models were proposed on the basis of high-resolution electron microscopy for phases previously designated as 11L, 9L and 16L, which were found to exist in the title systems. Two types of blocks were found, which are composed of five and six layers of octahedra. In the present paper, various intergrowth phases which are composed of the two types of blocks are described. A new notation is proposed to denote these intergrowth phases as well as the 11L, 9L and 16L structures. Two-dimensional ordering of pentavalent ions in the six-layer block is found, giving rise to diffuse scattering in electron diffraction patterns. Two-dimensional images, calculated on the basis of the proposed model, are found to reproduce the observed images.

- 19912.** Watters, R. L., Jr., Norris, J. A., **Factors influencing precision and accuracy of analysis with inductively coupled plasmas**, *Proc. Eastern Analytical Symp.*, New York, NY, Nov. 31-Dec. 2, 1977, pp. 65-81 (Franklin Inst. Press, Philadelphia, PA, 1978).

**Key words:** emission spectroscopy; inductively coupled plasma; instrumental control; multi-element analysis; plasma system; trace element analysis.

In order to analyze Standard Reference Materials for certification, it is necessary to establish which instrumental factors contribute to the errors of the analysis technique. The first step is to attain adequate control of the random errors in the entire measurement process. Once this is achieved it becomes possible to evaluate the magnitude of the error and thereby to properly estimate accuracy.

This paper describes some of the problems encountered in realizing adequate control of the random errors associated with

the Inductively Coupled Plasma. The effects of some important instrumental parameters on the precision of the analytical signal will be described. Preliminary analysis data will be presented to demonstrate the possible magnitude of systematic errors which arise from instrumental sources.

- 19913.** Wasik, S. P., Brown, R. L., **Analysis of complex aromatic hydrocarbon mixtures with solid silver nitrate columns**, *Anal. Chem.* **48**, No. 14, 2218-2220 (Dec. 1976).

**Key words:** aromatic hydrocarbons; gas-solid chromatography; silver nitrate.

A highly efficient chromatographic column consisting of glass beads coated with solid silver nitrate and modified by water vapor in the carrier gas can be used at room temperature to analyze, in a reasonable time, mixtures containing aromatic hydrocarbons having boiling points up to  $180^\circ\text{C}$ . The construction of this column is described and its properties discussed. Its efficiency is compared with conventional gas-liquid chromatographic columns.

- 19914.** Wasik, S. P., **Determination of transition temperatures on sodium stearate using gas chromatography**, *J. Chromatogr. Sci.* **14**, 516-518 (Nov. 1976).

**Key words:** gas chromatography; sodium stearate; transition temperatures.

A gas chromatographic method is presented for detecting structural changes in a solvent by observing the solubility behavior of a "probe" solute molecule. The transition temperatures of solid and liquid sodium stearate were determined at this point on the  $\log V_g$  vs  $1/T$  plot where the slope changes abruptly. The observed transition temperatures were compared with differential scanning calorimetry measurements on the same compound and the results of other investigators using different physical methods.

- 19915.** Hahn, T. A., **Thermal expansion of single crystal sapphire from 293 to 2000 K Standard Reference Material 732**, *Proc. Int. Symp. on Thermal Expansion, Hecla Island, Manitoba, Canada, Aug. 29-31, 1977*, No. 6, 11 pages (Plenum Press Inc., New York, NY, Aug. 1977).

**Key words:** high temperature; interferometer; sapphire- $\text{Al}_2\text{O}_3$ ; standard reference material; tele-microscope; thermal expansion.

This single crystal sapphire is the fifth Standard Reference Material (SRM) to be certified from thermal expansion by the National Bureau of Standards. Expansion measurements to 1000 K on three samples indicate that the stock of material is of consistent quality suitable for certification. In the temperature range from 293 to 1000 K measurements were made using an interferometer apparatus resulting in  $(L_{1000} - L_{293}) / (L_{293}) = 5500 \times 10^{-6}$  with a standard deviation of  $5 \times 10^{-6}$ . Above 1000 K length measurements were made using twin tele-microscopes with the sample heated in a tungsten mesh furnace. From 293 to 2000 K  $(L_{2000} - L_{293}) / (L_{293}) = 15700 \times 10^{-6}$  with a standard deviation of  $25 \times 10^{-6}$ . Measurements were made parallel to the rod axis which is oriented  $59^\circ$  from the c-axis of the crystal. Smoothed values of the expansion and coefficients of expansion were obtained by fitting the expansion with a variation of Grüneisen's equation.

Final values of the four parameters were obtained by minimizing the standard deviation in a least-squares analysis. The results of this study are generally in good agreement with expansion values found in the literature. Major differences, however, are observed in the comparison with x-ray diffraction studies and with extrapolated data appearing in the literature. No systematic deviations of the data from the final equation were observed. A comparison of the results of this study with data found in the literature will be presented.



**19916.** Turk, G. C., Travis, J. C., DeVoe, J. R., O'Haver, T. C., **Analytical flame spectrometry with laser enhanced ionization**, *Anal. Chem.* **50**, No. 6, 817-820 (1978).

Key words: atomic absorption; atomic detection limits; flame spectrometry; laser enhanced ionization; laser spectrometry; tunable laser.

A new flame spectrometric technique using laser-enhanced ionization is described. The method is based on the increase in flame conductivity resulting from the enhanced thermal ionization of an element following the absorption of laser radiation at a transition wavelength for that element.

Detection limits are reported for Cu, Mg, Mn, Na and Pb. In most cases the detection limits are comparable or better than the best reported values for other flame spectrometric techniques.

Also discussed is the unique ability of laser-enhanced ionization to use nonresonance or weak resonance lines, often with sensitivity comparable or better than the traditional lines used in other flame spectrometric techniques.

**19917.** Tsong, T. T., Yee, S. N., Melmed, A. J., **ToF atom-probe mass spectra of GaAs**, *Surf. Sci. Lett.* **77**, L187-L192 (1978).

Key words: field evaporation; molecular ions; semiconductor mass analysis.

Time-of-flight mass analysis is applied to GaAs. Analyses are done in the presence of hydrogen and argon, as well as in vacuum. Significant differences are found in the spectra obtained under these conditions. Particularly interesting is the apparent specificity of hydrogen to react with As compared to Ga. The existence of the molecular ion  $As_2^+$  is established.

**19918.** Travis, J. C., Turk, G. C., Green, R. B., **Laser-enhanced ionization for trace metal analysis in flames**, (Proc. ACS Division of Analytical Chemistry at the 175th Meeting of the American Chemical Society, Anaheim, CA, Mar. 14-15, 1978), Paper No. 6 in *New Applications of Lasers to Chemistry*, G. M. Hieftje, Ed., *ACS Symp. Series* **85**, pp. 91-101 (American Chemical Society, Washington, DC, 1978).

Key words: atomic spectrometry; flame spectrometry; laser enhanced ionization; laser spectrometry; opto-galvanic effect; trace metal analysis.

A new laser-based flame analytical method, requiring no optical detection, promises to outperform traditional methods in many applications. Detection is based on the enhanced flame ionization of analyte atoms maintained in an excited state by a laser tuned to the desired electrical probes located at the outer edges of the flame. This configuration yields ng/ml detection of Cr, Fe, Ga, In, K, Mg, Mn, Na, Pb, and Tl, with negligible probe deterioration over days of operation. Less impressive results for the few remaining elements studied to date are attributed to the role of the ionization potential, and more appropriate transitions are being explored.

Both precision and accuracy may be affected by the presence of large excesses of easily ionized species in the sample. Operational procedures to minimize and/or correct for such interferences are being developed in conjunction with studies of the basic mechanisms of ionization from excited states, recombination, and electron transport in flames.

Advantages existing or foreseen are: high sensitivity, no optical detection, Doppler-limited spectral resolution, and additional useful atomic transitions.

**19919.** Staples, B. R., **Correlation of thermodynamic properties of aqueous polyvalent electrolytes**, (Proc. 9th Int. Conf. on the Properties of Steam, Technische Universitat, Munchen, Germany, Sept. 10-14, 1979), Paper in *Water and Steam. Their Properties and Current Industrial Applications*, J. Straub and K. Scheffler, Eds., pp. 608-615 (Pergamon Press, Oxford, England, 1979).

Key words: activity coefficient; correlation; critical evaluation; electrolyte theories; excess Gibbs energy; models; osmotic coefficient; polyvalent electrolytes; solutions; thermodynamic properties.

The techniques used in the critical evaluation and correlation of thermodynamic properties of aqueous polyvalent electrolytes will be described. The Electrolyte Data Center at the U.S. National Bureau of Standards is engaged in the correlation of activity and osmotic coefficients, enthalpies of dilution and solution, heat capacities, and ionic equilibrium constants for aqueous salt solutions.

The substances include all inorganic salts for which data are available. The range of concentrations extend from very dilute to saturation. The Debye-Hückel theoretical slopes are used as the basis of correlations in the very dilute region and an empirical equation in powers of  $m^{1/2}$  is used to extend the correlating equation to high concentrations.

Current results for about 100 correlations will be compared and observed periodic trends and trends according to charge-type will be discussed.

**19920.** Staples, B. R., **Electrolyte Data Center**, *SSIE Sci. Newslett.* **VIII**, No. 6, 5 (Apr. 1979).

Key words: aqueous electrolytes; electrolyte data center; evaluations; reviews; solutions; thermodynamic properties.

A short description of the activities and kinds of output of the Electrolyte Data Center, NBS, is provided.

**19921.** Small, J. A., Heinrich, K. F. J., Newbury, D. E., Myklebust, R. L., **Progress in the development of the peak-to-background method for the quantitative analysis of single particles with the electron probe**, *Scanning Electron Microsc.* **II**, 807-816 (1979).

Key words: electron probe microanalysis; glass particles; mineral particles; Monte Carlo methods; particle; peak-to-background ratios; quantitative analysis; x-ray microanalysis.

A method is described for the quantitative analysis of particles with electron excitation. For this method, the ratios of the characteristic x-ray intensities to the continuous x-ray intensities of the same energy are used to eliminate major particle effects. The procedure consists of scaling the peak intensity of the particle up to a value appropriate to a bulk material. The scaled intensity can then be compared to a standard and the concentration determined by a ZAF routine.

In order to use the analytical procedure it is necessary to calculate a value of the continuous x-ray intensity for a hypothetical bulk material with the same composition as the unknown. To date, two methods have been used to calculate this value. The first method uses Kramers' law with Green's corrections to Kramers' constant. The results from the analysis of both glass and talc particles with this version of the program are in good agreement with the actual concentrations. The second method uses an empirical equation derived at NBS to calculate the continuous x-ray intensity of the bulk. The results on  $FeS_2$  particles with this version of the program decrease the relative error in the Fe concentration from 19 percent for Kramers' equation to six percent.

In addition to calculating the values for the hypothetical bulk material, work is also being done with a Monte Carlo program in an effort to identify those conditions under which the correspondence of the peak-to-background ratio between particles and bulk material of the same composition breaks down. Calculations show that there is a significant deviation in the peak-to-background ratios from particles compared to bulk due to two effects: 1) the anisotropy of the generation of the continuous x-radiation and 2) differences in the energy dependence of the cross-section for characteristic and continuous x-radiation coup-



led with differences in the energy distribution of electrons backscattered from bulk and particle targets.

- 19922.** Madey, T. E., Yates, J. T., Jr., The adsorption of cycloparaffins on Ru(001) as studied by temperature programmed desorption and electron stimulated desorption, *Surf. Sci.* **76**, 397-414 (1978).

Key words: adsorption; angular distribution; cyclohexane; cyclooctane; cyclopropane; desorption; electron stimulated desorption; ethane.

The adsorption of  $C_2H_6$ , and the cycloparaffins  $C_3H_6$ ,  $C_6H_{12}$ , and  $C_8H_{16}$  on Ru(001) at 80 K has been studied using LEED, temperature programmed desorption, and ESDIAD (Electron Stimulated Desorption Ion Angular Distributions). An aim of these studies has been to examine the relationship between ESDIAD ion desorption angles and bond angles in weakly adsorbed species having known internal structure. Fractional monolayers of  $C_2H_6$  and  $C_3H_6$  both yield ESDIAD patterns due to  $H^+$  ions desorbed in wide cones centered on the surface normal, consistent with adsorption into mobile, disordered layers. In contrast, a fractional monolayer of  $C_6H_{12}$  yields a hexagonal  $H^+$  ESDIAD pattern. These results indicate the azimuthal orientation of the C-H bonds and are consistent with a simple model of  $C_6H_{12}$  adsorption. In thermal desorption studies, the weakly adsorbed layer in contact with the substrate is easily distinguished from condensed multilayers. Mass analysis of ESD ions reveals that the only ESD ion product is  $H^+$  for hydrocarbon coverages  $< 1$  monolayer. For multilayers of adsorbed  $C_6H_{12}$  and  $C_8H_{16}$ , the ESD ion products have a mass distribution similar to the gas phase mass spectrometer cracking pattern. For all these fragments, the ESD cross sections are  $\geq 2 \times 10^{-17} \text{ cm}^2$ .

- 19923.** Arens, E., Gonzalez, R., Berglund, L., McNall, P. E., Zeren, L., A new bioclimatic chart for passive solar design, *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980*, pp. 1202-1206 (American Section ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: bioclimatic chart; human comfort; indoor environment; outdoor environment; thermal comfort.

This paper presents a substantially revised version of the original bioclimatic chart developed by Olgyay and Yaglou in the 1950s, incorporating recent research results. A thermophysiological model developed at the J. B. Pierce Foundation Laboratory was used to simulate the thermal behavior and resulting comfort sensation of an individual at two clothing levels, and a rate of activity typical of office work, house work, or shopping. The criteria for the boundaries of the comfort zone are based on the ASHRAE Standard 55-74, as currently being proposed for revision. Examples of the chart are presented, in both the original format and in the format of the psychrometric chart.

- 19924.** Madey, T. E., The geometry of CO on Ru(001): Evidence for bending vibrations in adsorbed molecules, *Surf. Sci.* **79**, 575-588 (1979).

Key words: carbon monoxide; chemisorption; electron stimulated desorption; ion angular distribution; nitric oxide; ruthenium; surface.

As a test of the utility of the ESDIAD method (Electron Stimulated Desorption Ion Angular Distributions) in studies of the geometry of adsorbed molecules, the chemisorption of CO on Ru(001) has been examined. Data previously reported using UPS (ultraviolet photoemission spectroscopy) and EELS (electron energy loss spectroscopy) have indicated that CO is terminally bonded to the Ru surface through the C atom, with the CO axis perpendicular to the surface. The ESDIAD results for CO confirm this orientation; for all CO coverages in the tem-

perature range 90 K to  $\sim 350$  K, the angular distributions of  $O^+$  and  $CO^+$  ESD ions are centered about the surface normal. The widths of the ion beams are temperature dependent; for both  $O^+$  and  $CO^+$ , the half widths at half maximum,  $\alpha$ , of the ion cones are  $\sim 16^\circ$  at 300 K, and  $\sim 12^\circ$  at 90 K. This temperature dependence, coupled with a simple model calculation, indicates that the dominant factors contributing to the width of the ESD ion beams are the CO surface bending vibrations, i.e., initial state effects. Thus, the data suggest that both the directions and widths of ESDIAD beams are determined largely by the structure and dynamics of the initial adsorbed state.

- 19925.** Munro, R. G., On a parametrization for solids under hydrostatic pressures, *Phys. Lett.* **66A**, No. 5, 392-394 (June 12, 1978).

Key words: anomalous behavior; frequency shifts; hydrostatic pressure; Knight shift; scaling theory; solids; Van Vleck susceptibility.

A newly developed parametrization successfully used to calculate the hydrostatic pressure dependence of the  $Cr^{3+}$  spectra of ruby is shown to be useful also for describing some cases of hydrostatic pressure shifts of Van Vleck susceptibilities and Knight shifts.

- 19926.** Krishnamurthy, T., Wasik, S. P., Fluorometric determination of partition coefficients of naphthalene homologues in octanol-water mixtures, *J. Environ. Sci. Health* **A13**, No. 8, 595-602 (1978).

Key words: fluorimetry; naphthalene homologues; octanol/water; organic pollutants; partition coefficients.

The octanol/water partition coefficients of 12 naphthalene homologues have been measured using a newly developed fluorometric technique. The log P values of alkyl substituents obtained by this method were found to be in reasonable agreement with the literature values.

- 19927.** Lashmore, D., Melmed, A. J., Field ion microscopy of polycrystalline iron whiskers, *J. Appl. Phys.* **49**, No. 8, 4586-4587 (Aug. 1978).

Key words: chemical vapor deposition; field ion microscopy; iron carbides; microstructure; polycrystalline iron whiskers; whiskers.

Field ion micrographs of polycrystalline iron (steel) whiskers are presented. These micrographs indicate that the whiskers examined here possess a two-phase structure consisting of an ordered iron phase and a randomly imaging phase interpreted to be the iron carbide,  $Fe_3C$ . The iron image indicates not only a high defect density but also the presence of twins.

- 19928.** Linsky, J. L., On the differences at chromospheric levels between RS CVn-type binaries, active and quiet chromosphere single stars, and active and quiet regions in the sun, (Proc. Joint Meeting of Close Binaries and Stellar Activity, Montreal, Canada, Aug. 18, 1979), Paper in *Highlights of Astronomy*, P. A. Wayman, Ed., pp. 861-862 (D. Reidel, Dordrecht, The Netherlands, 1980).

Key words: binary stars; chromospheres, stellar; chromosphere, sun; ultraviolet spectra.

This paper summarizes the differences in the properties of active chromospheres compared with quiet chromospheres by comparing active and quiet regions on the Sun, active and quiet chromosphere stars, and the very active chromospheres seen in close binary systems with chromospheres of single stars. In particular the chromospheres of the RS CVn-type binary systems UX Arietis and HR 1099 and the chromosphere of UX Arietis during a flare are modeled.



**19929.** Stone, J., Thiele, E., Goodman, M. F., Stephenson, J. C., King, D. S., **Collisional effects in the multiphoton dissociation of CF<sub>2</sub>CFCI**, *J. Chem. Phys.* **73**, No. 5, 2259-2270 (Sept. 1, 1980).

Key words: laser chemistry; laser induced fluorescence; molecular spectroscopy; multiphoton chemistry; unimolecular reactions; vibrational energy transfer.

We report results of a combined experimental and theoretical study of the effects of collisions with an inert buffer gas, on the CO<sub>2</sub> laser induced MPD of CF<sub>2</sub>CFCI to form CF<sub>2</sub> and CFCI. Rates of formation of the primary product CF<sub>2</sub> have been determined, in real time using the laser excited fluorescence technique, at four IR laser intensities ( $I_{max} = 35, 47, 73, 220$  MW/cm<sup>2</sup>) and a range of argon buffer gas pressures ( $0 < P_{Ar} < 500$  Torr). The experimental data clearly show the effects of collisional hole filling at low pressures and  $V$ - $T$  collisional deactivation at higher ( $> 100$  Torr) pressures. We present a generally applicable theoretical model for collisional effects in MPD, in which two parameters ( $1/\tau$ ,  $\Delta E$ ) specify the collisional deactivation, two parameters ( $s$ ,  $< \omega >$ ) specify the density of states of the absorber, two parameters ( $A$ ,  $E_{act}$ ) specify the microscopic reaction rates and one parameter ( $\delta$ ) specifies the radiative pumping rates. In applying this model to CF<sub>2</sub>CFCI five of these seven parameters are readily estimated from independent kinetic or spectroscopic data. Treating only the remaining two parameters  $\Delta E$  and  $\delta$  as adjustable, an excellent theoretical fit of the high pressure experimental data is obtained. In this fit a value ( $\Delta E = 2.6$  kcal/mole) is found for the mean energy transferred per collision to the buffer gas molecules. This value lies within the range expected for  $\Delta E$  on the basis of chemical activation studies. The overall closeness of fit confirms the basic soundness of the "single quantum exchange" model for  $T_2$  relaxation, from which expressions are derived for the microscopic radiative pumping rates. Using only parameters determined in the MPD fit, we predict as a function of laser intensity and buffer gas pressure the energy absorbed from the light field. This prediction can be tested in an experiment that measures absorbed energy by the acousto-optic technique.

**19930.** Sieck, L. W., **Fingerprinting and partial quantification of complex hydrocarbon mixtures by chemical ionization mass spectrometry**, *Anal. Chem.* **51**, No. 1, 128-132 (Jan. 1979).

Key words: analysis; chemical ionization; hydrocarbons; ion-molecule reactions; mass spectrometry; photoionization.

A modification of chemical ionization mass spectrometry, which involves photoionization and cyclohexane as the source of the reagent ion, has been used to develop a technique for discriminatory "fingerprinting" of neat liquid fossil fuels. The method provides a 2-min turn-around time between samples and batch introduction, with no requirements for prior separation or fractionation. Depending upon the conditions chosen, the technique may also be extended to the partial quantification of aromatic and olefinic sample components.

**19931.** Shold, D. M., Ausloos, P. J., **The photochemistry of ethyl chloride**, *J. Photochem.* **10**, 237-249 (1979).

Key words: ethyl chloride; halocarbons; photochemistry.

Ethyl chloride and deuterium-labelled ethyl chlorides have been photolyzed at 184.9, 163.3, 147.0 and 123.6 nm in the gas phase and at 163.3 and 147.0 nm in the liquid phase. The use of NO, O<sub>2</sub> and HI as radical scavengers has permitted a determination of the quantum yields of primary photodecomposition processes as a function of wavelength. At low energies, excitation of an electron into an antibonding  $\sigma^*$  orbital leads primarily to C-Cl bond cleavage, while at higher energies this process is largely replaced by loss of HCl and hydrogen. Both 1,1- and 1,2-HCl eliminations are observed. The absence of significant amounts of hydrogen atom production at 163.3 nm and at low

pressures suggests that one excited state may be responsible for HCl elimination and a second for chlorine atom loss, in agreement with the mechanism of Ichimura *et al.*

**19932.** Sengers, J. M. H. L., **Liquidons and gasons; controversies about the continuity of states**, *Physica* **98A**, 363-402 (1979).

Key words: Andrews; condensation; critical point; diffusion; gaseous; history of science; Kamerlingh Onnes; liquidons; liquids; mixtures; van der Waals; vapors.

Two basic ideas about the nature of the gas-liquid transition were voiced around 1870: that in the supercritical state, vapor and liquid are indistinguishable (Andrews), and that condensation and critical behavior can be understood on the basis of a simple assumption about molecular interaction (Van der Waals). For many scientists at the time, however, the notion of continuity of states was almost inconceivable. The older ideas, that liquid and gas molecules were different from each other, and that the liquid "dissolves" in the vapor at the critical point, survived for a long time. Unfamiliarity with the implications of Gibbs' thermodynamics in Europe helped to keep the older ideas alive. This paper describes the controversies that raged between proponents and opponents of the Andrews-Van der Waals view between 1880 and 1907, and how they were fanned by erroneous or incorrectly interpreted experiments carried out all over Europe. Kamerlingh Onnes and his staff in Leiden repeated a number of the controversial experiments in the period 1892-1907 and discovered that impurity was by far the largest source of error. By 1907 the controversy was unequivocally decided by the Leiden group in favor of the Andrews-Van der Waals view. A replay of the old controversy took place in the period 1933-1952.

**19933.** Schwarz, F. P., Braun, W., Wasik, S. P., **Oscillating slit mechanism for the determination of hydrogen isotope ratios in a microwave induced plasma**, *Anal. Chem.* **50**, 1903-1905 (Nov. 1978).

Key words: deuterium; gas chromatography; hydrogen; isotope dilution; microwave plasma; oscillating slit mechanism.

A low pressure microwave discharge through deuterated and hydrogenated hydrocarbon mixtures eluting from a gas chromatograph results in fragmentation of the hydrocarbons and generation of intense atomic hydrogen emission at 6562.8 Å and atomic deuterium emission at 6561.0 Å. By replacing the exit slit mechanism of the monochromator viewing the emissions with an oscillating slit mechanism (OSM), the hydrogen emission is measured alternately with the deuterium emission. The operation of the OSM is based on oscillating mechanically the exit slit aperture twice across the hydrogen line and once across the deuterium line during one cycle of oscillation. Two lock-in amplifiers resolve the modulated emissions into a hydrogen and a deuterium signal. The ratio of the two signals is a linear function of the atomic hydrogen isotope ratio in the isotope hydrocarbon mixtures over one order of magnitude.

**19934.** Schwarz, F. P., **Characterization of the emission from atomic hydrogen in a microwave induced plasma**, *Anal. Chem.* **51**, 1508-1512 (Aug. 1979).

Key words: hydrogen emission; microwave induced plasma detector.

Microwave induced plasma detectors (MPD) are typically operated with small amounts of oxygen added to the helium or argon plasma gas in order to keep the plasma cell walls clean. It is shown, however, that the presence of oxygen in the plasma gas causes a nonlinear response in the hydrogen emission dependence on concentration, as well as the enhancement of the hydrogen background emission upon passage of deuterium through the MPD. Both effects diminish with increasing plasma pressure and disappear in the absence of oxygen. A kinetic scheme, based on radiative charge recombination between pro-



tons and electrons and generation of the protons and electrons via energy transfer from the metastable He 2s<sup>3</sup>S state, is presented to account for these effects. It is suggested that oxygen affects the hydrogen emission through a charge transfer reaction between protons and molecular oxygen.

**19935.** Schaefer, A. R., **Measurement of synchrotron radiation from the NBS SURF II using a silicon radiometer**, (Proc. 23d Annual Int. Tech. Symp. of the SPIE, San Diego, CA, Aug. 27-30, 1979), Paper in *Measurements of Optical Radiations*, H. P. Field, E. F. Zalewski, and F. Zweibaum, Eds., 197, 84-89 (Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, 1979).

Key words: radiometry; silicon photodetector; storage ring; synchrotron radiation.

A project is described in which the synchrotron radiation output from the NBS storage ring known as SURF II, will be measured using a well characterized silicon based radiometer. The radiometer consists of a silicon photodiode coupled with two interference filters to restrict the spectral response to a finite and convenient spectral region for the measurement. Considerations required for the characterization of the radiometer will be discussed. The absolute radiant flux from the storage ring is also calculable from various machine parameters. A measurement of the number of circulating electrons will be derived from electron counting techniques at low levels. This will yield an important intercomparison between two entirely different determinations of the synchrotron radiant flux.

**19936.** Ruff, A. W., **Introductory remarks on erosion**, *Proc. NACE Conf. on Corrosion/Erosion of Coal Conversion System Materials*, Berkeley, CA, Jan. 24-26, 1979, pp. 383-392 (National Association of Corrosion Engineers, Houston, TX 77084 1979).

Key words: deformation; erosion; impact; metals; surfaces.

The status of the science of solid particle erosion of materials is reviewed briefly. Examples of recent studies of single particle and also multiple particle exposures are given. Suggestions of critical needs in the field are presented.

**19937.** Peterlin, A., **Accordion-type laser-Raman (ALR) oscillations in crystalline polymers**, *J. Appl. Phys.* 50, No. 2, 838-844 (Feb. 1979).

Key words: accordion type oscillation; coupled rod oscillation; crystalline polymers; elastic modulus; helical chains; inelastic neutron scattering; laser-Raman scattering; polyethylene; polyethyleneoxide; polyhexafluoropropylene; polyoxymethylene; polypropylene; polytetrafluoroethylene.

If one interprets the ALR absorption lines of crystalline polymers in terms of oscillating elastic rods of length equal to the thickness  $L$  of the crystalline lamellae, or the thickness  $D$  of the crystalline core of the lamellae, one obtains for the elastic modulus of these rods values which are substantially higher than the axial elastic modulus  $E_c$  of the crystal lattice. The effect is particularly conspicuous with polymers which in the crystalline state exhibit a helical-chain conformation. The explanation of this effect seems to be the elastic coupling of longitudinal oscillations of chain stems of subsequent lamellae by the intervening amorphous layers. The apparent increase of the ALR oscillation frequency by such coupling is particularly large if the elastic modulus  $E_a$  of the amorphous layers is equal or even higher than that of the crystal lattice. The high value of  $E_a$  derived from such an analysis is a consequence of the very high ALR frequency ( $\sim 0.3$  THz), which makes the amorphous layer react as a rigid glass.

**19938.** Peterlin, A., **Elastic modulus and strength of fibrous material**, *Polym. Eng. Sci.* 19, No. 2, 118-124 (Feb. 1979).

Key words: elastic modulus; extruded semicrystalline polymers; fibrous materials; polymers; strength.

As a rule, the large increase of elastic modulus with increasing draw ratio obtainable in highly-drawn or extruded semicrystalline polymers is not reflected in a similarly large increase of strength. This is closely connected with the well-known fact that with increasing plastic deformation one obtains fibrous material with decreasing strain to break. The axial elastic modulus is mainly caused by the taut tie molecules which bridge the amorphous layers between consecutive crystal blocks and thus provide an efficient axial force transmission through the sample. The defects at the ends of microfibrils interrupt this transmission because they contain few if any taut tie molecules connecting the end of microfibril with adjacent fibrillar elements. As a consequence of the small number of such ends, they only marginally reduce the elastic modulus. But as the mechanically weakest areas of the fibrous material, they drastically depress the strength. They fail as soon as the strain concentration upon them reaches their strain to break. The growth and coalescence of resulting microcracks finally lead to bulk fracture as the growing crack reaches critical dimensions.

**19939.** Page, S. W., Mazzola, E. P., Himes, V. L., Mighell, A. D., Hubbard, C. R., **Structure of (3-chloro-2-hydroxy-5-nitrophenyl)-(2'-chlorophenyl)iodonium hydroxide inner salt**, *J. Am. Chem. Soc.* 101, No. 19, 5858-5860 (Sept. 12, 1979).

Key words: inner salt; iodonium compound; reaction mechanism; synthetic intermediate; x-ray structure determination; zwitterion.

$C_{12}H_6NO_3Cl_2I_6$  MW = 409.98; monoclinic,  $P2_1/n$ ;  $a = 15.928(9)$ ;  $b = 18.271(6)$ ;  $c = 4.623(2)$  Å,  $\gamma = 105.58^\circ$ ;  $Z = 4$ ;  $D_c = 2.106$  g cm<sup>-3</sup>;  $D_m = 2.11$  (floatation); final  $R = 0.060$  (1787 observed reflections). The molecule exists as a zwitterion with an intramolecular I...O distance of 2.768(8) Å. The I-C bond distances were found to be 2.08(1) and 2.11(1) Å, with a C-I-C angle of 97.8(4)°. Intermolecular ionic attraction between I and O causes the formation of infinite chains along the z-axis of the cell. This zwitterion is the first reported example of a phenoxide-iodonium betaine. The title compound is a key intermediate in the synthesis of O-diphenyl ethers. A reaction mechanism based on the zwitterion formation is proposed.

**19940.** Melmed, A. J., Tung, R. T., Graham, W. R., Smith, G. D. W., **Evidence for reconstructed Y001X tungsten obtained by field-ion microscopy**, *Phys. Rev. Lett.* 43, No. 20, 1521-1524 (Nov. 12, 1979).

Key words: atomic surface structure; field-ion microscopy; surface physics; surface reconstruction.

New results have been obtained, by field-ion microscopy, relating to the atomic structure of clean Y001X W. The evidence supports a reconstruction model with periodic displacements of atoms having vertical components. The reconstructed atomic configuration prevails over the entire temperature range of this investigation ( $\sim 15$ –460 K), suggesting that no phase transition may be needed to account for the structural features of Y001X W.

**19941.** Ives, L. K., Ruff, A. W., **Electron microscopy study of erosion damage in copper**, *Am. Soc. Test. Mater. Spec. Tech. Publ.* 664, pp. 5-35 (1979).

Key words: copper; electron microscopy; erosion; impingement erosion; metal erosion; wear.

Solid-particle erosion data have been reported for many materials. The mechanics of the impact process has also been examined. However, relatively little effort has been expended in studying the microstructural aspects of material response to erosion. Effects such as deformation hardening, plastic flow, and particle embedding are recognized as being important but have



not been subjected to careful study. Understanding the erosion mechanism at large attack angles and accounting for differences in erosion behavior of different metals and alloys are areas where knowledge of materials response factors will be most important. In the present work surface and subsurface erosion damage in copper is investigated by transmission and scanning electron microscopy techniques.

**19942.** Parr, A. C., Jason, A. J., Stockbauer, R., **Photoionization and threshold photoelectron-photoion coincidence study of cyclopropene from onset to 20 eV**, *Int. J. Mass Spectrom. Ion Phys.* 33, 243-251 (1980).

Key words: breakdown curve; cyclopropene; photoionization.

The photoionization efficiency curves have been obtained for cyclopropene and its fragments  $C_3H_3^+$ ,  $C_3H_2^+$ , and  $C_3H^+$  from threshold to 20 eV. The threshold photoelectron spectra and breakdown curves are given over the same energy range. The breakdown curve is almost identical to those obtained previously for allene and propyne when put on a common energy scale. This suggests that all three ions isomerize to a common structure before fragmentation.

**19943.** Parr, A. C., Jason, A. J., Stockbauer, R., **Photoionization and threshold photoelectron-photoion coincidence study of allene from onset to 20 eV**, *Int. J. Mass Spectrom. Ion Phys.* 26, 23-38 (1978).

Key words: allene; autoionization; coincidence; fragmentation; mass spectrometry; photoionization; threshold photoelectron spectroscopy; time of flight mass spectrometry.

The photoionization efficiency curves for allene and its fragments  $C_3H_3^+$ ,  $C_3H_2^+$  and  $C_3H^+$  are given from threshold to 20 eV. The threshold photoelectron spectra and breakdown curves are given over the same energy span. The adiabatic ionization potential is determined to be  $9.69 \pm 0.01$  eV and the heats of formation of the fragments are derived from the appearance potentials. Autoionization is found to be an important factor in the parent ionization and fragmentation.

**19944.** Lindstrom, R. M., Harrison, S. H., Harris, J. M., **Accurate calibration of gold film standards by neutron activation and gravimetry**, *J. Appl. Phys.* 49, No. 12, 5903-5908 (Dec. 1978).

Key words: accuracy and precision; gold films; gravimetry; neutron activation analysis; Rutherford backscattering; standards.

A set of evaporated gold films on silicon substrates has been prepared for use as standards in the measurement of film thickness by Rutherford backscattering. The mass of gold in the films was determined independently by gravimetry and by instrumental neutron activation. The area was measured with an optical comparator; film uniformity was assayed by backscattering. Systematic errors in the single-element comparator method of activation analysis have been assessed and either eliminated or compensated, with the result that the single-sample agreement in mass between the two methods was 0.3% and the mean relative bias was below the random errors, also 0.3%.

**19945.** Surek, T., Coriell, S. R., Chalmers, B., **The growth of shaped crystals from the melt**, *J. Crystal. Growth* 50, 21-32 (1980).

Key words: crystal; Czochralski; edge-defined film-fed growth (EFG); floating zone; meniscus; silicon; stability.

The growth of shaped crystals from the melt occurs by a process referred to as meniscus-controlled growth. In a meniscus-controlled process, the relationship of the crystal shape to that of the liquid-vapor interface is reflected by the observed constancy of the relative angle  $\phi_0$  between the crystal and liquid free-surfaces at the crystal-liquid-vapor junction. An experimen-

tal technique is described for determining the characteristic values of  $\phi_0$  for silicon and germanium. A general theory is presented for the time evolution and stability of the crystal shape in meniscus-controlled growth processes. A linear perturbation analysis of the dynamic crystal growth equations is carried out to derive the necessary and sufficient conditions for crystal shape stability. Application of the analysis is made to the more conventional shaped growth processes such as Czochralski and floating zone growth, and to techniques which utilize a die shaper such as the Stepanov and Edge-defined Film-fed Growth (EFG) methods. The advantages and disadvantages of using wetted and non-wetted dies in the shaping process are discussed. Specific numerical examples deal with the growth of silicon crystals by the various methods.

**19946.** Cahn, J. W., Coriell, S. R., Boettinger, W. J., **Rapid solidification**, (Proc. of Laser and Electron Beam Processing of Materials, Boston, MA, Nov. 27-30, 1979), Paper in *Laser and Electron Beam Processing of Materials*, C. W. White and P. S. Percy, Eds., pp. 89-103 (Academic Press, Inc., New York, NY, 1980).

Key words: interface stability; kinetics; microsegregation; rapid solidification; solute trapping; thermodynamics.

Rapid solidification phenomena are described in terms of a hierarchy of increasing deviation from equilibrium. Results of morphological stability theory applied to silicon regrowth indicates that factors outside of conventional constitutional supercooling can explain the observed absence of lateral segregation. A model for interface response functions applicable to solute trapping is presented and a thermodynamic limit to the amount of solute trapping, which seems to be operating in some systems, is proposed.

**19947.** Ives, L. K., Kasen, M. B., Schramm, R. E., Ruff, A. W., Reed, R. P., **A microstructural study of the Tishomingo meteorite**, *Geochim. Cosmochim. Acta* 42, 1051-1066 (1978).

Key words: electron microscopy; Fe-Ni alloys; martensite; shock deformation; Tishomingo meteorite; x-ray diffraction.

Metallography, electron microscopy and x-ray diffraction techniques were employed to study a fragment of the Tishomingo iron meteorite. The results suggest the following thermal-mechanical history: The fragment was originally a large crystal of taenite ( $\gamma$ ). Cooling through the  $\alpha + \gamma$  phase boundary did not result in accompanying precipitation of kamacite ( $\alpha$ ). Transformation to a martensitic structure initiated between  $-25$  and  $-65$  °C. Transformation continued as the temperature fell to  $-75$  to  $-115$  °C, resulting in approx. 80% martensite ( $\alpha'$ ). Subsequent shock deformation and thermal aging processes substantially modified the taenite and martensite microstructures. Twins in the retained taenite phase are attributed to shock deformation at a pressure estimated for a single event at  $\sim 170$  kbar. The existing complex, altered martensite structure containing both taenite and kamacite (3-15% Ni) particles was apparently the product of both shock deformation and thermal aging processes. The maximum temperature reached during thermal aging is estimated to be less than 400 °C, and perhaps below 310 °C.

**19948.** Peterlin, A., **Fracture of fibrous polymers**, *Polym. Eng. Sci.* 18, No. 14, 1062-1067 (Nov. 1978).

Key words: coalescence of microcracks; end of microfibril; microcrack formation; microfibrillar structure; rupture of taut tie molecules; strain to break; stress to break.

The fibrous material obtained by drawing or extrusion exhibits a more than linear increase in the axial elastic modulus with draw ratio, a much slower increase in tensile strength and a decrease in strain to break. The reason for such a behavior is found in the existence of structural defects of fibrous material, which is composed of very long and narrow microfibrillar ele-



ments. At their ends the axial connection by taut-tie molecules is almost completely interrupted. Hence the transfer of tensile stress through such a defect is only possible by lateral shift of the load to adjacent microfibrils. The incompleteness of this transfer, the excess straining of the material in the defect area, and the relatively easy axial displacement of the ends of microfibrils favor the local formation of microcracks which grow and coalesce with close-by microcracks until a critical size crack is formed and the strained sample fails. The process is favored by a high elastic modulus of microfibrils which is practically identical with that of the drawn or extruded sample. Hence the fibrous polymer fails at lower strain the higher its axial elastic modulus, i.e., the higher the draw ratio.

**19949.** Larche, F. C., Cahn, J. W., *Thermochemical equilibrium of multiphase solids under stress*, *Acta Metall.* **26**, 1579-1589 (1978).

Key words: coherent interfaces; equilibrium; incoherent interfaces; solid-fluid interface; stressed solid; thermodynamics; vacancies.

General conditions are derived for thermochemical equilibrium among multiphase and multicomponent network solids that are stressed nonhydrostatically and nonuniformly, and are in contact with each other and with fluids. Different multiphase equilibrium conditions are obtained depending on whether or not vacancies are present and which of three types of phase contact, coherent or incoherent solid-solid or solid-fluid interfaces, govern the constraints on displacement and mass transfer at these contacts. When no vacancies are present, Gibbs' result for the solid-fluid case is obtained and generalized. When vacancies are present, nonuniform and nonhydrostatic equilibrium is possible, but strong restrictions are placed on solid-fluid (all fluids must have the same pressure) and incoherent boundaries. A local equilibrium condition may be valid in some cases when vacancies prevent global equilibrium. Equilibria at coherent boundaries are unaffected by the presence or absence of vacancies, because vacancies behave like any other conserved chemical species there. The additional constraints at coherent boundaries reduce the number of degrees of freedom for phase equilibria.

**19950.** Ruff, A. W., *Measurements and standards for dry wear*, *Proc. Natl. Symp. on Wear and Corrosion*, Washington, DC, June 1979, 4 pages (American Chemical Society, Washington, DC, 1979).

Key words: corrosion; measurements; metals; standards; wear.

The needs for improved capability in accurately determining the wear rates of materials will be discussed. Activities currently underway to develop and provide reference materials for wear testing, to improve wear measurement procedures and to obtain meaningful wear data will be described. A comparison will be attempted in the current state-of-the-art between wear and corrosion.

**19951.** Rubin, R. J., *Comment on explicit integration method for the time-dependent Schrodinger equation*, *J. Chem. Phys.* **70**, No. 10, 4811 (May 15, 1979).

Key words: numerical integration; stability; time-dependent Schrodinger equation.

An argument is presented which disputes Askar and Cakmak's contention that their outline for a numerical method for explicit integration of the time-dependent Schrodinger equation is new and unconditionally stable.

**19952.** Reneker, D. H., Edelman, S., Dereggi, A., Vanderhart, D. L., *A nondestructive evaluation method using piezoelectric polymer transducers and Fourier transform vibrational spectroscopy*, (Proc. Int. Conf. on Polymer Processing, The Massa-

chusetts Institute of Technology, Cambridge, MA, Aug. 1977), Paper in *Science and Technology of Polymer Processing*, N. P. Suh and N. H. Sung, Eds., pp. 844-856 (The MIT Press, Cambridge, MA, 1979).

Key words: mechanical integrity; nondestructive evaluation; normal modes; orthopedic implants; piezoelectric polymer; plastics; vibrations.

The normal mode vibrational spectrum of a particular object contains a wealth of information about the mechanical integrity of the object. The nondestructive evaluation of objects by observation of such vibrational spectra is facilitated by the combination of recently developed low mass, high compliance piezoelectric polymer transducers, a synchronized method for exciting the sample, and a small minicomputer capable of making digital Fourier transforms. The sensitivity of this method is examined.

**19953.** Rebbert, R. E., Ausloos, P., *Decomposition of N<sub>2</sub>O over particulate matter*, *Geophys. Res. Lett.* **5**, No. 9, 761-764 (Sept. 1978).

Key words: catalysis; nitrous oxide; photochemistry; sand; surface reactions; tropospheric sink.

Nitrous oxide is shown to undergo both a thermal and a photochemical decomposition at 296 K when it is adsorbed on various dry sands. The photochemical process occurs with light of wavelengths greater than 280 nm where gaseous N<sub>2</sub>O does not absorb. At low pressures (< 0.1 torr) the half-life for the thermal decomposition of nitrous oxide to nitrogen when placed in contact with ~5 gms of heat treated Tunisian sand in a one-liter vessel was 350 ± 35 days. Under certain photolytic conditions this half-life was reduced. The efficiency of the photolytic process for a particular sand depends on the pressure (fraction of surface covered) and on the wavelength of light. For Tunisian sand at 1.1 torr and with the full mercury arc (> 280 nm), the destruction efficiency is ~2 × 10<sup>-5</sup> molecules/incident photon.

These results indicate that particulate matter in the troposphere may be responsible for the decomposition of nitrous oxide and hence act as an atmospheric sink for N<sub>2</sub>O. However, moisture causes a drastic reduction in the number of molecules dissociated per incident photon.

**19954.** Ogburn, F., *Preparation of calibration standards for coating thickness instruments*, *Proc. First American Electroplaters Society Symp. on Thickness Testing of Surface Finishing*, New York, NY, Feb. 28-Mar. 1, 1978, pp. 1-9 (American Electroplaters Society, Winter Park, FL, 1978).

Key words: calibration; calibration of thickness gages; calibration standards; coatings; coating thickness; coating thickness gages; coating thickness measurement; electrodeposited coatings; electrodeposition; thickness; thickness gages.

Coating thickness gages can be calibrated with specimens having adherent coatings of known thickness, with foils, or with synthetic standards. To prepare calibration standards with adherent coatings, the coatings must be plated with uniform thickness distribution. This requires a cell geometry providing an uniform primary current distribution and careful control of solution agitation, current efficiency, and polarization. Measurement of new standards with coating thickness gages perpetuates past measurement errors associated with the calibration and use of the measuring gage. It is preferable to use independent measurements such as microscopical measurements of coating cross-sections or coating weight measurements. To use a destructive measurement, each of a group of specimens is measured. The instrument is then calibrated by the destructive measurement of several specimens from the group. The thicknesses of the remaining specimens are obtained by interpolation from the earlier measurements. Microscopical measurements have significant



limitations and the technique of the operator must be checked against independent measurements. The preparation of accurate calibration standards requires careful plating and measurement techniques by a skilled and patient technician.

**19955.** Geist, J., **On the possibility of an absolute radiometric standard based on the quantum efficiency of a silicon photodiode**, (Proc. 23d Annual Int. Tech. Symp. of the SPIE, San Diego, CA, Aug. 27-30, 1979), Paper in *Measurements of Optical Radiations*, H. P. Field, E. F. Zalewski, and F. Zweibaum, Eds., 197, 75-83 (Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, 1979).

Key words: radiometric measurements; silicon photovoltaic; specific adsorption.

The physical mechanisms governing the behavior of silicon photovoltaic p-n junctions are reviewed from the point of view of using the internal quantum efficiency of such devices as absolute radiometric standards.

**19956.** Smyth, K. C., Schenck, P. K., Mallard, W. G., **What really does happen to electronically excited atoms in flames?**, *Proc. American Chemical Society Symp. Series No. 134, Laser Probes of Combustion Chemistry*, Washington, DC, Sept. 1979, pp. 175-181 (American Chemical Society, Washington, DC, 1980).

Key words: collisional ionization; opto-galvanic spectroscopy; sodium; state specific rate constants; two-photon.

In this paper we compare experimental results on the opto-galvanic spectra of high-lying d states in sodium with model calculations which incorporate ionization and quenching rates. The main conclusions are: (1) Hollander's "low" rate constant for sodium ionization is sufficient to model the opto-galvanic signal magnitudes as a function of excitation energy. Abnormally high rates are not required. (2) Essentially all ( $> 90\%$ ) of the sodium atoms excited to  $n \geq 7d$  are ionized at a flame temperature of 2000 K. For  $n = 7$  the energy needed for ionization  $2249 \text{ cm}^{-1}$ , which is approximately  $2kT$  ( $kT = 1390 \text{ cm}^{-1}$ ).

**19957.** Yates, J. T., Jr., Madey, T. E., **Prospectives for surface chemistry**, Paper in *ONR-37, Science, Technology, and the Modern Navy, Thirtieth Anniversary 1946-1976*, pp. 415-432 (Department of the Navy, Office of Naval Research, Arlington, Va, 1976); *Proc. Fourth Symp. on Fluid/Solid Surface Interactions, National Bureau of Standards, Gaithersburg, MD, Oct. 18-20, 1978*, pp. 121-149 (Commanding Officer, Naval Research Laboratory, Code 6170, Washington, DC 20375, 1980).

Key words: alloy catalysts; catalytic reactions; electron diffraction; electron spectroscopy; kinetics of surface processes; surface chemical analysis; surface chemistry; surface spectroscopy.

Recent historical developments in the field of surface chemistry are reviewed as a basis for future work within the field. The relationship of basic studies in surface chemistry and surface physics to technological applications is outlined.

**19958.** Ives, L. K., **Electron microscopy studies of wear in copper**, *Proc. Thirty-Seventh Annual EMSA Meeting, San Antonio, TX, Aug. 13-17, 1979*, pp. 452-543 (Electron Microscopy Society of America, Oak Ridge, TN, 1979).

Key words: abrasive wear; copper; erosive wear; scanning electron microscopy; transmission electron microscopy; wear.

Electron microscopy studies were conducted on copper surfaces worn under conditions of lubricated and nonlubricated sliding against solid contacts, sliding against abrasive sand ( $\text{SiO}_2$ ) particles, and solid particle erosion by  $\text{Al}_2\text{O}_3$  particles. Topographic and subsurface microstructural features associated with

the various wear modes are described. In all cases, the high contact stresses and accompanying strains led to the development of a layer of fine polycrystalline grains at the surface. This layer extended to a depth of a few micrometers below the surface. At greater depths, a dislocation cell structure was observed. Deformation twins were found near the surface of specimens worn by solid particle erosion. Embedment of abrasive particle fragments in the surface was characteristic of both the abrasive and erosive types of wear.

**19959.** Boettinger, W. J., Burdette, H. E., Kuriyama, M., **Energy dispersive XRF composition profiling using crystal collimated incident radiation**, (Proc. Conf. on Advances in X-ray Analysis, Denver, CO, July 30-Aug. 3, 1979), Paper in *Advances in X-ray Analysis* 23, pp. 209-217 (Plenum Publ. Corp., New York, NY, 1980).

Key words: chemical profiling; energy dispersive; macrosegregation; monochromatic incident x-ray beam; multiphase structure; x-ray fluorescence.

In order to measure changes in composition as a function of distance (macrosegregation) in directionally solidified two phase samples, a well collimated incident x-ray beam is required for XRF analysis. This is accomplished using Bragg diffraction of  $\text{AgK}\alpha$  radiation from a highly perfect Si crystal. Because the incident beam is also monochromatic, additional advantages are realized: a) the backgrounds caused by Compton and thermal diffuse scattering (TDS) of the incident beam are well localized in the energy spectrum and do not interfere with the fluorescent peaks, b) the TDS can be used as a monitor of the incident photon flux and hence eliminates often substantial errors caused by incident beam intensity fluctuations.

Using several prepared standards, the ratio of PbL counts to TDS counts was found to be a function of the total Pb content of the two phase microstructure, with a reproducibility determined only by counting statistics. Furthermore, the function was found to be nearly linear over a wide range of compositions. Standard methods of absorption or enhancement correction can be employed using this ratio. The spatial resolution, determined by profiling a sharp discontinuity between two metals, was 0.5 mm.

Macrosegregation data is presented for Pb-Sn two phase alloys whose compositions range from 35 wt % Pb to 70 wt % Pb. Comparison of compositions with those determined by a titration method agrees to within 2 wt % for most of the metallurgical structures present in the work. Somewhat larger deviations were found for samples with high Pb contents with extremely coarse two phase microstructures.

**19960.** Ives, L. K., **Microstructural changes in copper due to abrasive, dry, and lubricated wear**, *Proc. Int. Conf. on Wear of Materials, Dearborn, MI, Apr. 16-18, 1979*, pp. 246-255 (The American Society of Mechanical Engineers, New York, NY, 1979).

Key words: abrasive wear; copper; dry sliding wear; lubricated sliding wear; wear; wear debris.

Copper was exposed to wear under conditions of abrasive, dry, and lubricated sliding contact in air. An examination of surface morphology and subsurface microstructure was conducted by scanning and transmission electron microscopy methods in order to study the detailed nature of the wear process on a microscopic level. Wear debris fragments were also examined and the results correlated with surface and subsurface observations. A number of diverse characteristics specific to the particular wear condition were revealed. However, some features common to all wear conditions were found. In particular, a fine-grained polycrystalline structure was observed immediately below the surface on all specimens. This layer appears significant with regard to many of the wear-related processes.

19961. Crist, B. W., Smith, J. H., Hicho, G. E., **Fracture analysis of a pneumatically burst seamless-steel compressed gas container**, *Am. Soc. Test. Mater. Spec. Tech. Publ.* 667, pp. 734-745 (1979).

Key words: ductile fracture; fracture toughness; part-through crack; pneumatic burst; pressure vessel; steel.

This paper describes the fracture analysis of a seamless steel compressed gas container which burst at a reported pressure of 17.3 MPa (2500 psi) during filling. Design burst pressure was about 35.2 MPa (5100 psi). The container was made of a quenched and tempered carbon-manganese steel with yield and tensile strengths of 517 and 687 MPa (75,000 and 99,800 psi), respectively. The vessel had been in service for about 6 months and had been filled perhaps twice before it burst. The fracture origin was a pair of part-through cracks in a gouged region on the outside surface. Fracture at the origin was ductile and the fast fracture was also ductile. The empirical methodology developed at Battelle-Columbus for analyzing the burst of line pipe was utilized to analyze the ductile fracture initiation of this compressed gas container.  $K_{IC}$ ,  $J_{IC}$  and  $K_{IC}$  were estimated for this carbon-manganese pressure vessel steel.



## 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

- TN1113-1. Highway noise criteria study: Traffic noise data base, D. R. Flynn, C. R. Voorhees, and S. L. Yaniv, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 1113-1*, 381 pages (Apr. 1980) SN003-003-02169-5.
- TN1113-2. Highway noise criteria study: Outdoor/indoor noise isolation, P. R. Donavan, D. R. Flynn, and S. L. Yaniv, *Nat. Bur. Stand. (U.S.)*, *Tech. Note 1113-2*, 180 pages (Aug. 1980) SN003-003-02235-7.
19061. Chwirut, D. J., A simple technique for visualizing transmitted or reflected sound fields, *Mater. Eval.* 37, No. 13, 29-32 (Dec. 1979).
19071. Moldover, M. R., Waxman, M., Greenspan, M., Spherical acoustic resonators for temperature and thermophysical property measurements, (Proc. 6th European Thermophysical Properties Conf., Dubrovnik, Yugoslavia, June 26-30, 1978), *High Temp.—High Pressures* 11, 75-86 (1979).
19116. Mansbach, P. A., Corley, D. M., Errors due to temporal sampling, (Proc. American Society for Testing and Materials Symp. on Community Noise, Kansas City, MO, May 24-26, 1978), *Am. Soc. Test. Mater. Spec. Tech. Publ.* 692, pp. 172-182 (Nov. 1979).

## Analytical Chemistry

- Absolute isotopic abundance and the atomic weight of a reference sample of thallium, L. P. Dunstan, J. W. Gramlich, I. L. Barnes, and W. C. Purdy, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 1, 1-10 (Jan.-Feb. 1980).
- Pseudo-oxocarbons. Synthesis of 2,1,3-bis-, and 1,2,3-tris (dicyanomethylene) croconate salts. New bond-delocalized dianions, "Croconate Violet" and "Croconate Blue", A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.)*, 85, No. 2, 73-86 (Mar.-Apr. 1980).
- SP533. Characterization of particles. Proceedings of the Particle Analysis Session of the 13th Annual Conference of the Microbeam Analysis Society held at Ann Arbor, MI, June 22, 1978, K. F. J. Heinrich, Ed., *Nat. Bur. Stand. (U.S.)*, *Spec. Publ.* 533, 222 pages (Apr. 1980) SN003-003-02175-0.
- Characterization of particles, K. F. J. Heinrich, *SP533*, pp. 1-3 (Apr. 1980).
- Optical microscopy of particles, E. B. Steel, *SP533*, pp. 5-11 (Apr. 1980).
- Variation in x-ray intensity ratios used to identify asbestos fibers, J. C. Russ, *SP533*, pp. 13-19 (Apr. 1980).
- Quantitative analysis of small particles using wavelength and energy dispersive systems in an electron beam instrument, J. Gavrilovic, *SP533*, pp. 21-27 (Apr. 1980).
- Procedure for the quantitative analysis of single particles with the electron probe, J. A. Small, K. F. J. Heinrich, D. E. Newbury, R. L. Myklebust, and C. E. Fiori, *SP533*, pp. 29-38 (Apr. 1980).
- Monte Carlo electron trajectory simulation—An aid for particle analysis, D. E. Newbury, R. L. Myklebust, K. F. J. Heinrich, and J. A. Small, *SP533*, pp. 39-61 (Apr. 1980).
- Quantitative characterization of particulates by scanning and high voltage electron microscopy, R. J. Lee and R. M. Fisher, *SP533*, pp. 63-83 (Apr. 1980).
- Characterization of coal gasification particulates by SEM, EDS, AES, XPS, and its relevance to inhalation toxicology, D. L. Davidson and E. M. Gause, *SP533*, pp. 85-99 (Apr. 1980).
- Accuracy of electron microprobe analysis of biological fluids: Choice of standard solutions, and range of linearity of the

calibration curves, N. Roinel, L. Meny, and J. Henoc, *SP533*, pp. 101-130 (Apr. 1980).

Application of auger-electron spectroscopy and x-ray photoelectron spectroscopy to the characterization of pollutant particles, C. J. Powell, *SP533*, pp. 131-137 (Apr. 1980).

Secondary ion mass spectrometry for the analysis of single particles, D. E. Newbury, *SP533*, pp. 139-152 (Apr. 1980).

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- APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming; *NBSIR 80-2073*.
- APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming; software specifications; *NBSIR 80-2073.3*.
- APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming; *NBSIR 80-2073.2*.
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- Apatite; carbonate apatite; hydrolysis; impurities; octacalcium phosphate; sodium; tooth enamel; 19647.
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- Automated testing; continuous monitoring; nondestructive testing; radiography; signal processing; tomography; ultrasonics; *19475*.
- Automatic; digital-to-analog converter testing; gain; high resolution; linearity; noise; offset; static test set; analog-to-digital converter testing; *19075*.
- Automatic data processing; computer retrieval; data base retrieval; residential buildings; solar data base; solar energy system; solar heating and cooling; *NBSIR 80-2144*.
- Automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; *FIPS PUB 60-1*.
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- Automatic network analyzer; calibration; microwave; microwave measurements; six-port; *19303*.
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- Automatic sprinklers; building codes; building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; safety evaluation; smoke detection; *NBSIR 78-1555-1*.
- Automatic typewriters; cost effectiveness; typewriter evaluation; typewriter productivity; typewriters; word processing; *19565*.
- Automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming; APT; *NBSIR 80-2073.2*.
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- Automation; information systems; integrated systems; library automation; *19361*.
- Automation; instrumentation; microcomputer; minicomputer; analytical chemistry; *19411*.
- Automobile standards; design standards; economics of standards; health care standards; innovation; performance standards; standards; *NBS-GCR-80-287*.
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 Awards; computers; didymium glass filters; energy efficiency; inventors; innovation; labels; standards; sulfuric acid; tools; *DIM/NBS 64*, No. 7, 1-28 (1980).  
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 Bailey criterion; damage accumulation; failure; fatigue; mechanical properties; PMMA; polyethylene; poly(methyl methacrylate); time-dependent behavior; additivity of damage; *19690*.  
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 Bandwidth; laser diodes; material dispersion; mode scramblers; optical detectors; optical fibers; transfer function; *TN1019*.  
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 Bare electrodes; multichannel detectors; nondestructive evaluation; optical; temperature; trace elements; water; Alaskan pipeline; atmospheric chemistry; *DIM/NBS 64*, No. 9, 1-28 (1980).

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 Baryon resonances; delta-nucleus interaction; nuclear structure; pion absorption; pion nucleus interaction; pion scattering; *19221*.  
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 Beam instabilities; beam lifetime; bunch shape oscillations; electron storage ring; particle accelerator; synchrotron light source; *19437*.  
 Beam lead devices; electronic devices; hermeticity; hybrids; nondestructive tests; semiconductor; tape bonded devices; acoustic emission; *19108*.  
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- Benchmark analysis; ENDF/B-V; fuel cycle sensitivities; LWR data needs; *SP594*, pp. 1-5 (Sept. 1980).
- Benchmark cross sections; electron impact; He excitation; *n*<sup>1</sup>S levels of He; 19787.
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- Benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; economics; evaluation; literature search; regulation; standardization; standards; *NBSIR 80-2015*.
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- Benefit-cost analysis; combinatorial optimization; high-speed rail; mathematical models; modal split; network analysis; *NBSIR 79-1724*.
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- Beryllium; creep; dimensional instability; inertial guidance; microcreep; optical mirrors; 19896.
- Beryllium sequence; collision strength; effective Gaunt-factor; electron impact excitation; magnesium sequence; zinc sequence; 19353.
- Bessel functions; generalized asymptotic expansions; irregular singularities; Liouville-Green approximation; multiple asymptotic expansions; Stokes Phenomenon; WKB approximation; 19379.
- Between-laboratory precision; components of variance; duplicity; ideal conditions; measurement process; omnifariousness; precision; round robin; routine conditions; variance model; within-laboratory precision; accuracy; *SP591*, pp. 31-40 (Aug. 1980).
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- Bias factors; neutron transport; shielding; *SP594*, pp. 275-284 (Sept. 1980).
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- Bibliography; coal mines; electrical equipment; enclosures; explosion; explosion containment; mine safety; *NBSIR 80-2112*.
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- Bioclimatic chart; human comfort; indoor environment; outdoor environment; thermal comfort; 19923.
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- Biological matrix; bovine liver; certified reference materials; chromium; foods; interlaboratory study; standard reference materials; yeast; 19420.
- Biology and medicine; kerma factors; neutron dosimetry; absorbed dose; 19599.
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- Bootleg R&D; government laboratories; industrial management; R&D; R&D in World War II; 19506.
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- Breakdown curve; cyclopropane; photoionization; 19942.
- Break-even analysis; building economics; commercial buildings; economic feasibility; economic optimization; solar energy systems; active solar energy; 19350.
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- Bridges; calibration; current comparator; dissipation factor; electrical measurements; energy loss; shunt reactors; 19767.
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- Buckets; hashing; open addressing; worst case retrievals; 19060.
- Budget; calibration service; chain reactions; gamma rays; gas flow meters; microwaves; radio antennas; trace characterization; *DIM/NBS 64*, No. 3, 1-24 (1980).
- Budgets; economic analysis; enforcement; housing codes; personnel; *SP586*, pp. 135-148 (June 1980).
- Buffer gas; cavity pulling; frequency dependence; line inhomogeneity;  $Rb^{87}$  frequency standard; wall coating; 19517.
- Buffeting; buildings; buildings (codes); deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; 19121.
- Building; building codes; building design; disaster mitigation; earthquakes; engineering; standards; *NBSIR 80-2111-9*.
- Building; building codes; building design; earthquakes; engineering; standards; structural engineering; *NBSIR 80-2111-2*.
- Building; ice; load; roof; roof load; snow; solar collector; structural engineering; *NBS-GCR-79-180*.
- Building acoustics; environmental pollution; noise control; noise isolation; sound; acoustics; *TN1113-2*.
- Building automation; building controls; building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; *NBSIR 80-2065*.
- Building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy; 19729.
- Building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy; *SP586*, pp. 181-185 (June 1980).
- Building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy; *NBSIR 79-1957*.
- Building code enforcement; buildings; design; energy conservation; housing codes; regulatory approaches; *SP586*.
- Building codes; building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; safety evaluation; smoke detection; automatic sprinklers; *NBSIR 78-1555-1*.
- Building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; *SP585*.
- Building codes; building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; *NBSIR 80-1965*.
- Building codes; building design; disaster mitigation; earthquakes; engineering; standards; building; *NBSIR 80-2111-9*.
- Building codes; building design; earthquakes; engineering; standards; structural engineering; building; *NBSIR 80-2111-2*.
- Building codes; building economics; cost estimation; economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; *BSSI29*.
- Building codes; building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation; *SP586*, pp. 205-224 (June 1980).
- Building codes; building inspectors; code enforcement; course



- development; educational requirements; inspection; licensing; testing; training code officials; *SP586*, pp. 71-83 (June 1980).
- Building codes; building laws and regulations; code development; court decisions; legal basis; liability; regulation; regulatory impacts; technology; *NBS-GCR-80-286*.
- Building codes; building regulations; building technology; economics; rehabilitation; *19160*.
- Building codes; building standards; dimensional coordination; metrication; regulatory coordination; standardization and international harmonization; *19518*.
- Building (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology); *BSS124*.
- Building codes; conversion strategies; harmonization; metrication; metric transition; *SP586*, pp. 227-251 (June 1980).
- Building codes; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; optimization; renovation; applied economics; *NBSIR 79-1929*.
- Building collapse; ice; snow; wind; *SP586*, pp. 259-270 (June 1980).
- Building components; building materials; durability; life testing; prediction; recommended practice; reliability service life; accelerated aging tests; *TN1120*.
- Building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; safety evaluation; smoke detection; automatic sprinklers; building codes; *NBSIR 78-1555-1*.
- Building controls; building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; building automation; *NBSIR 80-2065*.
- Building departments; building inspection; code administration; Indiana building code enforcement; local government; political appointments; survey of local building departments; *SP586*, pp. 33-42 (June 1980).
- Building design; building energy performance standards; building standards; component performance standards; energy conservation; housing; *NBSIR 80-2161*.
- Building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; *SP585*.
- Building design; building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; *NBSIR 80-1965*.
- Building design; computer analysis; energy conservation; HVAC loads; thermal insulation; thermal performance; *NBSIR 80-2076*.
- Building design; construction economics; discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; *SP544*.
- Building design; disaster mitigation; earthquakes; engineering; standards; building; building codes; *NBSIR 80-2111-9*.
- Building design; earthquakes; engineering; standards; structural engineering; building; building codes; *NBSIR 80-2111-2*.
- Building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; *NBSIR 79-1948*.
- Building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning; applied economics; *NBSIR 80-1977*.
- Building economics; buildings; building systems standard; cost; discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; *NBSIR 80-2040*.
- Building economics; commercial buildings; economic feasibility; economic optimization; solar energy systems; active solar energy; break-even analysis; *19350*.
- Building economics; commercial buildings; investment analysis; life-cycle cost analysis; passive solar energy; retrofit; revitalization; solar energy systems; benefit-cost analysis; *BSS125*.
- Building economics; construction; cost estimation; econometric models; economic analysis; engineering economics; mathematical models; program planning; *NBS-GCR-80-197*.
- Building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; *NBSIR 80-2167*.
- Building economics; cost estimation; economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; *BSS129*.
- Building economics; discounting; economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; *H132*.
- Building economics; economic analysis; energy conservation; windows; *19073*.
- Building energy; computerized climate data; *BSS126*.
- Building energy calculations; hourly climate data; test reference (TRY); *19224*.
- Building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; building automation; building controls; *NBSIR 80-2065*.
- Building energy performance standards; building standards; component performance standards; energy conservation; housing; building design; *NBSIR 80-2161*.
- Building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating; *19235*.
- Building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; *NBSIR 79-1948*.
- Building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; *SP585*.
- Building fires; building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; *NBSIR 80-1965*.
- Building fires; cable fires; compartment fires; decision analysis; fabric flammability; fire suppression; fire tests; flame research; smoke detectors; toxicity; bibliographies; *NBSIR 80-2114*.
- Building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; *NBSIR 80-2004*.
- Building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation; building codes; *SP586*, pp. 205-224 (June 1980).
- Building fires; computer-aided design; environmental psychology; fire research; fire safety; human behavior in fires; modeling technique; programming; simulation of human behavior; architectural research; *NBSIR 80-1982*.
- Building fires; doors; egress; evacuation; fire departments; fire fighters; fire investigations; mattresses; smoke; apartments; *NBS-GCR-79-187*.
- Building fires; electrical fires; explosions; fire investigations; fire investigators; hydrocarbons; photography; accelerants; arson; *H134*.
- Building fires; fire resistance; fire tests; flow measurement; gas temperatures; heat release rate; interior finishes; residential buildings; room fires; *NBSIR 80-2120*.



Building fires; fire tests; flow measurement; furniture; interior finishes; residential buildings; room fires; static pressure; *NBSIR 80-1984*.

Building heat transfer; energy conservation; passive solar heating, cooling, and performance monitoring; *19819*.

Building illumination systems; energy budget; energy conservation; energy performance criteria; illumination; lighting; power budget; *NBSIR 80-2052*.

Building inspection; code administration; Indiana building code enforcement; local government; political appointments; survey of local building departments; building departments; *SP586*, pp. 33-42 (June 1980).

Building inspectors; code enforcement; course development; educational requirements; inspection; licensing; testing; training code officials; building codes; *SP586*, pp. 71-83 (June 1980).

Building laws and regulations; code development; court decisions; legal basis; liability; regulation; regulatory impacts; technology; building codes; *NBS-GCR-80-286*.

Building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; building fires; *SP585*.

Building management; egress; emergencies; escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; building fires; *NBSIR 80-1965*.

Building materials; durability; life testing; prediction; recommended practice; reliability service life; accelerated aging tests; building components; *TN1120*.

Building materials; economic analysis; housing; lead-based paint; lead poisoning; applied economics; building economics; *NBSIR 80-1977*.

Building models; building performance data; computer simulations, building; energy conservation in commercial buildings; heat pumps; validation of computer models, buildings; *NBSIR 80-2093*.

Building module; controlling dimensions; coordinating sizes; dimensional coordination; metric building design; metric building products; modular coordination; *19516*.

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Building products; certification; laboratory accreditation; *SP591*, pp. 146-155 (Aug. 1980).

Building regulations; building standards development; consensus standards; development of standards; structural design standards; *19091*.

Building regulations; building technology; economics; rehabilitation; building codes; *19160*.

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Building research; building technology; codes; criteria; project summaries; standards; technical bases; *SP446-4*.

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Buildings; environment; health; measurements; radiation; radon; radon daughters; ventilation; *SP581*.

Buildings (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology); *19835*.

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Building standards; dimensional coordination; metrication; regulatory coordination; standardization and international harmonization; building codes; *19518*.

Building standards development; consensus standards; development of standards; structural design standards; building regulations; *19091*.

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Building technology; codes; criteria; project summaries; standards; technical bases; building research; *SP446-3*.

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Built-up roofs; measurement technology; moisture accumulation; nondestructive tests; thermal resistance; *NBSIR 80-2100*.

Bulk measurements; material control and accounting; nondestructive assay; nuclear material measurements; precision; research and development; safeguards; accuracy; *19705*.

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- Calibration; coincidence counter; neutron; nondestructive assay; precision; random driver; stability; uranium; *SP582*, pp. 201-220 (June 1980).
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- Calibration; diagnostic x-rays; electrical measurements; health; radiation; radiation safety; safety; x rays; *NBSIR 80-2072*.
- Calibration; distance; fifth wheel; inspection; measured course; odometer; taximeter; test procedure; tire pressure; tolerances; *H137*.
- Calibration; dosimetry; high-energy bremsstrahlung; operational characteristics; radiation therapy; recommendations; selection of thermoluminescence dosimetry system; survey; thermoluminescence; United States; *TN1119*.
- Calibration; eddy currents; magnetic particles; nondestructive evaluation; radiography; traceability; ultrasonics; visual testing; acoustic emission; *NBSIR 80-2109*.
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- Calibration; flatness; intercomparison; random error; squareness; standard deviation; systematic error; uncertainty; angle block; autocollimator; *NBSIR 80-1967*.
- Calibration; image quality indicator; nondestructive testing; radiography; sensitivity; standards; ultrasonics; *19877*.
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- Calibration interval; calibration interval algorithms; calibration requirements; decision table; interval adjustment; measurement; metrology; PMTE; recall intervals; *NBS-GCR-80-283*.
- Calibration interval algorithms; calibration requirements; decision table; interval adjustment; measurement; metrology; PMTE; recall intervals; calibration interval; *NBS-GCR-80-283*.
- Calibration laboratory; certification; evaluation; inspection; audit; calibration; *SP591*, pp. 41-44 (Aug. 1980).
- Calibration labs; calibration, out-of-service; central calibration; in situ calibration; measurement; metrology; on-site calibration; PMTE; *NBS-GCR-80-282*.
- Calibration of thickness gages; calibration standards; coatings; coating thickness; coating thickness gages; coating thickness measurement; electrodeposited coatings; electrodeposition; thickness; thickness gages; calibration; *19954*.
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- Calibration-quality standards; density; electrical conductance; molten salts; potassium nitrate; sodium chloride; surface tension; viscosity; *JPCRD 9*, No. 4, 791-830 (1980).
- Calibration report; correction to mass measurements; error checking; FORTRAN program; least squares solution; mass calibration; mass measurement; *TN1127*.
- Calibration requirements; decision table; interval adjustment; measurement; metrology; PMTE; recall intervals; calibration interval; calibration interval algorithms; *NBS-GCR-80-283*.
- Calibrations; collaborative reference programs; laboratory performance; measurement assurance; measurement evaluation technology; measurement services; physical standards; proficiency testing; standard reference materials; testing; traceability; *SP591*, pp. 15-22 (Aug. 1980).
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- Calibration standards; coatings; coating thickness; coating thickness gages; coating thickness measurement; electrodeposited coatings; electrodeposition; thickness; thickness gages; calibration; calibration of thickness gages; *19954*.
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- Calorimetry; damage; electric field; high energy laser; laser damage; reflectors; thin film; absorption; *SP568*, pp. 377-390 (July 1980).
- Calorimetry; electrolytes; enthalpy of dilution; heat; hydrochloric acid; lithium chloride; relative apparent molal enthalpy; relative partial molal enthalpy; sulfuric acid; thermochemistry; *J. Res. 85*, No. 1, 11-17 (Jan.-Feb. 1980).
- Calorimetry; enthalpy of solution; KCl; solution calorimetry; standard reference materials; thermochemistry; tris(hydroxymethyl)aminomethane; *J. Res. 85*, No. 6, 467-481 (Nov.-Dec. 1980).
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- Calorimetry,  $\Delta C_p$ , endothermic reaction; enthalpy of dilution; enthalpy of solution; KCl; SRM 1655; standard reference material; thermochemistry; adiabatic calorimeter; *J. Res. 85*, No. 6, 449-465 (Nov.-Dec. 1980).
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- Communications equipment standard; compatibility; interchangeability; law enforcement; microphone cable; microphone connector; mobile FM transceiver; 19701.
- Communications networks; CROSSFIRE; link protocols; local survivability; *NBSIR 80-2149*.
- Communications security; computer security; cryptography; Data Encryption Standard; in-service testing; maintenance tests; Monte-Carlo testing; stuck-fault testing; test cases; validation vs. maintenance; *SP500-61*.
- Communications security; computer security; cryptography; encryption standard; interface requirements; Monte-Carlo testing; testbed; test cases; validating correctness; *SP500-20, Revised 1980*.
- Communications technology; computer networks; computer technology; data entry; distributed processing; Educational Resources Information Center (ERIC); information systems; intelligent terminals; mass storage technology; microfiche; micrographics; *NBSIR 80-2005*.
- Community noise; measurement errors; noise; noise exposure; sampling (temporal); statistics; time-varying signals; 19116.
- Compact range; data; daylighting; energy; environmental; shale oil; SRM; weights and measures; x-ray exams; *DIM/NBS 64*, No. 6, 1-24 (1980).
- Compact tabulation; critical evaluation; hydrogen through iron; selected transition probabilities; atomic oscillator strengths; 19824.
- Comparative study; local area network; performance; communications; *SP500-65*, pp. 87-97 (Oct. 1980).
- Comparison; existing buildings; housing codes; model codes; performance levels; regulations; rehabilitation; code provisions; *SP586*, pp. 117-133 (June 1980).
- Comparison; performance of computer systems; UNIX; upgrading changes; *SP500-65*, pp. 233-243 (Oct. 1980).
- Comparison; total neutron spectra; Al and Nb; *SP594*, pp. 73-77 (Sept. 1980).
- Comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance; collector efficiency; 19239.
- Comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance; collector efficiency; 19325.
- Comparison neutron yields; GELINA; HELIOS; KFK; ORELA; PSR; "white" neutron sources; WNR; *SP594*, pp. 920-928 (Sept. 1980).
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- Comparison to experimental data; coupled channels model calculation; nuclear reactions; *SP594*, pp. 52-57 (Sept. 1980).
- Comparison with calculated excitation functions; inferred level cross sections for 22 states; measured  $\sigma_{\gamma}(\text{E}_{\gamma}, 125^{\circ})$ ; nuclear reactions  $^{232}\text{Th}(\text{n},\text{n}'\gamma)$ ; time-of-flight; *SP594*, pp. 685-689 (Sept. 1980).



Comparison with He<sup>3</sup>, Ne; critical anomaly; dielectric constant; differential capacitance cell; SF<sub>6</sub>; 20 microK thermostat; 19484.

Compartment fires; decision analysis; fabric flammability; fire suppression; fire tests; flame research; smoke detectors; toxicity; bibliographies; building fires; cable fires; *NBSIR 80-2114*.

Compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; test methods; building fires; *NBSIR 80-2004*.

Compatibility; interchangeability; law enforcement; microphone cable; microphone connector; mobile FM transceiver; communications equipment standard; 19701.

Competition; Experimental Technology Incentives Program; government policy; innovation; semiconductor industry; technological change; *NBS-GCR-ETIP 80-91*.

Competition; economics of standards; law; standards; antitrust; certification; *NBSIR 79-1921*.

Competitive reactions; complex reactions; heating rate; independent reactions; kinetics; lifetime prediction; nonisothermal kinetics; thermal analysis; activation energy; 19267.

Compilation of solubility data; disproportionation of mercury (I); electromotive force measurements; mercury (I) chloride; solubility; solubility product; standard electrode potentials; standard thermodynamic functions; *JPCRD 9*, No. 4, 1307-1330 (1980).

Complete damping; consistency; coupled channels; integral data; microscopic data analysis; *SP594*, pp. 862-866 (Sept. 1980).

Complexometric titration of uranium and thorium; dissolution of nuclear fuel-cycle materials; half lives plutonium isotopes; plutonium and thorium; plutonium reference materials; assay of uranium; automated controlled-potential analyzer; *SP582*, pp. 129-139 (June 1980).

Complex reactions; decomposition; degradation; durability; heating rates; initial rates; kinetics; lifetime prediction; polystyrene; polyurethane; pyrolysis; stability; thermal analysis; thermogravimetry; accelerated aging; 19752.

Complex reactions; heating rate; independent reactions; kinetics; lifetime prediction; nonisothermal kinetics; thermal analysis; activation energy; competitive reactions; 19267.

Compliance; discriminant analysis; game theory; law enforcement; taxation; utility; audit; behavior; *NBSIR 79-1711*.

Compliance analysis; curved crack profile; double-torsion testing; fracture (materials); fracture toughness; side grooves; three-dimensional crack; torsional beam; 19693.

Compliance analysis; curved crack profile; double-torsion testing; fracture (materials); fracture toughness; side grooves; three-dimensional crack; torsional beam; 19684.

Compliance testing; laboratory criteria; product certification; proficiency testing; quality control; standardization; testing laboratory; accreditation; *NBSIR 79-1956*.

Component level bus; local area networks; microcomputer bus; microcomputer interfacing; microcomputer standards; backplane bus; *NBS-GCR-80-288*.

Component performance standards; energy conservation; housing; building design; building energy performance standards; building standards; *NBSIR 80-2161*.

Components of variance; duplicity; ideal conditions; measurement process; omnifariousness; precision; round robin; routine conditions; variance model; within-laboratory precision; accuracy; between-laboratory precision; *SP591*, pp. 31-40 (Aug. 1980).

Composite; cyanoacrylate; dental alloy; initiator; rator; resin; wear; alloy; base metal; casting; *NBSIR 79-1943*.

Composite; elastic constants; sound velocity; boron-aluminum; 19212.

Composite materials; corrosion fatigue; dislocations; fatigue mechanism; fracture mechanics; mathematical modeling; micromechanics; polymers; quantitative microscopy; slip bands; statistical aspects of fatigue; striations; 19087.

Composite materials; corrosion fatigue; durability; fatigue; fatigue mechanism; fatigue research; fracture mechanics; mathematical modeling; metals fatigue; plastics fatigue; quantitative microscopy; statistical aspects of fatigue; 19448.

Composite restorative resins; dimethylaminogluthethimide; dimethylaminophenylacetic acid and esters; properties of composites; tertiary aromatic amines; amine accelerators; 19072.

Composites; coupling agent; dental adhesion; PolySAM; adsorption; chemisorption; 19658.

Composites; degradation resistance; fiberglass/epoxy; fiber reinforced composites; graphite/polysulfone; orthopedic materials; PECF; polymer matrix; polypropylene; polysulfone; aromatic polyamide fiber; autoclave stability; biomaterial; 19689.

Composites; durability; eutectics; Rayleigh waves; stability; surface anisotropy; 19153.

Composition; crystal structure; grain size; molybdenum thin films; reflectance; chemical vapor deposition; *SP568*, pp. 287-292 (July 1980).

Compound interest; inequalities; rearrangements inequality; arithmetic-geometric mean inequality; 19381.

Compound-nucleus reactions; cross sections; elastic enhancement factors; factorization; Hauser-Feshbach theory; statistical models; width fluctuation correction factor; *SP594*, pp. 762-764 (Sept. 1980).

Comprehensive evaluation; ENDF format; optical-model interpretations; *SP594*, pp. 829-833 (Sept. 1980).

Comprehensive strength of amalgam; density of dental amalgam; dental amalgam; dimensional change in dental amalgam; mercury/alloy ration in dental amalgam; mercury content in dental amalgam; zinc in dental amalgam; 19632.

Compressed gas; corona; electron avalanche; inception voltage; ionization; ion mobilities; partial discharge; photodetachment; space charge; sulfur hexafluoride (SF<sub>6</sub>); uv radiation; 60 Hz ac and dc; 19786.

Compressibility; density; ethylene; melting pressures; PVT; vapor pressure; 19682.

Compressibility; finite elasticity; modulus; rubber; shear; bulk modulus; 19886.

Compressibility; piezoelectricity; plasma; polarization; poly(vinylidene fluoride); pyroelectricity; thermal expansion; charge; 19324.

Compressional (P) modes; cracks; defect characterization; dimensioning; one-transducer technique; shear (S) mode; ultrasonic diffraction; welds; *NBSIR 80-1983*.

Compressive failure; laser damage; plastic flow; sapphire; thermomechanical analysis; *SP568*, pp. 141-149 (July 1980).

Compressive strength; control charts; in-house quality control; quality control system; cement and concrete reference laboratory; cement and concrete testing; *SP591*, pp. 109-123 (Aug. 1980).

Compressive strength; exposure to geothermal fluids; geothermal-well cements; permeability to water; shear-bond strength to steel; splitting tensile strength; *NBSIR 80-2099-2*.

Compressive strength; geothermal well; hydrothermal exposure; splitting-tensile strength; cement; *NBSIR 80-2099-1*.

Compton scattering; gamma rays; pair production; photoelectric absorption; photons; triplet production; x rays; attenuation coefficient; coherent scattering; *JPCRD 9*, No. 4, 1023-1148 (1980).

Compute-and-test loop; CPU transfer rates; I/O performance; overhead CPU; *SP500-65*, pp. 245-254 (Oct. 1980).

Computer; data; digital; Ethernet; local; network; terminal; area; 19126.

Computer; energy; heat transfer; hot water; measurement; modeling; solar; testing; 19375.

Computer; energy; heat transfer; hot water; measurement; modeling; solar; testing; 19459.

Computer; energy; heat transfer; hot water; measurement; modeling; solar; testing; 19498.

Computer; evaluation; Federal Information Processing Standards Publication; measurement; performance; remote batch; selection; service; analysis; *FIPS PUB 72*.

Computer; instrumentation; laboratory automation; scientific



- computation; *19133*.
- Computer access; computer networks; minicomputers; protocols; user interfaces; command languages; communications; *SP500-68*.
- Computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation; building codes; building fires; *SP586*, pp. 205-224 (June 1980).
- Computer-aided design; environmental psychology; fire research; fire safety; human behavior in fires; modeling technique; programming; simulation of human behavior; architectural research; building fires; *NBSIR 80-1982*.
- Computer aided manufacturing; NC machining; NC programming; numerical control; part programming; APT; automation; *NBSIR 80-2073.2*.
- Computer aided manufacturing; NC machining; NC programming; numerical control; part programming; software specifications; APT; automation; *NBSIR 80-2073.3*.
- Computer aided manufacturing; NC machining; NC programming; numerical control; part programming; APT; automation; *NBSIR 80-2073*.
- Computer analysis; energy conservation; HVAC loads; thermal insulation; thermal performance; building design; *NBSIR 80-2076*.
- Computer applications; computer programs; data administration; database management; database standards; data processing; data resource management; Federal Information Processing Standards Publication; file processing; software; software selection; *FIPS PUB 77*.
- Computer applications; computer reliability; computer security; data confidentiality; data integrity; data security; Federal Information Processing Standards Publication; security controls; system life cycle; system security; ADP availability; ADP security; *FIPS PUB 73*.
- Computer architecture; computer hardware; computer computer mass storage systems; computers; computer storage; *NBS-GCR-80-278*.
- Computer architecture; modular expansion analysis; performance evaluation; performance modeling; queueing models; queueing networks; approximate queueing models; *SP500-69*.
- Computer assessment; crystal structures; epitaxy; inter-layerings; nonstoichiometry; structural considerations; twinning; *J. Res. 85*, No. 5, 347-362 (Sept.-Oct. 1980).
- Computer-assisted coulometry; controlled-potential coulometry; control-potential adjustment; electrical calibration; plutonium; plutonium determination; *SP582*, pp. 164-168 (June 1980).
- Computer-Based Message Systems; computer based office systems; office automation; CBMS; communications; *NBS-GCR-80-210*.
- Computer based office systems; office automation; CBMS; communications; Computer-Based Message Systems; *NBS-GCR-80-210*.
- Computer-based system; dynamic concentration measurements; inventory control; nondestructive measurements; on-line real-time measurements; plutonium concentration and isotopics determinations; reprocessing plant process control; uranium; *SP582*, pp. 584-601 (June 1980).
- Computer code; depth-dose data; electron bremsstrahlung; electrons; protons; space shielding; *TN1116*.
- Computer communications; computer networking; data communications; networks; performance requirements; telecommunications; *SP500-65*, pp. 71-75 (Oct. 1980).
- Computer communications; computer networks; computer protocols; data communications; local area networks; *19124*.
- Computer communications; computer networks; data communications; data networks; local area networks; networks; communications; *19125*.
- Computer comparison; computer measurement; computer service; data analysis; performance evaluation; ranking and selection; selection methodology; binary selection; *SP500-58*.
- Computer computer mass storage systems; computers; computer storage; computer architecture; computer hardware; *NBS-GCR-80-278*.
- Computer dissemination; crystal data; identification; materials analysis; materials design; NBS crystal data center; user evaluation; *TN1112*.
- Computer fraud; computer security; job tracking; security violations; SMF retrieval; audit trails; *SP500-65*, pp. 33-46 (Oct. 1980).
- Computer hardware; computer computer mass storage systems; computers; computer storage; computer architecture; *NBS-GCR-80-278*.
- Computer installation; workload; capacity planning; *SP500-65*, pp. 199-203 (Oct. 1980).
- Computerized axial tomography; Fresnel zone; holographic reconstruction; imaging; laminagraphy; nondestructive testing; radiography; three-dimensional radiography; tomography; x-ray laser; *19855*.
- Computerized climate data; building energy; *BSS126*.
- Computerized data bases; information storage and retrieval systems; libraries-automation; machine-readable bibliographic data; bibliographic data bases; *NBSIR 80-2133*.
- Computer measurement; computer service; data analysis; performance evaluation; ranking and selection; selection methodology; binary selection; computer comparison; *SP500-58*.
- Computer model; electric utilities; Experimental Technology Incentives Program; financial projections; productivity; regulatory commissions; regulatory process; technological innovation; *NBS-GCR-ETIP 79-74*.
- Computer models; electric utilities; Experimental Technology Incentives Program; marginal costing; rate structure; regulatory commissions; regulatory process; technological innovation; time varying rates; *NBS-GCR-ETIP 79-79*.
- Computer networking; computer security; controlled access; identification; passwords; personal authentication; *19825*.
- Computer networking; data communications; networks; performance requirements; telecommunications; computer communications; *SP500-65*, pp. 71-75 (Oct. 1980).
- Computer networking; data conversion; data transfer; data transformation; data translation; network operating systems; *SP500-71*.
- Computer network protocols; design specification; formal specification; network architecture; networking; session protocols; transport protocols; communication protocols; *NBS-GCR-80-246*.
- Computer network protocols; feature analysis; file access function; file manipulation function; network architecture; common command language; communication protocols; *NBS-GCR-80-256*.
- Computer network protocols; feature analysis; network architecture; networking; session protocol; transport protocols; communication protocols; *NBS-GCR-80-245*.
- Computer network protocols; network architecture; networking; protocol design specification; session protocols; transport protocols; communication protocols; *NBS-GCR-80-289*.
- Computer networks; computer protocols; data communications; local area networks; computer communications; *19124*.
- Computer networks; computer technology; data entry; distributed processing; Educational Resources Information Center (ERIC); information systems; intelligent terminals; mass storage technology; microfiche; micrographics; optical character recognition; *NBSIR 80-2005*.
- Computer networks; data communications; data networks; local area networks; networks; communications; computer communications; *19125*.
- Computer networks; minicomputers; protocols; user interfaces; command languages; communications; computer access; *SP500-68*.
- Computer Performance Management Technical Center; CPM project officer; Air Force Data Systems Design Center; *SP500-65*, pp. 295-300 (Oct. 1980).
- Computer performance evaluation; ADP management; *SP500-65*, pp. 289-293 (Oct. 1980).



- Computer performance evaluation; computer performance management; computer performance measurement; standard performance measures; ADP installation management; ADP installation models; *19051*.
- Computer performance evaluation; computer performance measurement; computer performance prediction; computer system acquisition; CPE in auditing; installation management; on-line system evaluation; queuing models; simulation; workload definition; benchmarking; *SP500-65*.
- Computer performance evaluation; data processing performance; data processing service; information system design; information system usability; performance management; *SP500-65*, pp. 265-276 (Oct. 1980).
- Computer performance management; computer performance measurement; standard performance measures; ADP installation management; ADP installation models; computer performance evaluation; *19051*.
- Computer performance measurement; computer performance prediction; computer system acquisition; CPE in auditing; installation management; on-line system evaluation; queuing models; simulation; workload definition; benchmarking; capacity planning; *SP500-65*.
- Computer performance measurement; standard performance measures; ADP installation management; ADP installation models; computer performance evaluation; computer performance management; *19051*.
- Computer performance prediction; computer system acquisition; CPE in auditing; installation management; on-line system evaluation; queuing models; simulation; workload definition; benchmarking; capacity planning; computer performance evaluation; *SP500-65*.
- Computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; *FIPS PUB 61*.
- Computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; *FIPS PUB 60-1*.
- Computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces; operational specifications for magnetic tape subsystems; automatic data processing (ADP); channel level power control interface; *FIPS PUB 62*.
- Computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; Federal Information Processing Standards Publication; software; *FIPS PUB 76*.
- Computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; software; *NBSIR 80-2115*.
- Computer program; decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering; codes; *NBS-GCR-80-258*.
- Computer program; decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering; codes; *NBS-GCR-80-257*.
- Computer program; deviation plots; equation of state; helium II; mathematical model; superfluid; thermodynamic properties; *TN1029*.
- Computer program; electrical properties of silicon; Hall effect; mobility; resistivity; silicon; carrier density; *SP400-63*.
- Computer program; electric utilities; ETIP; financial projections; regulatory commissions; regulatory process; technological innovation; *NBS-GCR-ETIP 79-73*.
- Computer program; finite automata; formal description technique; graphs; natural language; Petri net; state diagram; action table; *NBS-GCR-80-247*.
- Computer program; fitting Gaussian profiles; incomplete charge collection; lithium-drifted silicon detector; sequential simplex procedure; x-ray spectra; *19130*.
- Computer programs; contention; CSMA; GPSS; local area networks; packet switching; simulation; bus networks; bus performance; *SP500-65*, pp. 79-85 (Oct. 1980).
- Computer programs; corrections; energy distribution; finite geometry; Monte Carlo method; multiple scattering; neutron scattering; angular distribution; *SP594*, pp. 504-508 (Sept. 1980).
- Computer programs; data administration; database management; database standards; data processing; data resource management; Federal Information Processing Standards Publication; file processing; software; software selection; computer applications; *FIPS PUB 77*.
- Computer programs; data analysis; data base management; data retrieval; information retrieval; MIS; on-line retrieval; *19884*.
- Computer programs; density; enthalpy; entropy; equation of state; heat capacity at constant pressure; heat capacity at constant volume; helium; hydrogen; methane; neon; nitrogen; oxygen; thermal conductivity; velocity of sound; viscosity; argon; *TN1025*.
- Computer programs; electric utilities; Experimental Technology Incentives Program; interim adjustment procedures; regulatory commissions; regulatory process; *NBS-GCR-ETIP 79-77*.
- Computer programs; least squares; regression; statistics; test problems; algorithms; *19158*.
- Computer protocols; data communications; local area networks; computer communications; computer networks; *19124*.
- Computer reliability; computer security; data confidentiality; data integrity; data security; Federal Information Processing Standards Publication; security controls; system life cycle; system security; ADP availability; ADP security; application system security; *FIPS PUB 73*.
- Computer retrieval; data base retrieval; residential buildings; solar data base; solar energy system; solar heating and cooling; automatic data processing; *NBSIR 80-2144*.
- Computers; computer storage; computer architecture; computer hardware; computer mass storage systems; *NBS-GCR-80-278*.
- Computers; data acquisition; electron linac; gas scintillator; inelastic neutron scattering; majority logic; neutron cross sections; prebuncher; pulsed neutron source; time-of-flight; *SP594*, pp. 929-935 (Sept. 1980).
- Computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; national government; representations and codes; standards; statistical data; ADP standards; *FIPS PUB 6-3*.
- Computers; data processing; gamma-ray spectroscopy; x-ray spectroscopy; activation analysis; *19128*.
- Computers; didymium glass filters; energy efficiency; inventors; innovation; labels; standards; sulfuric acid; tools; awards; *DIM/NBS 64*, No. 7, 1-28 (1980).
- Computers; digital electronics; Josephson effect; quantum interference; superconductivity; aerospace; *19405*.
- Computers; electrical wiring; radiation exposure; solar absorber coatings; SRM's; structural safety; automation; *DIM/NBS 64*, No. 8, 1-28 (1980).
- Computers; emissions testing; energy; fundamental constants; gas; grants; marketplace; measurement seminars; photon-recoil components; SRM's; atomic properties; *DIM/NBS 64*, No. 1, 1-24 (1980).
- Computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; computer peripherals; *FIPS PUB 60-1*.
- Computers; Federal Information Processing Standard; input/output; interfaces; automatic data processing (ADP); channel level power control interface; computer peripherals; *FIPS PUB 61*.
- Computers; Federal Information Processing Standard; input/output; interfaces; operational specifications for magnetic tape subsystems; automatic data processing (ADP); channel level power control interface; computer peripherals; *FIPS PUB 62*.



- Computer security; controlled access; identification; passwords; personal authentication; computer networking; 19825.
- Computer security; cryptography; Data Encryption Standard; in-service testing; maintenance tests; Monte-Carlo testing; stuck-fault testing; test cases; validation vs. maintenance; communications security; *SP500-61*.
- Computer security; cryptography; data security; DES; encryption; modes of operation; *NBSIR 80-2019*.
- Computer security; cryptography; encryption standard; interface requirements; Monte-Carlo testing; testbed; test cases; validating correctness; communications security; *SP500-20, Revised 1980*.
- Computer security; data confidentiality; data integrity; data security; Federal Information Processing Standards Publication; security controls; system life cycle; system security; ADP availability; ADP security; application system security; computer applications; *FIPS PUB 73*.
- Computer security; job tracking; security violations; SMF retrieval; audit trails; computer fraud; *SP500-65*, pp. 33-46 (Oct. 1980).
- Computer service; data analysis; performance evaluation; ranking and selection; selection methodology; binary selection; computer comparison; computer measurement; *SP500-58*.
- Computer simulation; conformal solution theory; mixing rules; mixture; nonequilibrium molecular dynamics; Van der Waals 1 theory; viscosity; 19180.
- Computer simulation; conformal solution theory; mixture; molecular dynamics; radial distribution function; soft spheres; 19538.
- Computer simulation; damage morphology; dielectric function; beam deformation; *SP568*, pp. 529-530 (July 1980).
- Computer simulation; damper leakage; performance criteria; solar heating systems; air corrections; air leakage; 19615.
- Computer simulation; end-to-end length; entanglement effects; excluded volume effects; lattice-model polymer chains; polymer chain dynamics; random-coil polymer chains; relaxation times; self-entanglement effects; 19864.
- Computer simulation; energy analysis; energy conservation; calculation procedures; *NBSIR 80-2068*.
- Computer simulation; fire research; human performance; modeling; regulatory process; simulation; building codes; building fires; computer-aided design; *SP586*, pp. 205-224 (June 1980).
- Computer simulation; Lennard-Jones potential; liquid; molecular dynamics non-equilibrium processes; second sound; shock wave profile; thermal relaxation; argon; 19487.
- Computer simulation; performance criteria; solar air heating systems; solar collector; air leakage; 19619.
- Computer simulations, building; energy conservation in commercial buildings; heat pumps; validation of computer models, buildings; building models; building performance data; *NBSIR 80-2093*.
- Computer storage; computer architecture; computer hardware; computer computer mass storage systems; computers; *NBS-GCR-80-278*.
- Computer system acquisition; CPE in auditing; installation management; on-line system evaluation; queuing models; simulation; workload definition; benchmarking; capacity planning; computer performance evaluation; computer performance measurement; *SP500-65*.
- Computer systems; data processing concurrent with data acquisition; pulse-height analysis, on line; analog-to-digital conversion; 19131.
- Computer technology; data entry; distributed processing; Educational Resources Information Center (ERIC); information systems; intelligent terminals; mass storage technology; microfiche; micrographics; optical character recognition; communications technology; *NBSIR 80-2005*.
- Computer vulnerabilities; data base controls; data base management systems controls; EDP audit; internal audit; operating system controls; system controls; system vulnerabilities; terminal controls; applications controls; *SP500-57*.
- Concave; geometric mean; Jensen's inequality; blood lead levels; *J. Res.* 85, No. 5, 363-366 (Sept.-Oct. 1980).
- Concentrated solution; interchain interference; polyisoprene; radius of gyration; single chain scattering form factor; small angle neutron scattering; 19355.
- Concentration; department; formaldehyde; formaldehyde-based chemicals; formaldehyde level; standards; urea-formaldehyde resins; committee; *SP586*, pp. 253-258 (June 1980).
- Concentration distribution; diffusion; glass-gel boundary; sphere weight gain; 19667.
- Concentrator; electrically heated inlet; gas chromatography; injector; vapor sampler; capillary columns; 19667.
- Concrete; concrete strength; construction; construction loads; cooling tower; dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell; collapse; *NBSIR 80-2010*.
- Concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; shell; collapse; *NBSIR 78-1578*.
- Concrete; construction; cooling tower; formwork; hoisting system; regulations; safety; standards; *NBSIR 80-1964*.
- Concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); *SP577*.
- Concrete (reinforced); creep tests; evaluation; organic coating; pullout tests; reinforcing steels; structural engineering; 19077.
- Concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); *SP577*.
- Concrete strength; construction; construction loads; cooling tower; dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell; collapse; concrete; *NBSIR 80-2010*.
- Concrete strength; construction; cooling tower; failure; hyperbolic shell; shell; collapse; concrete; *NBSIR 78-1578*.
- Concrete testing laboratories; field concrete licensing; prequalifying agency; testing agency; accreditation; *SP591*, pp. 156-163 (Aug. 1980).
- Condensation; critical point; diffusion; gaseous; history of science; Kamerlingh Onnes; liquidons; liquids; mixtures; van der Waals; vapors; Andrews; 19932.
- Condensation in walls; effect of moisture on heat transmission; moisture within wood-frame cavity walls; 19147.
- Condensed phase; emission; laser absorption; molecules; site selection; 19111.
- Conducting ceramic; conductivity; diffusion; oxygen conductor; slow transient effect; transport; Y-doped CeO<sub>2</sub>; CeO<sub>2</sub>; 19444.
- Conductivity; diffusion; oxygen conductor; slow transient effect; transport; Y-doped CeO<sub>2</sub>; CeO<sub>2</sub>; conducting ceramic; 19444.
- Conductivity; disordered alloy; localization; phonon; strong scattering; transport anomalies; 19755.
- Conductivity; electrical; electrical conductivity; ferric; ferric/ferrous ratio; ferrous; ionic; ionic conductivity; magnetohydrodynamics iron; MHD; silicates; coal slag; 19576.
- Conductivity anomalies; differential magnetic measurements; geomagnetism; induced currents; Sq current system variations; tectonomagnetism; 19181.
- Conference; fission; fusion; nuclear cross sections; reactors; standards; technology; biomedical; *SP594*.
- Confidence; criteria; evaluation; hospitals; inspectors; marketing; qualification; re-examination; technicians; accreditation; certification; colleges; *SP591*, pp. 3-5 (Aug. 1980).
- Configuration analysis; queuing network modeling; asymptotic bound analysis; benchmark tests; capacity planning; *SP500-65*, pp. 165-171 (Oct. 1980).
- Configuration interaction; energy levels; magnesium; wavelengths; 19556.
- Configuration interaction; energy levels; sodium; wavelengths; aluminum; 19562.
- Configuration interaction theory; perturbations; quantum defect



theory; Rydberg states; spectra; atomic spectroscopy; Cd; 19369.

Configuration mixing; gauge theory; glueball; hyperball; quark; spectroscopy; 19327.

Configuration planning; file assignment problem; optimization; performance evaluation; performance oriented design; queueing networks; capacity planning; *SP500-65*, pp. 129-135 (Oct. 1980).

Confluent hypergeometric functions; error bounds; parabolic cylinder functions; turning points; Whittaker functions; asymptotic expansions; 19773.

Conformal solution theory; corresponding states; critical point; gas/gas equilibria; mixtures; Van der Waals one fluid model; *J. Res.* 85, No. 6, 441-448 (Nov.-Dec. 1980).

Conformal solution theory; mixing rules; mixture; nonequilibrium molecular dynamics; Van der Waals 1 theory; viscosity; computer simulation; 19180.

Conformal solution theory; mixture; molecular dynamics; radial distribution function; soft spheres; computer simulation; 19538.

Conformation; crystal; electron; helix; irrational; Phase II; polytetrafluoroethylene; units per turn; 19797.

Conformationally irregular polymers; Green's functions; molecular vibrations; normal mode calculations; numerical methods; polymer review; Raman and infrared spectroscopy; 19713.

Conglomerates; innovation; invention; large corporations; productivity; small business; 19230.

Congressional Budget Office; interactive systems; user requirements; application prototyping; *SP500-65*, pp. 311-315 (Oct. 1980).

Conical antenna; effective length; FFT; moment method; resistively loaded antenna; TEM horn; time domain measurement; transient response; 19464.

Conjugate gradient algorithm; elliptic partial differential equations; iterative methods for linear algebraic equations; Neumann boundary conditions; sparse matrices; *J. Res.* 85, No. 5, 367-390 (Sept.-Oct. 1980).

Connection; environment; gage element; leads; load; protective coating; resistance; sensitivity change; stability; strain gages; structure; transducers; zero shift; adhesive; backing; 19049.

Consensus standards; development of standards; structural design standards; building regulations; building standards development; 19091.

Consensus standards; measurement technology; photovoltaic energy conversion; photovoltaics; solar cells; test method preparation; *NBSIR 80-2060*.

Conservation; consolidating materials; deterioration of stone; preservation; stone; stone consolidation; *TN1118*.

Conservation; costs; energy; EPCA; residential; usage; appliances; *NBSIR 80-1994*.

Conservation; energy; field survey; insulation; moisture content; residences; retrofit; thermal resistivity; *TN1131*.

Conservation equations; cool-down; numerical solutions; superconducting transmission lines; 19761.

Consistency; coupled channels; integral data; microscopic data analysis; complete damping; *SP594*, pp. 862-866 (Sept. 1980).

Consistency; fission cross section; JENDL-2; nuclear data; optical potential parameter; relative measurement; simultaneous evaluation; absolute measurement; *SP594*, pp. 715-719 (Sept. 1980).

Consolidating materials; deterioration of stone; preservation; stone; stone consolidation; conservation; *TN1118*.

Conspicuity; contrast; energy conservation; illumination; illumination levels; lighting; suprathreshold seeing; visibility; vision; *NBSIR 79-1925*.

Constant current coulometry; low level titration; uranium titration; vanadium (V) titrant; *SP582*, pp. 140-146 (June 1980).

Constitutional supercooling; local equilibrium; perturbation; solidification; solid-liquid interface; stability; alloy; 19748.

Constitution diagram; intermetallic compounds; palladium alloys; phase diagram; phase transformations; tantalum alloys; 19595.

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Constraints on composition; orbital evolution; Saturn's satellites; 19774.

Constriction resistance; contact resistance; electrical connections; 19531.

Constructing program; DBMS benchmarking; interface functions; *SP500-65*, pp. 11-20 (Oct. 1980).

Construction; construction loads; cooling tower; dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell; collapse; concrete; concrete strength; *NBSIR 80-2010*.

Construction; cooling tower; failure; hyperbolic shell; shell; collapse; concrete; concrete strength; *NBSIR 78-1578*.

Construction; cooling tower; formwork; hoisting system; regulations; safety; standards; concrete; *NBSIR 80-1964*.

Construction; cost estimation; econometric models; economic analysis; engineering economics; mathematical models; program planning; building economics; *NBS-GCR-80-197*.

Construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; soil classification; soil pressure; soil testing; trenching; braced excavations; *BSS121*.

Construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; *NBS-GCR-80-202*.

Construction; retaining structures; shoring; slope stability; soil classification; soil pressure; standards; trenching; braced excavation; *BSS127*.

Construction economics; discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; building design; *SP544*.

Construction industries; dimensional coordination; metric bibliography; metric conversion timetable; metric decision; metric product sizes; metric system (SI); *SP598*.

Construction loads; cooling tower; dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell; collapse; concrete; concrete strength; construction; *NBSIR 80-2010*.

Construction lumber; construction safety; excavation; hardwood; lumber grading; shoring; softwood; timber engineering; trench bracing; trenching; *BSS122*.

Construction practices; construction safety; excavation; shoring; trenching; *NBSIR 79-1936*.

Construction regulations; construction safety; employee casualties; environmental hazards; human factors; occupational safety; scaffold failures; scaffolds; accidents; accident statistics; *NBSIR 79-1955*.

Construction safety; construction standards; excavation; safety regulations; shoring; trenching; *NBSIR 80-1988*.

Construction safety; design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces; codes and standards; *NBSIR 79-1937*.

Construction safety; employee casualties; environmental hazards; human factors; occupational safety; scaffold failures; scaffolds; accidents; accident statistics; construction regulations; *NBSIR 79-1955*.

Construction safety; excavation; hardwood; lumber grading; shoring; softwood; timber engineering; trench bracing; trenching; construction lumber; *BSS122*.

Construction safety; excavation; shoring; trenching; construction practices; *NBSIR 79-1936*.

Construction standards; excavation; safety regulations; shoring; trenching; construction safety; *NBSIR 80-1988*.

Consultant; engineer; equivalent life safety; municipal attorney; product endorsement; professional liability; variances; appeals process; architect; certification; checklists; code official; *SP586*, pp. 45-57 (June 1980).

Consumer; information; label; product; testing; benefits; *NBSIR 80-2016*.



- Consumer affairs; education; electronic devices; International Organization of Legal Metrology; legal metrology; measurement assurance; metrication; model laws and regulations; moisture loss; packaging and labeling; specifications and tolerances; weights and measures; *SP566*.
- Consumer awareness and legality; customer and laboratory responsibilities; Institute of Electrical and Electronic Engineers Specifications; laboratory capabilities; laboratory performance evaluation; manufacturers response to laws and consumers; *SP591*, pp. 131-134 (Aug. 1980).
- Consumer education; energy conservation; feedback; incentives; metering; rate structures; water conservation; *NBSIR 80-2119*.
- Consumer product; laboratory-test development; life cycle; performance; reliability; *19191*.
- Consumer products; life-cycle performance; methodology; reliability; terminology; testing; useful life; *NBSIR 76-1157*.
- Contact angle; critical point; cyclohexane; interface; methanol; phase transition; surface; surface tension; wetting; *19306*.
- Contact resistance; electrical codes; fire safety; glowing electrical connections; house wiring; innovative electrical connections; performance testing; *BSS128*.
- Contact resistance; electrical connections; constriction resistance; *19531*.
- Containment and surveillance; detection probability; evaluation of safeguards effectiveness; waste management; backend facilities; *SP582*, pp. 740-749 (June 1980).
- Contaminants from building materials; engineering and health effects; environmental contaminants; health science; air quality; *19156*.
- Contaminated waste; delayed neutrons; Monte Carlo; spent fuel; assay; *SP582*, pp. 472-496 (June 1980).
- Contention; CSMA; GPSS; local area networks; packet switching; simulation; bus networks; bus performance; computer programs; *SP500-65*, pp. 79-85 (Oct. 1980).
- Continuous monitoring; nondestructive testing; radiography; signal processing; tomography; ultrasonics; automated testing; *19475*.
- Continuum intensity; electron probe; microanalysis; particle analysis x-ray; quantitative analysis; *19679*.
- Continuum model; correction factor; Laplace's equation; nonlinear differential equations; resistivity; spreading resistance; *19796*.
- Continuum model; critical strain; instability point; molecular weight distribution; necking; polyethylene; stress relaxation; uniaxial creep; *19681*.
- Continuum x-ray loss; electron probe; Monte Carlo method for electron trajectories; particle analysis; quantitative analysis; x-ray continuum; backscattered electrons; *19867*.
- Contrast; energy conservation; illumination; illumination levels; lighting; suprathreshold seeing; visibility; vision; conspicuity; *NBSIR 79-1925*.
- Control chart; control limits; corrective action; data validation; precision; proficiency analytical testing; quality control; statistical quality control; accuracy; *SP591*, pp. 104-108 (Aug. 1980).
- Control charts; in-house quality control; quality control system; cement and concrete reference laboratory; cement and concrete testing; compressive strength; *SP591*, pp. 109-123 (Aug. 1980).
- Controllable weak link; cryoelectronic; Josephson effect; nonequilibrium superconductivity; quasiparticle injection; superconducting tunnel junction; superconducting weak link; *19416*.
- Controlled access; identification; passwords; personal authentication; computer networking; computer security; *19825*.
- Controlled doping profile; critical channeling angle; crystallographic orientation effects; ion channeling; random equivalent implants; capacitance-voltage profiling; *19428*.
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- Controlled-potential coulometry; control-potential adjustment; electrical calibration; plutonium; plutonium determination; computer-assisted coulometry; *SP582*, pp. 164-168 (June 1980).
- Control limits; corrective action; data validation; precision; proficiency analytical testing; quality control; statistical quality control; accuracy; control chart; *SP591*, pp. 104-108 (Aug. 1980).
- Controlling dimensions; coordinating sizes; dimensional coordination; metric building design; metric building products; modular coordination; building module; *19516*.
- Control-potential adjustment; electrical calibration; plutonium; plutonium determination; computer-assisted coulometry; controlled-potential coulometry; *SP582*, pp. 164-168 (June 1980).
- Control rod worth; Doppler coefficient; JENDL-1; reaction rate distribution; reaction rate ratio; reactivity worth; sodium void coefficient; structural materials; benchmark tests; *SP594*, pp. 581-585 (Sept. 1980).
- Control units; queueing model; capacity; *SP500-65*, pp. 189-198 (Oct. 1980).
- Convection; field; flame impingement; heat transfer; radiation; temperature; velocity; ceilings; *NBS-GCR-80-251*.
- Convection; gallium; heat capacity; lead-tin alloys; magnetic field effect; phase diagram; potassium-iron-silicon oxides; solidification; surface tension; thermodynamic properties; Auger measurements on liquids; *NBSIR 80-2082*.
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- Convention of the meter; economic benefits; epistemology; measurement system; metric system; SI; base units; *19639*.
- Conversion; data base; data-description; data-dictionary; data-directory; data-manipulation; DBMS; languages; query; *SP500-64*.
- Conversion costs; conversion problems; conversion tools; database management; Federal agencies; language translators; maintenance; portability; *SP500-62*.
- Conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; measurement uncertainties; microwave mixer diodes; modulation; point-contact diodes; reflectometer; return loss; Schottky-barrier diodes; semiconductor diodes; standing-wave ratio (SWR); *SP400-16*.
- Conversion problems; conversion tools; database management; Federal agencies; language translators; maintenance; portability; conversion costs; *SP500-62*.
- Conversion strategies; harmonization; metrication; metric transition; building codes; *SP586*, pp. 227-251 (June 1980).
- Conversion tools; database management; Federal agencies; language translators; maintenance; portability; conversion costs; conversion problems; *SP500-62*.
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- Coolant; index-matching liquids; nonlinear refractive index; self-focusing; Abbe value; *SP568*, pp. 91-98 (July 1980).
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- Cool environments; microclimatic prediction; pedestrian comfort; wind; wind environment; *19106*.
- Cooling; durability/reliability; performance criteria; safety; solar collectors; solar energy; standards; thermal performance; buildings; *SP586*, pp. 151-160 (June 1980).
- Cooling power; dilution refrigerator; liquid He<sup>3</sup>; refrigeration; thermometry; *19074*.
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Cooling tower; dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell; collapse; concrete; concrete strength; construction; construction loads; *NBSIR 80-2010*.

Cooling tower; failure; hyperbolic shell; shell; collapse; concrete; concrete strength; construction; *NBSIR 78-1578*.

Cooling tower; formwork; hoisting system; regulations; safety; standards; concrete; construction; *NBSIR 80-1964*.

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Copper; Debye temperature; elastic constants; polycrystals; sound velocities; tensor-property averaging; *19696*.

Copper; dry sliding wear; lubricated sliding wear; wear; wear debris; abrasive wear; *19960*.

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Copper; electron microscopy; erosion; impingement erosion; metal erosion; wear; *19941*.

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Copper alloys; friction; microstructure; solid contact; wear; copper; *19708*.

Copper crystal; fatigue; persistent slip band; plastic strain; random cycling; single crystal copper; *19694*.

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Corrective action; data validation; precision; proficiency analytical testing; quality control; statistical quality control; accuracy; control chart; control limits; *SP591*, pp. 104-108 (Aug. 1980).

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Correlation length; mean field; sum rule; susceptibility; three coexistence phases; tricritical point; *19135*.

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Corrosion; electrochemical noise; instrumentation; iron; nickel; potentiostat; aluminum; *19878*.

Corrosion; elevated temperature; heat transfer; liquid flow rate; solar-heat transfer liquid containment; stagnation; *NBSIR 79-1919*.

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Corrosion noise; electrochemistry; polarization techniques; underground corrosion; corrosion; *NBSIR 80-2083*.

Corrosion of steel; polarization technique; rebar corrosion;



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- Cost; discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; building economics; buildings; building systems standard; *NBSIR 80-2040*.
- Cost analysis; decision analysis; dielectric fluids; fire safety; flammable liquids; standards; transformers; *NBS-GCR-80-198*.
- Cost benefit analysis; cost effectiveness; fire departments; fire losses; fire models; fire protection; marine transportation; merchant vessels; shipboard fires; *NBS-GCR-79-173*.
- Cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; *NBSIR 80-2167*.
- Cost-effective; energy conservation; investment problems; life-cycle costing; buildings; 19102.
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- Cost effectiveness; fire departments; fire losses; fire models; fire protection; marine transportation; merchant vessels; shipboard fires; cost benefit analysis; *NBS-GCR-79-173*.
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- Costs; economic; prices; testing; accreditation; *SP591*, pp. 92-96 (Aug. 1980).
- Costs; economic analysis; energy consumption; HVAC systems; Total Energy systems; cogeneration; *NBS-GCR-80-164*.
- Costs; economic analysis; HVAC systems; Total Energy system; cogeneration; *NBS-GCR-80-165*.
- Costs; economics; evaluation; literature search; regulation; standardization; standards; benefit-cost analysis; benefit-risk analysis; benefits; bibliography; *NBSIR 80-2015*.
- Costs; energy; EPCA; residential; usage; appliances; conservation; *NBSIR 80-1994*.
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- Coulometry; electrochemistry; Faraday constant; silver; coulometer; 19472.
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- Counter; estimates; gamma rays; neutrons; nondestructive assay; plutonium waste; safeguards; uranium waste; verification; *SP582*, pp. 622-632 (June 1980).
- Countercheck reference tests; critical control features; feedback; implementation; inspections; laboratory accreditation; laboratory performance evaluation; noncompliance; proficiency; *SP591*, pp. 79-84 (Aug. 1980).
- Coupled-channel; deformation parameter; differential cross sections; DWBA; elastic scattering; global optical potential; inelastic scattering; neutron; *SP594*, pp. 146-149 (Sept. 1980).
- Coupled-channel methods; Hauser-Feshbach; neutron cross-section calculations; preequilibrium; *SP594*, pp. 333-335 (Sept. 1980).
- Coupled channels; integral data; microscopic data analysis; complete damping; consistency; *SP594*, pp. 862-866 (Sept. 1980).
- Coupled channels and Hauser-Feshbach analysis; optical model; *SP594*, pp. 78-79 (Sept. 1980).
- Coupled channels model calculation; nuclear reactions; comparison to experimental data; *SP594*, pp. 52-57 (Sept. 1980).
- Coupled growth; eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification; amorphous alloys; 19891.
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- tion; computer performance measurement; computer performance prediction; *SP500-65*.
- CPM project officer; Air Force Data Systems Design Center; Computer Performance Management Technical Center; *SP500-65*, pp. 295-300 (Oct. 1980).
- CPU transfer rates; I/O performance; overhead CPU; compute-and-test loop; *SP500-65*, pp. 245-254 (Oct. 1980).
- CROSSFIRE; link protocols; local survivability; communications networks; *NBSIR 80-2149*.
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- Criteria; evaluation; hospitals; inspectors; marketing; qualification; re-examination; technicians; accreditation; certification; colleges; confidence; *SP591*, pp. 3-5 (Aug. 1980).
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- Critical current; critical temperature; losses; magnetic property; standards; superconductor; *NBSIR 80-1629*.
- Critical current; fiberglass/epoxy composite; mechanical properties; niobium-tin; niobium-titanium; strain; superconducting coil composite; superconducting wire; *NBSIR 80-1633*.
- Critical dimensions; linewidth; metrology; micrometrology; microscopy; optical imaging; *19802*.
- Critical evaluation; derivative lattices; indexing; lattice relationships; lattices; single-crystal methods; twinning; *19804*.
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- Critically evaluated data; critical review; data compilation; International Formulation; static dielectric constant; steam; water; *JPCRD 9*, No. 4, 1291-1306 (1980).
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- Data evaluation; enthalpy; entropy; Gibbs energy; heat capacity; thermochemical tables; uranium-halogen containing compounds; *NBSIR 80-2029*.
- Data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant; air pollution; atmospheric chemistry; chemical kinetics; *19513*.
- Data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate coefficient; air pollution; atmospheric chemistry; chemical kinetics; *JPCRD 9*, No. 2, 295-472 (1980).
- Data evaluation; nitrogen oxides; photoabsorption cross section; photochemistry; quantum yield; rate coefficient; atmospheric chemistry; chemical kinetics; *NBSIR 80-2032*.
- Data evaluation; nuclear-decay data; radioactivity; random error; systematic error; weighting factors; *19407*.
- Data integrity; data security; Federal Information Processing Standards Publication; security controls; system life cycle; system security; ADP availability; ADP security; application system security; computer applications; computer reliability; computer security; *FIPS PUB 73*.
- Data interchange; Federal Information Processing Standards Publication; file structure; magnetic tapes; tape labels; *FIPS PUB 79*.
- Data inventory; data management; data standards; documentation; Federal Information Processing Standards Publication; software; computer program; database; database management system; data dictionary system; *FIPS PUB 76*.
- Data inventory; data management; data standards; documentation; software; computer program; database; database management system; data dictionary system; *NBSIR 80-2115*.
- Data library; fission products; full energy peak; gamma-ray spectrum; multiplets; optimization; peak/Compton ratio; simulation; apparatus spectrum; *SP594*, pp. 878-880 (Sept. 1980).
- Data link control procedures; data transparency; interoperability; teleprocessing; transmission; advanced data communication control procedures; ANSI X3.66; bit-oriented; code independence; data; *FIPS PUB 71*.
- Data management; data standards; documentation; Federal Information Processing Standards Publication; software; computer program; database; database management system; data dictionary system; data inventory; *FIPS PUB 76*.
- Data management; data standards; documentation; software; computer program; database; database management system; data dictionary system; data inventory; *NBSIR 80-2115*.
- Data-manipulation; DBMS; languages; query; conversion; data base; data-description; data-dictionary; data-directory; *SP500-64*.
- Data manipulation language; performance evaluation; schema; simulation modeling; CODASYL; data base; data base management systems; data description language; *SP500-65*, pp. 3-10 (Oct. 1980).
- Data networks; interactive systems; numerical data bases; on-line data; physical data; spectroscopic data systems; chemical data; data banks; data bases; *TN1122*.
- Data networks; local area networks; networks; communications; computer communications; computer networks; data communications; *19125*.
- Data processing; data resource management; Federal Information Processing Standards Publication; file processing; software; software selection; computer applications; computer programs; data administration; database management; database standards; *FIPS PUB 77*.
- Data processing; Federal Information Processing Standard; FORTRAN; numeric methods; programming language; scientific computing engineering; software; standards; *FIPS PUB 69*.
- Data processing; Federal Information Processing Standard; interactive programming; programming language; software; standards; time-sharing; BASIC; *FIPS PUB 68*.
- Data processing; Federal Information Processing Standards; geography; information processing standards; information systems; national government; representations and codes; standards; statistical data; ADP standards; computers; data elements and codes; *FIPS PUB 6-3*.
- Data processing; gamma-ray spectroscopy; x-ray spectroscopy; activation analysis; computers; *19128*.
- Data processing; HTGR spent fuel reprocessing; in-line measurements; off-line measurements; process control; remote pipettes; remote sample preparation; SNM accountability; x-ray fluorescence; automation; *SP582*, pp. 55-65 (June 1980).
- Data processing concurrent with data acquisition; pulse-height analysis, on line; analog-to-digital conversion; computer systems; *19131*.
- Data processing performance; data processing service; information system design; information system usability; performance management; computer performance evaluation; *SP500-65*, pp. 265-276 (Oct. 1980).
- Data processing service; information system design; information system usability; performance management; computer performance evaluation; data processing performance; *SP500-65*, pp. 265-276 (Oct. 1980).
- Data reporting; environmental; measurements; radiation; random uncertainty; systematic uncertainty; *19301*.
- Data resource management; Federal Information Processing Standards Publication; file processing; software; software selection; computer applications; computer programs; data administration; database management; database standards; data processing; *FIPS PUB 77*.
- Data retrieval; information retrieval; MIS; on-line retrieval; computer programs; data analysis; data base management; *19884*.
- Data security; DES; encryption; modes of operation; computer security; cryptography; *NBSIR 80-2019*.
- Data security; Federal Information Processing Standards Publication; security controls; system life cycle; system security; ADP availability; ADP security; application system security; computer applications; computer reliability; computer security; data confidentiality; *FIPS PUB 73*.
- Data standards; documentation; Federal Information Processing Standards Publication; software; computer program; database; database management system; data dictionary system; data inventory; data management; *FIPS PUB 76*.
- Data standards; documentation; software; computer program; database; database management system; data dictionary system; data inventory; data management; *NBSIR 80-2115*.
- Data structures; programming languages; software engineering; abstract data types; artificial intelligence; data abstraction; database management systems; *SP500-59*.
- Data testing; ENDF/B-IV; ENDF/B-V; fast reactors; group cross sections; integral experiments; least-squares adjustment;



chi-square; data consistency; *SP594*, pp. 182-186 (Sept. 1980).

Data transfer; data transformation; data translation; network operating systems; computer networking; data conversion; *SP500-71*.

Data transformation; data translation; network operating systems; computer networking; data conversion; data transfer; *SP500-71*.

Data translation; network operating systems; computer networking; data conversion; data transfer; data transformation; *SP500-71*.

Data transparency; interoperability; teleprocessing; transmission; advanced data communication control procedures; ANSI X3.66; bit-oriented; code independence; data; data link control procedures; *FIPS PUB 71*.

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Data validation; precision; proficiency analytical testing; quality control; statistical quality control; accuracy; control chart; control limits; corrective action; *SP591*, pp. 104-108 (Aug. 1980).

Daylighting; energy; environmental; shale oil; SRM; weights and measures; x-ray exams; compact range; data; *DIM/NBS 64*, No. 6, 1-24 (1980).

DBMS; languages; query; conversion; data base; data-description; data-dictionary; data-directory; data-manipulation; *SP500-64*.

DBMS benchmarking; interface functions; constructing program; *SP500-65*, pp. 11-20 (Oct. 1980).

D-c MOSFET dopant profile method; dopant profile method; MOSFET, d-c; *19425*.

Dc transmission; deep-level measurements; energy conservation; measurement methods; neutron transmutation doped silicon; power-device grade silicon; resistivity variations; silicon; spreading resistance measurements; thermally stimulated measurements; *NBSIR 80-2061*.

DES; encryption; modes of operation; computer security; cryptography; data security; *NBSIR 80-2019*.

Death; doors; egress; evacuation; fire alarm systems; fire departments; fire fighters; flashover; nursing homes; nursing staff; patients; room fires; smoke detectors; *NBS-GCR-80-191*.

Debye temperature; elastic constants; polycrystals; sound velocities; tensor-property averaging; copper; *19696*.

Debye theory; equation of state; ideal gas; Van der Waals equation; virial coefficient; virial equation; *19772*.

Decay heat; evaluation; fission-products; *SP594*, pp. 667-671 (Sept. 1980).

Decay heat; fission beta energy; fission gamma energy; *SP594*, pp. 25-33 (Sept. 1980).

Decibal levels; fire departments; frequency distribution; noise (sound); sleep; smoke detectors; wakefulness; adults; alarm responses; auditory perception; *NBS-GCR-80-284*.

Decision analysis; dielectric fluids; fire safety; flammable liquids; standards; transformers; cost analysis; *NBS-GCR-80-198*.

Decision analysis; fabric flammability; fire suppression; fire tests; flame research; smoke detectors; toxicity; bibliographies; building fires; cable fires; compartment fires; *NBSIR 80-2114*.

Decision table; interval adjustment; measurement; metrology; PMTE; recall intervals; calibration interval; calibration interval algorithms; calibration requirements; *NBS-GCR-80-283*.

Decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering; codes; computer program; *NBS-GCR-80-258*.

Decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering; codes; computer program; *NBS-GCR-80-257*.

Decision tables; information networks; modeling; standards; standards-writers; systems analysis; building standards; classification; *NBSIR 80-1979*.

Decision theory; editing; networks; specifications standards; systems analysis/engineering; codes; *NBS-GCR-80-259*.

Decomposition; decyclization; isomerization; olefins; shock tube; 1-hexene; allylic resonance energy; allyl radicals; biradical; cyclohexane; *19784*.

Decomposition; degradation; durability; heating rates; initial rates; kinetics; lifetime prediction; polystyrene; polyurethane; pyrolysis; stability; thermal analysis; thermogravimetry; accelerated aging; complex reactions; *19752*.

Decomposition; degradation; electron capture; gas chromatography; infrared spectroscopy; mass spectroscopy; phosgene; polymer; poly(vinyl chloride); PVC; pyrolysis; carbonyl chloride; combustion; *19503*.

Decomposition; disproportionation; H-transfer; initiation; isomerization; *n*-alkane pyrolysis; rate constants; recombination; addition; chemical kinetics; *JPCRD 9*, No. 3, 523-560 (1980).

Decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; *NSRDS-67*.

Decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; *NBSIR 80-2118*.

Decomposition temperatures; polymeric solids; thermogravimetry; *SP580*, pp. 89-97 (Aug. 1980).

Decyclization; isomerization; olefins; shock tube; 1-hexene; allylic resonance energy; allyl radicals; biradical; cyclohexane; decomposition; *19784*.

Deduced coupled-channel optical potential parameters; enriched targets; nuclear reactions; quadrupole and hexadecapole deformation parameters; calculated direct-interaction and compound-nucleus cross sections; *SP594*, pp. 672-676 (Sept. 1980).

Deduced  $J$ ,  $\pi$ ,  $B(CL)$ ; enriched  $^{22}\text{Ne}$  target;  $E = 60$  to  $110$  MeV; measured  $\sigma(E)$  at  $110^\circ$  and  $128^\circ$  up to  $8.6$  MeV in excitation energy; nuclear reactions; *19691*.

Deduced levels; multilevel R-matrix analysis; *SP594*, pp. 496-499 (Sept. 1980).

Deep-level measurements; energy conservation; measurement methods; neutron transmutation doped silicon; power-device grade silicon; resistivity variations; silicon; spreading resistance measurements; thermally stimulated measurements; thyristor materials measurements; *NBSIR 80-2061*.

Deep level studies; ion implantation; predeposition technique; sulfur impurities in silicon; thermally-stimulated measurements; chemical impurities; *19429*.

Deep level studies; ion implantation; predeposition technique; sulfur impurities in silicon; thermally-stimulated measurements; chemical impurities; *19231*.

Deep level transient spectroscopy; electrical properties; electronics; electron irradiation. hole mobility; integrated circuits; ion knock-on effect; ion microprobe mass analysis; Irvin's curves; isothermal transient capacitance method; linewidth measurements; *SP400-45*.

Defect; diffuse scattering; neutron; niobium; strain; alloy; *19307*.

Defect; KBr; KCN; libration; translation-rotation coupling; tunnelling; *19612*.

Defect characterization; dimensioning; one-transducer technique; shear (S) mode; ultrasonic diffraction; welds; compressional (P) modes; cracks; *NBSIR 80-1983*.

Defect characterization; flaws; materials characterization; non-destructive testing; residual stress; ultrasonics; velocity; attenuation; *SP596*.

Defects; neutron transmutation doping; power device materials; radiation damage; silicon; thyristors; *SP400-60*.

Defining temperature fixed point; gallium; gallium melting-point temperature; gallium triple-point temperature; secondary temperature fixed point; thermometry; *19058*.

Definitions; directory of accreditation systems; international; laboratory accreditation; legal constraints; *SP591*, pp. 173-178 (Aug. 1980).

Definitions; flux phenomena; Josephson phenomena; stabilization; superconductors; terminology; critical parameters; *19539*.

Definitions; fracture testing; nomenclature; symbols; terminology; terms; *19892*.

Definitive method; electrolytes; flame atomic absorption spec-



- troscopy; interlaboratory testing; precision; reference method; semiautomated pipetting; serum lithium analysis; statistical analysis; accuracy; clinical analysis; clinical chemistry; *SP260-69*.
- Definitive method; gas chromatography/mass spectrometry; isotope dilution/mass spectrometry; reference method; statistical analysis; total serum cholesterol; cholesterol; *19554*.
- Definitive methods; environmental measurements; quality assurance; reference methods; standard reference materials; *19574*.
- Definitive methods; glucose; human serum; isotope dilution; mass spectrometry; research associate; urea; uric acid; cholesterol; College of American Pathologists; *19706*.
- Definitive methods; measurement compatibility; protocol; reference methods; SI units; standard reference materials; traceability; *SP582*, pp. 15-24 (June 1980).
- Definitive methods; measurement compatibility; reference methods; standard methods; standard reference materials; *19575*.
- Deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; buffeting; buildings; buildings (codes); *19121*.
- Deformation; erosion; impact; metals; surfaces; *19936*.
- Deformation parameter; differential cross sections; DWBA; elastic scattering; global optical potential; inelastic scattering; neutron; coupled-channel; *SP594*, pp. 146-149 (Sept. 1980).
- Deformation texture; electron microscopy; grain boundary sliding; plastic deformation; alumina; basal slip; cavitation; *19582*.
- Degradation; durability; heating rates; initial rates; kinetics; lifetime prediction; polystyrene; polyurethane; pyrolysis; stability; thermal analysis; thermogravimetry; accelerated aging; complex reactions; decomposition; *19752*.
- Degradation; electron capture; gas chromatography; infrared spectroscopy; mass spectroscopy; phosgene; polymer; poly(vinyl chloride); PVC; pyrolysis; carbonyl chloride; combustion; decomposition; *19503*.
- Degradation resistance; fiberglass/epoxy; fiber reinforced composites; graphite/polysulfone; orthopedic materials; PEFC; polymer matrix; polypropylene; polysulfone; aromatic polyamide fiber; autoclave stability; biomaterial; composites; *19689*.
- Delayed failure; fracture; mechanical reliability; mechanics; strength; ceramics; crack growth; *19636*.
- Delayed neutron; fission; phonon distribution;  $U_3O_8$ ;  $UO_2$ ; chemical state; *19683*.
- Delayed neutron data; eigenvalue; ENDF/B-IV; integral experiments; reaction rate ratios; reactivity worths; ZPR critical assembly; *SP594*, pp. 297-306 (Sept. 1980).
- Delayed neutrons; fission yield; thermal neutrons; chemical dependence; *SP594*, pp. 105-107 (Sept. 1980).
- Delayed neutrons; Monte Carlo; spent fuel; assay; contaminated waste; *SP582*, pp. 472-496 (June 1980).
- D-electrons; Mossbauer isomer shifts; transition metals; alloy phase formation; charge transfer; Coulomb energy; *19567*.
- Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; safety evaluation; smoke detection; automatic sprinklers; building codes; building construction; *NBSIR 78-1555-1*.
- Delta Cephei; H $\alpha$  profiles; *19259*.
- Delta ferrite; ferrite content; fracture; mechanical properties; stainless steel; strength; toughness; welds; cryogenic; *19673*.
- Delta function; hyperviral theorems; *19712*.
- Delta-nucleus interaction; nuclear structure; pion absorption; pion nucleus interaction; pion scattering; baryon resonances; *19221*.
- Demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; cost components; data analysis; data collection; *NBSIR 80-2167*.
- Demonstration program; institutional constraints; solar builder/developer; solar energy; building code; code official; *19729*.
- Demonstration program; institutional constraints; solar builder/developer; solar energy; building code; code official; *SP586*, pp. 181-185 (June 1980).
- Demonstration program; institutional constraints; solar builder/developer; solar energy; building code; code official; *NBSIR 79-1957*.
- Denatured fuel; denatured Pu; nuclear proliferation; once-through cycles; *SP594*, pp. 115-118 (Sept. 1980).
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- Denatured Pu; nuclear proliferation; once-through cycles; denatured fuel; *SP594*, pp. 115-118 (Sept. 1980).
- Denatured uranium-thorium fuel cycles; fuel cycles; nuclear data needs; thorium reactor introduction; thorium reactors; advanced converters; *SP594*, pp. 108-114 (Sept. 1980).
- Densities; equation of state; fluids; orthobaric densities; propane; specific heats; thermodynamic properties; vapor pressures; coexistence boundary; critical point; *19204*.
- Densities; excess volumes; liquid mixtures; LNG components; multicomponent systems; orthobaric; *19537*.
- Densitometer evaluation; uranium and plutonium solutions assay; x-ray absorption-edge densitometry; *SP582*, pp. 633-650 (June 1980).
- Densitometry; gamma-ray NDA; product solutions; reprocessing; transmission-corrected gamma-ray assay; *SP582*, pp. 568-583 (June 1980).
- Densitometry; uranium assay; *SP582*, pp. 324-341 (June 1980).
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- Density; enthalpy; entropy; equation of state; heat capacity at constant pressure; heat capacity at constant volume; helium; hydrogen; methane; neon; nitrogen; oxygen; thermal conductivity; velocity of sound; viscosity; argon; computer programs; *TN1025*.
- Density; ethylene; melting pressures; PVT; vapor pressure; compressibility; *19682*.
- Density; long-period variable; model; nebosity; R Aquarii; spectrum; temperature; *19507*.
- Density; thermal properties; tissue equivalent plastic; A-150 plastic; calorimeter; *19208*.
- Density fluctuations; Lennard-Jones liquid; liquid rubidium; liquid state; molecular dynamics; velocity autocorrelation function; *19489*.
- Density gradient; equation of state; inhomogeneous fluid; lattice fluid; long-range interactions; surface entropy; Cahn-Hilliard theory; chemical potential; *19653*.
- Density of dental amalgam; dental amalgam; dimensional change in dental amalgam; mercury/alloy ratio in dental amalgam; mercury content in dental amalgam; zinc in dental amalgam; comprehensive strength of amalgam; *19632*.
- Dental; hydroxyapatites; tooth mineral; adhesion; bonding; calcium phosphates; crystal structure; *19262*.
- Dental accomplishments; dental diseases; dental history; dental treatment; prevention of dental diseases; *19396*.
- Dental adhesion; PolySAM; adsorption; chemisorption; composites; coupling agent; *19658*.
- Dental agencies; devices; history; materials; programs; specifications; *SP571*.
- Dental alloy; initiator; rator; resin; wear; alloy; base metal; casting; composite; cyanoacrylate; *NBSIR 79-1943*.
- Dental amalgam; dimensional change in dental amalgam; mercury/alloy ratio in dental amalgam; mercury content in dental amalgam; zinc in dental amalgam; comprehensive strength of amalgam; density of dental amalgam; *19632*.
- Dental amalgam; high-copper alloy; mercury content; creep; *19107*.
- Dental amalgam; manganese alloys; marginal stability; silver



- alloys; copper alloys; corrosion behavior; creep properties; 19247.
- Dental casting techniques; dental die; porcelain fused to metal alloys; casting accuracy; casting ring liners; crown and bridge castings; 19137.
- Dental composite resin restorations; finishability; gelled inorganic "polymers"; microporous filler; system nontoxicity; x-ray opacification; *U.S. Patent 4,217,264*.
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- Dental diseases; dental history; dental treatment; prevention of dental diseases; dental accomplishments; 19396.
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- Dental materials; gypsums, dental; impression materials, dental; polymers, dental; refractories, dental; specifications, dental; waxes, dental; alloy, base, dental; alloy, gold, dental; amalgam, dental; cements, dental; 19052.
- Dental monomers; initiator systems; organic peroxides; redox reactions; stability; transition metals; accelerators; ambient polymerization; ascorbic acid; 19062.
- Dental treatment; prevention of dental diseases; dental accomplishments; dental diseases; dental history; 19396.
- Dentin; diisocyanates; hydroxyethyl; isocyanato urethane methacrylates; methacrylate; polymerization; synthesis; adhesion; 19136.
- Dentin; mordants; smear layer; acid etch; adhesion; coupling agents; 19329.
- Department; formaldehyde; formaldehyde-based chemicals; formaldehyde level; standards; urea-formaldehyde resins; committee; concentration; *SP586*, pp. 253-258 (June 1980).
- Department of Commerce; integrated circuits; metrology for semiconductors; National Bureau of Standards; photomasking; resistivity; second breakdown; semiconductors; test structures; thermal resistance; very large scale integration; VLSI; wire bonds; *NBSIR 80-2057*.
- Depletable energy; HUD Demonstration Program; passive solar buildings; performance criteria; statistical evaluation; thermal analysis; 19823.
- Depolarization; polarized electron source; polarized photoemission GaAs; spin-exchange scattering; spin polarization; 19078.
- Depolarized light scattering; lattice-gas; Lorentzian shape; oscillatory; parameters; polarizability; rare-gas; Zwanzig-Mori theory; 19756.
- Deposition parameters; index of refraction; absorption coefficient; chalcogenide material; *SP568*, pp. 343-355 (July 1980).
- Deposition technique; environmental stability; masking layer; potassium chloride window; scattering; thallium iodide; antireflective coating; *SP568*, pp. 355-357 (July 1980).
- Depth-dose data; electron bremsstrahlung; electrons; protons; space shielding; computer code; *TN1116*.
- Depth profiling; Laplace's equation; local slope analysis; multi-layer analysis; resistivity; sheet resistance; spreading resistance; correction factor; 19703.
- Derivative lattices; indexing; lattice relationships; lattices; single-crystal methods; twinning; critical evaluation; 19804.
- Derivatives; inequalities; intermediate point; mean-value theorem; Taylor's theorem; convexity; 19421.
- Design; energy conservation; housing codes; regulatory approaches; building code enforcement; buildings; *SP586*.
- Design; geothermal; process; thermodynamics; transport properties; aerospace; data accuracy; *SP590*.
- Design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces; codes and standards; construction safety; *NBSIR 79-1937*.
- Design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); *SP577*.
- Design criteria; disaster; earthquakes; ground motion; seismology; standards; storm surge; structural engineering; structural response; tsunamis; wind loads; winds; accelerograph; codes; *SP560*.
- Design elements; energy performance of windows; window attributes; window design; window design elements; window performance; *SP575*.
- Design methodology; formal specification; formal verification; hierarchical design; programming methodology; security; *SP500-67*.
- Design specification; formal specification; network architecture; networking; session protocols; transport protocols; communication protocols; computer network protocols; *NBS-GCR-80-246*.
- Design standards; economics of standards; health care standards; innovation; performance standards; standards; automobile standards; *NBS-GCR-80-287*.
- Desorption; electron stimulated; 19192.
- Desorption; electron stimulated desorption; ethane; adsorption; angular distribution; cyclohexane; cyclooctane; cyclopropane; 19922.
- Destructive; nondestructive assay; NRC Safeguards; special nuclear material; analyses; *SP582*, pp. 189-191 (June 1980).
- Destructive; nondestructive measurements; nuclear materials; reference materials; traceability; *SP582*, pp. 1-14 (June 1980).
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- Detection probability; evaluation of safeguards effectiveness; waste management; backend facilities; containment and surveillance; *SP582*, pp. 740-749 (June 1980).
- Detector; intrusion alarm; standard; test method; window foil; alarm; burglar alarm; 19697.
- Detector efficiency; gamma-ray efficiency; Marinelli beaker; Reentrant beaker; semiconductor detector efficiency; standards; 19408.
- Detector intercomparison; optical radiation measurements; photodetector; photometry; radiometry; absolute spectral response; 19908.
- Detector location; false alarms; health care facilities; hospitals; ionization detectors; maintenance; NFPA 101; nursing homes; photoelectric detectors; smoke detectors; surveys; *NBSIR 80-2130*.
- Detectors; extreme ultraviolet radiation; instrumentation; radiometric transfer standards; radiometry; synchrotron radiation; 19664.
- Detectors; irradiance; light source; photodiode; radiometry; calibration; 19592.
- Detector sensitivity; fire detectors; ionization detectors; light scattering detectors; monodisperse aerosols; particle size; photo-electric detectors; smoke detectors; aerosol generators; aerosols; *J. Res.* 85, No. 3, 223-238 (May-June 1980).
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- Determination of structure of carbohydrates; infrared spectra of carbohydrates; interpretation of infrared spectra; plane-polarized radiation; Raman spectra; attenuated total reflection; 19875.
- Deterrence; diversion of nuclear energy; evolution; safeguards performance criteria; safeguards systems; safeguards technology; detection; *SP582*, pp. 670-676 (June 1980).
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- threshold photoelectron spectroscopy; water; appearance energy; coincident ion mass spectrometry; 19345.
- Deuterium; Franck-Condon Factors; hydrogen; nitrogen; photoelectron spectra; spectroscopy; threshold photoelectron spectroscopy; autoionization; 19183.
- Deuterium; gas chromatography; hydrogen; isotope dilution; microwave plasma; oscillating slit mechanism; 19933.
- Deuterium; quadrupole triplet spectrometer; charged particle reactions; *SP594*, pp. 527-530 (Sept. 1980).
- Deuterium lamps; radiometry; spectral irradiance; standards; vacuum ultraviolet; 19852.
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- Development; Indonesia; industrialization; instrumentation; less developed country; metrology; standardization; Third World; calibration; *NBSIR 78-1583*.
- Development assistance; Honduras; legal metrology; metrification; metrology; quality assurance; standardization; test laboratories; weights and measures laws; Agency for International Development; *NBSIR 80-1969*.
- Development assistance; industrialization; less developed countries; measurement technology; Pakistan; standardization; Agency for International Development; *NBSIR 80-2051*.
- Development fee; planning cost; Proposition 13; affordable housing; *SP586*, pp. 13-16 (June 1980).
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- Device processing; electron devices; integrated circuit fabrication; ion-beam lithography; lithography; oxide layers; radiation absorbed dose; radiation damage; 19753.
- Devices; history; materials; programs; specifications; dental agencies; *SP571*.
- D-hole pairs; photoemission; satellite; 19271.
- Diagnostics; hydrogen; line-broadening; plasma; Stark; Balmer; 19281.
- Diagnostic x-rays; electrical measurements; health; radiation; radiation safety; safety; x rays; calibration; *NBSIR 80-2072*.
- Diamond anvil cell; high pressure; ruby pressure scale; advances; 19467.
- Diamond anvil cell; high pressure physics; perfluoro n-alkanes; phase transition; polytetrafluoroethylene; Raman spectroscopy; 19893.
- Diamond cell; optical microscopy; phase transition; resistivity; x-ray diffraction; cuprous chloride; 19687.
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- Diamond turning; infrared windows; laser breakdown; polishing; surface damage; *SP568*, pp. 195-197 (July 1980).
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- Dry chemical extinguishers; fire incident; ventilation procedures; accumulation of smoke; *NBS-GCR-80-243*.
- Dry sliding wear; lubricated sliding wear; wear; wear debris; abrasive wear; copper; 19960.
- DT fusion tritium breeding ratio; ENDF/B; integral and differential experiments; LiOH; liquid scintillator; quenching; activation; breeding blankets; *SP594*, pp. 246-253 (Sept. 1980).
- Dual wavelength; nitric acid; spectrophotometric; uranium; determination; *SP582*, pp. 121-128 (June 1980).
- Ductile fracture; fracture toughness; part-through crack; pneumatic burst; pressure vessel; steel; 19961.
- Ductility; elongation; heat treatment; NaCl; plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 2124-T851; 7075; 7075-T6; 7075-T7351; air; alternate immersion test; aluminum alloys; 19622.
- Duplex connectors; high resistance junctions; junction resistance; scanning electron microscopy; x-ray microanalysis; aluminum wiring; *J. Res.* 85, No. 6, 429-440 (Nov.-Dec. 1980).
- Duplicity; ideal conditions; measurement process; omnifariousness; precision; round robin; routine conditions; variance model; within-laboratory precision; accuracy; between-laboratory precision; components of variance; *SP591*, pp. 31-40 (Aug. 1980).
- Durability; environmental exposure; materials; polymeric materials; solar collectors; absorber materials; absorptive coatings; accelerated aging; cover plates; 19364.
- Durability; eutectics; Rayleigh waves; stability; surface anisotropy; composites; 19153.
- Durability; fatigue; fatigue mechanism; fatigue research; fracture mechanics; mathematical modeling; metals fatigue; plastics fatigue; quantitative microscopy; statistical aspects of fatigue; composite materials; corrosion fatigue; 19448.
- Durability; heating rates; initial rates; kinetics; lifetime prediction; polystyrene; polyurethane; pyrolysis; stability; thermal analysis; thermogravimetry; accelerated aging; complex reactions; decomposition; degradation; 19752.
- Durability; life testing; prediction; recommended practice; reli-



ability service life; accelerated aging tests; building components; building materials; *TN1120*.

Durability/reliability; environmental degradation; materials degradation; solar collector; *19451*.

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Duration; fission products; fluence; Gabon; natural fission reactor; temperature; age of deposit; *SP594*, pp. 909-915 (Sept. 1980).

Dust grains; molecular clouds; star formation; supernovae; supernova remnants; x rays; *19384*.

DWBA; elastic scattering; global optical potential; inelastic scattering; neutron; coupled-channel; deformation parameter; differential cross sections; *SP594*, pp. 146-149 (Sept. 1980).

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Dye dosimeters; electric wires; electron beams; isodose curves; radiation curing; radiation processing; radiochromic dye films; dose distribution; dosimetry; *19340*.

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Dye dosimetry; electron beams; gamma radiation; leucocyanides; radiation processing; radiation sterilization; radiochromic dyes; red Perspex; dose distributions; dose mapping; dosimetry; *19339*.

Dyed plastic dosimeters; electron beams; gamma rays; plastic dosimeters; polyvinylchloride; radiation processing; radiochromic dye films; blue cellophane; cellulose triacetate; clear Perspex; dose rate dependence; dosimetry; *19338*.

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Dynamic accounting; fuel reprocessing; nuclear safeguards; *SP582*, pp. 718-729 (June 1980).

Dynamic analysis; programming aids; software development; software management; software tools; static analysis; *NBSIR 80-2159*.

Dynamic concentration measurements; inventory control; non-destructive measurements; on-line real-time measurements; plutonium concentration and isotopics determinations; reprocessing plant process control; uranium; x-ray fluorescence analysis; *SP582*, pp. 584-601 (June 1980).

Dynamic effects; failure; failure investigation; hoisting loads; hyperbolic shell; collapse; concrete; concrete strength; construction; construction loads; cooling tower; *NBSIR 80-2010*.

Dynamic fatigue; fracture mechanics; lifetime prediction; proof testing; stress corrosion; subcritical crack growth; *NBSIR 80-2047*.

Dynamic materials accounting; in-process inventory; solvent-extraction contactors; chemical modeling; *SP582*, pp. 712-717 (June 1980).

Dynamic measurements; electrical resistivity; emittance; heat capacity; high temperature; melting point; stainless steel; thermodynamics; *19541*.

Dynamic measurements; high temperature; melting; normal spectral emittance; palladium; radiance temperature; *19063*.

Dynamic response; influence of wind-direction; tall buildings; wind loads; wind tunnels; aerodynamics; boundary layers; *19872*.

Dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; buffeting; buildings; buildings (codes); deflection; *19121*.

Dynamics; structural engineering; towers; turbulence; wind (meteorology); aerodynamics; buildings (codes); *19143*.

Dynamic techniques; heat of fusion; high temperatures; melting;

niobium; *19745*.

Dynamic techniques; high-speed measurements; high temperatures; thermodynamics; thermophysical properties; *19311*.

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Earthquake; engineers; Florida; inspection; legislation; recertification; architects; codes; *SP586*, pp. 197-203 (June 1980).

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Earthquakes; engineering; standards; structural engineering; building; building codes; building design; *NBSIR 80-2111-2*.

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EBR-II; Eu isotopes; integral cross sections; Nd; Sm; dosimetry; *SP594*, pp. 557-562 (Sept. 1980).

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Econometric models; energy modeling forum; energy models; evaluation; mathematical models; model access; model management; sensitivity analysis; validation; assessment; documentation; *SP569*.

Economic; elastomers; materials; ozone; paint; photochemical oxidants; reaction mechanisms; textile dyes; *19768*.

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Economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; building economics; discounting; *H132*.

Economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; *NBSIR 79-1948*.

Economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; cost components; data analysis; data collection; demonstration; *NBSIR 80-2167*.

Economic analysis; energy conservation; windows; building economics; *19073*.

Economic analysis; energy consumption; HVAC systems; Total Energy systems; cogeneration; costs; *NBS-GCR-80-164*.

Economic analysis; enforcement; housing codes; personnel; budgets; *SP586*, pp. 135-148 (June 1980).

Economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; building economics; cost estimation; *BSS129*.

Economic analysis; engineering economics; mathematical models; program planning; building economics; construction; cost estimation; econometric models; *NBS-GCR-80-197*.

Economic analysis; fire safety; fire safety evaluation system; health care facilities; life cycle; cash flow; *NBS-GCR-79-186*.

Economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; *NBSIR 79-1929*.

Economic analysis; furnaces; incremental savings; life-cycle



costs; minimum efficiency levels; minimum efficiency standards; boilers; central heating equipment; *NBSIR 80-2079*.

Economic analysis; HVAC systems; Total Energy system; cogeneration; costs; *NBS-GCR-80-165*.

Economic analysis; housing; lead-based paint; lead poisoning; applied economics; building economics; building materials; *NBSIR 80-1977*.

Economic analysis; incremental savings; life-cycle costs; minimum efficiency standards; minimum energy-efficiency levels; central air conditioners; *NBSIR 80-1993*.

Economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; building economics; buildings; building systems standard; cost; discounting; *NBSIR 80-2040*.

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Economic benefits; epistemology; measurement system; metric system; SI; base units; convention of the meter; 19639.

Economic deregulation; evaluability assessment; evaluation; Experimental Technology Incentives Program; intermodal freight transportation; Interstate Commerce Commission; rail freight transportation; regulatory experimentation; regulatory policy; *NBS-GCR-ETIP 80-85*.

Economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; building economics; discounting; economic analysis; *H132*.

Economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; economic analysis; *NBSIR 79-1948*.

Economic evaluations; energy conservation; Federal energy management program; life-cycle costing; public buildings; renewable energy; solar energy; solar photovoltaic; cost effectiveness; *H135*.

Economic feasibility; economic optimization; solar energy systems; active solar energy; break-even analysis; building economics; commercial buildings; 19350.

Economic impact of regulations; economic impact of standards; economic information on standards; Federal use of voluntary standards; procedural history; rationale; standardization; *NBSIR 80-2123*.

Economic impact of standards; economic information on standards; Federal use of voluntary standards; procedural history; rationale; standardization; economic impact of regulations; *NBSIR 80-2123*.

Economic incentives; Emission Offset Interpretative Ruling; Environmental Protection Agency; market mechanisms; regulation; air pollution; *NBS-GCR-ETIP 80-86*.

Economic incentives; emission offsets; emission reduction trading; enforcement; Environmental Protection Agency; market mechanisms; air pollution; Clean Air Act; *NBS-GCR-ETIP 80-87*.

Economic incentives; emission offsets; emission reduction trading; market mechanisms; regulation; air pollution; *NBS-GCR-ETIP 80-90*.

Economic information on standards; Federal use of voluntary standards; procedural history; rationale; standardization; economic impact of regulations; economic impact of standards; *NBSIR 80-2123*.

Economic optimization; solar energy systems; active solar energy; break-even analysis; building economics; commercial buildings; economic feasibility; 19350.

Economics; ENDF/B-V; fuel cycle; symbiotic energy system; tritium breeding; cross-section uncertainty; CTR; denatured fuel; *SP594*, pp. 839-843 (Sept. 1980).

Economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating; building envelope; cost effectiveness; 19235.

Economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; building design; construction economics; discounting; *SP544*.

Economics; evaluation; literature search; regulation; standardization; standards; benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; *NBSIR 80-2015*.

Economics; government policy; product certification; standardization research needs; standards; accreditation of testing laboratories; certification; certification industry; *NBSIR 80-2001*.

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Editing; networks; specifications standards; systems analysis/engineering; codes; decision theory; *NBS-GCR-80-259*.

Education; electronic devices; International Organization of Legal Metrology; legal metrology; measurement assurance; metrication; model laws and regulations; moisture loss; packaging and labeling; specifications and tolerances; weights and measures; consumer affairs; *SP566*.

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Educational requirements; inspection; licensing; testing; training code officials; building codes; building inspectors; code enforcement; course development; *SP586*, pp. 71-83 (June 1980).

EELS; electron spectroscopy; photoemission; UPS; XPS; AES; chemisorption; 19176.

Effective charge; oscillator strength; photoelastic; piezo-birefringence; piezo-optic; SrF<sub>2</sub>; strain; stress; transverse optic-phonon; anisotropy; BaF<sub>2</sub>; CaF<sub>2</sub>; 19579.

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Effective recombination time; nonequilibrium phenomena; phonon-trapping; quasiparticle; superconductor; acoustic mismatch; 19240.

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agement; *SP585*.

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Egress; evacuation; fire alarm systems; fire departments; fire fighters; flashover; nursing homes; nursing staff; patients; room fires; smoke detectors; death; doors; *NBS-GCR-80-191*.

Egress; evacuation; fire alarm systems; fire departments; fire fighters; hospitals; nursing staff; patients; smoke; *NBS-GCR-80-192*.

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Eigenvalue; ENDF/B-IV; integral experiments; reaction rate ratios; reactivity worths; ZPR critical assembly; delayed neutron data; *SP594*, pp. 297-306 (Sept. 1980).

Elastic and inelastic scattering cross sections; energy range 10 keV-15 MeV; optical and statistical model calculations; potential scattering radii; s- and p-wave strength functions; total cross sections; W isotopes; *SP594*, pp. 336-339 (Sept. 1980).

Elastic constants; fluctuations; high temperature properties; Monte Carlo simulations; aluminum; anharmonic effects; effective potentials for metals; *J. Res.* 85, No. 2, 109-112 (Mar.-Apr. 1980).

Elastic constants; gallium arsenide; indium antimonide; ionicity; optical phonons; Raman scattering; semiconductors; stress; zinc-blende structure; covalent bonding; diamond structure; *19580*.

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Elastic enhancement factors; factorization; Hauser-Feshbach theory; statistical models; width fluctuation correction factor; compound-nucleus reactions; cross sections; *SP594*, pp. 762-764 (Sept. 1980).

Elasticity; elastomers; extension; rubber; strain-energy function; Valanis-Landel form; biaxial; *19502*.

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Elastic scattering cross section; partial inelastic scattering cross section; resonance self-shielding effect; sensitivity analysis; shielding application; structural material; total cross section; unresolved resonance; *SP594*, pp. 586-590 (Sept. 1980).

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Elastomers; polyolefin rubber; segmented polyurethane; time dependent failure; urethane-silicone copolymer; biomaterials; blood pump materials; butyl rubber; *NBSIR 80-2008*.

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Electrical calibration; plutonium; plutonium determination; computer-assisted coulometry; controlled-potential coulometry; control-potential adjustment; *SP582*, pp. 164-168 (June 1980).

Electrical codes; fire safety; glowing electrical connections; house wiring; innovative electrical connections; performance testing; contact resistance; *BSSI28*.

Electrical conductance; hexafluoraluminates; metaphosphates; molten salts; molybdates; sulfates; sulfides; surface tension; tungstates; viscosity; carbonates; density; *JPCRD 9*, No. 4, 831-1022 (1980).

Electrical conductance; molten salts; potassium nitrate; sodium chloride; surface tension; viscosity; calibration-quality standards; density; *JPCRD 9*, No. 4, 791-830 (1980).

Electrical conductivity; ferric; ferric/ferrous ratio; ferrous; ionic; ionic conductivity; magnetohydrodynamics iron; MHD; silicates; coal slag; conductivity; electrical; *19576*.

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- ance; 19531.
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- Electrical equipment; enclosures; explosion; explosion containment; mine safety; bibliography; coal mines; *NBSIR 80-2112*.
- Electrical fires; explosions; fire investigations; fire investigators; hydrocarbons; photography; accelerants; arson; building fires; *H134*.
- Electrically calibrated radiometer; pyroheliometry; solar constant; absolute radiometry; cavity absorptance; cavity reflectance; 19909.
- Electrically conducting ceramics; electrical transmission; lightning arresters; nonlinear resistors; semiconductors; surge arresters; varistors; voltage-variable resistors; zinc oxide; *NBSIR 79-1939*.
- Electrically heated inlet; gas chromatography; injector; vapor sampler; capillary columns; concentrator; 19667.
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- Electrical measurements; energy loss; shunt reactors; bridges; calibration; current comparator; dissipation factor; 19767.
- Electrical measurements; Hall measurements; semiconductors; silicon; 19415.
- Electrical measurements; health; radiation; radiation safety; safety; x rays; calibration; diagnostic x-rays; *NBSIR 80-2072*.
- Electrical measurements; mobility; resistivity; semiconductors; silicon; dopant density; 19806.
- Electrical measurements; mobility; resistivity; semiconductors; silicon; dopant density; 19783.
- Electrical properties; electronics; electron irradiation. hole mobility; integrated circuits; ion knock-on effect; ion microprobe mass analysis; Irvin's curves; isothermal transient capacitance method; linewidth measurements; measurement technology; microelectronics; *SP400-45*.
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- Electrical resistivity; heat capacity; high temperature; palladium; pulse method; thermodynamics; 19770.
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- Electrical transmission; lightning arresters; nonlinear resistors; semiconductors; surge arresters; varistors; voltage-variable resistors; zinc oxide; electrically conducting ceramics; *NBSIR 79-1939*.
- Electrical transmission; partial discharges; polymers; precision electric measurements; pulse-height analysis; superconducting transmission; capacitance; cryogenic; dielectric constant; dielectric properties; dissipation factor; *NBSIR 79-1950*.
- Electrical wiring; radiation exposure; solar absorber coatings; SRM's; structural safety; automation; computers; *DIM/NBS 64*, No. 8, 1-28 (1980).
- Electric dipole; electroexcitation; giant resonance;  $^{13}\text{C}$ ; absolute measurement; activation; 19763.
- Electric field; high energy laser; laser damage; reflectors; thin film; absorption; calorimetry; damage; *SP568*, pp. 377-390 (July 1980).
- Electric field; integral equation; source dyadic; dyadic Green's functions; 19249.
- Electric-field strength; film materials; impurities; overcoat; polished surfaces; pulsedwidth dependence; thin-film coatings; 1 ns; 1.06  $\mu\text{m}$  damage; absorption; *SP568*, pp. 391-403 (July 1980).
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- Electric utilities; Experimental Technology Incentives Program; interim adjustment procedures; regulatory commissions; regulatory process; computer programs; *NBS-GCR-ETIP 79-77*.
- Electric utilities; Experimental Technology Incentives Program; marginal costing; rate structure; regulatory commissions; regulatory process; technological innovation; time varying rates; computer models; *NBS-GCR-ETIP 79-79*.
- Electric utilities; Experimental Technology Incentives Program; productivity; regulatory commissions; regulatory process; technological innovation; *NBS-GCR-ETIP 79-82*.
- Electric utilities; Experimental Technology Incentives Program; productivity; regulatory commissions; regulatory process; technological innovation; *NBS-GCR-ETIP 79-81*.
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- Electrocaloric effect; entropy; ferroelectrics; glass-ceramics; heat switches; polarization; refrigeration; specific heat strontium titanate; ceramics; cryogenics; dielectric constant; 19534.
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- Electrochemical detector; high performance liquid chromatography; methylmercury; organometals; speciation; 19555.
- Electrochemical equivalent; electrochemistry; Faraday; fundamental constants; silver; coulometry; *J. Res. 85*, No. 3, 175-191 (May-June 1980).
- Electrochemical measurements; galvanostat; impedance measurements; noise; potentiostat; *J. Res. 85*, No. 3, 211-217 (May-June 1980).
- Electrochemical noise; instrumentation; iron; nickel; potentiostat; aluminum; corrosion; 19878.
- Electrochemistry; ellipsometry; field ion microscopy; hydrogen; inhibitors; iron; organic coatings; titanium-palladium alloys; vanadium; chromate; *NBSIR 80-2101 (Navy)*.
- Electrochemistry; Faraday; fundamental constants; silver; coulometry; electrochemical equivalent; *J. Res. 85*, No. 3, 175-191 (May-June 1980).
- Electrochemistry; Faraday constant; silver; coulometer; coulometry; 19472.
- Electrochemistry; polarization techniques; underground corrosion; corrosion; corrosion noise; *NBSIR 80-2083*.
- Electrodeposited coatings; electrodeposition; thickness; thickness gages; calibration; calibration of thickness gages; calibration standards; coatings; coating thickness; coating thickness gages; coating thickness measurement; 19954.
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- Electrodeposition; epitaxy; tin aluminum; zinc; aluminum; coatings; 19730.
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Electrolytes; flame atomic absorption spectroscopy; interlaboratory testing; precision; reference method; semiautomated pipetting; serum lithium analysis; statistical analysis; accuracy; clinical analysis; clinical chemistry; definitive method; *SP260-69*.

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Energy distribution; finite geometry; Monte Carlo method; multiple scattering; neutron; scattering; angular distribution; computer programs; corrections; *SP594*, pp. 504-508 (Sept. 1980).

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Energy distribution functions; Jovanovich equation; Langmuir equation; monomolecular adsorption; nonlinear regression analysis; adsorption isotherms; *19771*.

Energy Extension Service (EES) program; regulations; standards; State energy conservation office contact personnel; State energy conservation plans and programs; energy conservation measures for consumer products; *NBSIR 80-2017*.

Energy efficiency; inventors; innovation; labels; standards; sulfuric acid; tools; awards; computers; didymium glass filters; *DIM/NBS 64*, No. 7, 1-28 (1980).

Energy-efficient building; ASHRAE Standard 62-73; building ventilation; carbon dioxide and ventilation; *19218*.

Energy estimates; geographical distribution; low temperature collectors; manufacturing activity; medium temperature collector; solar energy; special collectors; *19527*.

Energy-generation; lasers; molecules; air; electron; *19318*.

Energy levels; ion; ionization energy; niobium; spectrum; wavelengths; *19282*.

Energy levels; ion; ionization energy; spectrum; wavelengths; zirconium; *19118*.

Energy levels; isoelectric sequence; VUV spectra; wavelengths; xenon; Ag I; *19069*.

Energy levels; magnesium; wavelengths; configuration interaction; *19556*.

Energy levels; sodium; wavelengths; aluminum; configuration interaction; *19562*.

Energy levels; theta-pinch; wavelengths; Xenon; *19117*.



Energy levels, atomic; spectra, atomic; wavelengths, atoms and ions; atomic energy levels; atomic spectra; bibliography; *SP363. Supplement 2*.

Energy loss; shunt reactors; bridges; calibration; current comparator; dissipation factor; electrical measurements; *19767*.

Energy measurements; heat pump; laboratory tests; modifications test procedures; water heaters; energy consumption; *NBSIR 79-1951*.

Energy modeling forum; energy models; evaluation; mathematical models; model access; model management; sensitivity analysis; validation; assessment; documentation; econometric models; *SP569*.

Energy models; evaluation; mathematical models; model access; model management; sensitivity analysis; validation; assessment; documentation; econometric models; energy modeling forum; *SP569*.

Energy performance criteria; illumination; lighting; power budget; building illumination systems; energy budget; energy conservation; *NBSIR 80-2052*.

Energy performance of windows; window attributes; window design; window design elements; window performance; design elements; *SP575*.

Energy per ion pair; kerma; neutrons; secondary charged particles; tissue-equivalent gas; dosimetry; *19331*.

Energy range 10 keV-15 MeV; optical and statistical model calculations; potential scattering radii; s- and p-wave strength functions; total cross sections; W isotopes; elastic and inelastic scattering cross sections; *SP594*, pp. 336-339 (Sept. 1980).

Energy resolution; hard x-ray; imaging; Lixiscope; soft gamma-ray; spectrometer; *19403*.

Energy resolution; hard x-ray; imaging; Lixiscope; soft gamma-ray; spectrometer; *19404*.

Energy resolution; low-energy gamma rays; microchannel plates; position-sensitive detector; x-ray telescope; CsI scintillator; *19401*.

Energy retrofit; home audit; thermal time constant; energy analysis calculation; *NBSIR 80-1961*.

Energy spectra; integral experiment; pulse-shape discrimination; data unfolding; *SP594*, pp. 591-595 (Sept. 1980).

Energy transfer; laser-excited fluorescence; laser-induced chemistry; mass transport; multiphoton processes; vibrational relaxation; diffusion; *19179*.

Energy transfer; lasers; calcium; collision physics; dimer lasers; *19775*.

Enforcement; Environmental Protection Agency; market mechanisms; air pollution; Clean Air Act; economic incentives; emission offsets; emission reduction trading; *NBS-GCR-ETIP 80-87*.

Enforcement; housing codes; personnel; budgets; economic analysis; *SP586*, pp. 135-148 (June 1980).

Engineer; equivalent life safety; municipal attorney; product endorsement; professional liability; variances; appeals process; architect; certification; checklists; code official; consultant; *SP586*, pp. 45-57 (June 1980).

Engineering; missiles; structural engineering; tornadoes; wind; *NBSIR 80-2117*.

Engineering; standards; building; building codes; building design; disaster mitigation; earthquakes; *NBSIR 80-2111-9*.

Engineering; standards; structural engineering; building; building codes; building design; earthquakes; *NBSIR 80-2111-2*.

Engineering and health effects; environmental contaminants; health science; air quality; contaminants from building materials; *19156*.

Engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; building economics; cost estimation; economic analysis; *BSS129*.

Engineering economics; mathematical models; program planning; building economics; construction; cost estimation; econometric models; economic analysis; *NBS-GCR-80-197*.

Engineering standards; information interchange; measurement systems; product standards; standard reference data; standard reference materials; *19905*.

Engineers; Florida; inspection; legislation; recertification; architects; codes; earthquake; *SP586*, pp. 197-203 (June 1980).

Engine oil; hydraulic oil; industrial oil; lubricating oil; oil specifications; petroleum standards; petroleum test methods; recycled oil; re-refined oil; used oil; waste oil; *SP584*.

Enriched targets; nuclear reactions; quadrupole and hexadecapole deformation parameters; calculated direct-interaction and compound-nucleus cross sections; deduced coupled-channel optical potential parameters; *SP594*, pp. 672-676 (Sept. 1980).

Enriched targets; palladium isotopes; resonance parameters deduced; *SP594*, pp. 315-318 (Sept. 1980).

Enriched  $^{22}\text{Ne}$  target;  $E = 60$  to  $110$  MeV; measured  $\sigma(E)$  at  $110^\circ$  and  $128^\circ$  up to  $8.6$  MeV in excitation energy; nuclear reactions;  $^{22}\text{Ne}(e, e')$ ; *19691*.

Entanglement effects; excluded volume effects; lattice-model polymer chains; polymer chain dynamics; random-coil polymer chains; relaxation times; self-entanglement effects; computer simulation; end-to-end length; *19864*.

Enthalpimetry; glass processing; instrumentation; paper technology; polymer ignition; rubber processing; thermal analysis; thermogravimetry; adsorbents; chemical processing; coordination compounds; *SP580*.

Enthalpy; entropy; equation of state; heat capacity at constant pressure; heat capacity at constant volume; helium; hydrogen; methane; neon; nitrogen; oxygen; thermal conductivity; velocity of sound; viscosity; argon; computer programs; density; *TN1025*.

Enthalpy; entropy; Gibbs energy; heat capacity; thermochemical tables; uranium-halogen containing compounds; data evaluation; *NBSIR 80-2029*.

Enthalpy; heat capacity; high-temperature; standard reference material; thermodynamic functions; tungsten; drop calorimetry; electronic heat capacity; *19363*.

Enthalpy of dilution; enthalpy of solution; KCl; SRM 1655; standard reference material; thermochemistry; adiabatic calorimeter; calorimetry,  $\Delta C_p$ , endothermic reaction; *J. Res. 85*, No. 6, 449-465 (Nov.-Dec. 1980).

Enthalpy of dilution; heat; hydrochloric acid; lithium chloride; relative apparent molal enthalpy; relative partial molal enthalpy; sulfuric acid; thermochemistry; calorimetry; electrolytes; *J. Res. 85*, No. 1, 11-17 (Jan.-Feb. 1980).

Enthalpy of solution; KCl; SRM 1655; standard reference material; thermochemistry; adiabatic calorimeter; calorimetry,  $\Delta C_p$ , endothermic reaction; enthalpy of dilution; *J. Res. 85*, No. 6, 449-465 (Nov.-Dec. 1980).

Enthalpy of solution; KCl; solution calorimetry; standard reference materials; thermochemistry; tris(hydroxymethyl)aminomethane; calorimetry; *J. Res. 85*, No. 6, 467-481 (Nov.-Dec. 1980).

Enthalpy of water; heavy water;  $PvT$ ; saturation states; thermodynamic properties of water; vapor pressure; virial coefficients; water; *JPCRD 9*, No. 3, 735-750 (1980).

Entrepreneurship; innovation; innovation centers; invention; invention evaluation; Santa Cruz; *19261*.

Entropy; equation of state; heat capacity at constant pressure; heat capacity at constant volume; helium; hydrogen; methane; neon; nitrogen; oxygen; thermal conductivity; velocity of sound; viscosity; argon; computer programs; density; enthalpy; *TN1025*.

Entropy; ferroelectrics; glass-ceramics; heat switches; polarization; refrigeration; specific heat strontium titanate; ceramics; cryogenics; dielectric constant; electrocaloric effect; *19534*.

Entropy; Gibbs energy; heat capacity; thermochemical tables; uranium-halogen containing compounds; data evaluation; enthalpy; *NBSIR 80-2029*.

Environment; Federal programs; laboratory accreditation; monitoring; quality assurance; standard methods; data; *19715*.

Environment; gage element; leads; load; protective coating; resistance; sensitivity change; stability; strain gages; structure;



- transducers; zero shift; adhesive; backing; connection; 19049.
- Environment; health; measurements; radiation; radon; radon daughters; ventilation; buildings; *SP581*.
- Environment; health; modelling; scientific uncertainty; societal decisions; socioscientific problems; theory; time constants; basic research; challenge to the analytical chemist; chemical measurement process; energy; 19666.
- Environmental; measurements; radiation; random uncertainty; systematic uncertainty; data reporting; 19301.
- Environmental; shale oil; SRM; weights and measures; x-ray exams; compact range; data; daylighting; energy; *DIM/NBS 64*, No. 6, 1-24 (1980).
- Environmental analysis; foliar analysis; food analysis; nutrition; plant tissue analysis; standard reference material; trace analysis; agriculture; 19423.
- Environmental analysis; foliar analysis; food analysis; organic solvents; standard reference material; water analysis; 19571.
- Environmental chamber; fan depressurization; mobile home; sulfur hexafluoride; tracer gas; air leakage measurements; *NBSIR 80-2105*.
- Environmental contaminants; health science; air quality; contaminants from building materials; engineering and health effects; 19156.
- Environmental degradation; materials degradation; solar collector; durability/reliability; 19451.
- Environmental effects; lead chromate pigments; storm water runoff; toxicity; water pollution; air pollution; chromate ore; *NBSIR 80-1974*.
- Environmental exposure; materials; polymeric materials; solar collectors; absorber materials; absorptive coatings; accelerated aging; cover plates; durability; 19364.
- Environmental fracture; fracture; materials failure; reaction rate theory; slow crack growth; surface energy; 19843.
- Environmental hazards; human factors; occupational safety; scaffold failures; scaffolds; accidents; accident statistics; construction regulations; construction safety; employee casualties; *NBSIR 79-1955*.
- Environmental impact; feasibility study; integrated utilities; MIUS; on-site utilities; energy conservation; *NBSIR 79-1787*.
- Environmental influence; outdoor testing; solar collectors; solar simulators; thermal testing; ASHRAE Standard 93; collector rating; 19366.
- Environmental laboratories; licensure; performance evaluation; physician's office laboratories; proficiency testing; public health; recombinant DNA; registration and approval; voluntary standards; clinical laboratories; cost effectiveness; *SP591*, pp. 63-66 (Aug. 1980).
- Environmental measurements; materials science; measurement services; molecular science; National Measurement Laboratory; nondestructive evaluation; nuclear measurement technology; physics research; radiation research; recycled materials; standard reference data; *SP572*.
- Environmental measurements; quality assurance; reference methods; standard reference materials; definitive methods; 19574.
- Environmental Protection Agency; innovative technology; innovative waivers; regulation; air pollution; Clean Air Act; emission control technology; *NBS-GCR-ETIP 80-88*.
- Environmental Protection Agency; market mechanisms; air pollution; Clean Air Act; economic incentives; emission offsets; emission reduction trading; enforcement; *NBS-GCR-ETIP 80-87*.
- Environmental Protection Agency; market mechanisms; regulation; air pollution; economic incentives; Emission Offset Interpretative Ruling; *NBS-GCR-ETIP 80-86*.
- Environmental Protection Agency; public comment; regulation; rulemaking; air pollution; Clean Air Act; *NBS-GCR-ETIP 80-89*.
- Environmental particulates; thermal analytical methods; alpha-quartz particulate; chrysotile asbestos particulate; differential thermal analysis; 19890.
- Environmental pollution; highway noise; motor vehicle noise; noise; noise control; sound; traffic noise; transportation noise; acoustics; *TN1113-1*.
- Environmental pollution; noise control; noise isolation; sound; acoustics; building acoustics; *TN1113-2*.
- Environmental psychology; fire research; fire safety; human behavior in fires; modeling technique; programming; simulation of human behavior; architectural research; building fires; computer-aided design; *NBSIR 80-1982*.
- Environmental psychology; illumination; perception; questionnaires; research methodology; sensory environment; social sciences; thermal environment; architecture; audition; built environment; color; *SP474*.
- Environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance; collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; 19239.
- Environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance; collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; 19325.
- Environmental stability; masking layer; potassium chloride window; scattering; thallium iodide; antireflective coating; deposition technique; *SP568*, pp. 355-357 (July 1980).
- Environmental trace elements; NBS standard reference materials; SRM 1567, Wheat Flower; SRM 1568, Rice Flower; trace element nutrients; 19570.
- Environments; homogeneity; natural materials; nondestructive assay; particles; quality assurance; radiation; radioactivity; radiochemical assay; radionuclide; segregation; standard; calibration; 19298.
- Enzyme activity; molar absorptivity (molar absorption coefficient); 19561.
- EPCA; residential; usage; appliances; conservation; costs; energy; *NBSIR 80-1994*.
- Epistemology; measurement system; metric system; SI; base units; convention of the meter; economic benefits; 19639.
- Epitaxial growth; Hall measurements; indium-doped silicon; p-n junction isolation; two-layer structures; 19417.
- Epitaxy; inter-layerings; nonstoichiometry; structural considerations; twinning; computer assessment; crystal structures; *J. Res. 85*, No. 5, 347-362 (Sept.-Oct. 1980).
- Epitaxy; plating coatings; zinc; aluminum; electrodeposition; 19657.
- Epitaxy; tin aluminum; zinc; aluminum; coatings; electrodeposition; 19730.
- Epithermal neutron energy; neutron radiography; nondestructive assay; nondestructive evaluation; position-sensitive proportional counter; *SP594*, pp. 436-439 (Sept. 1980).
- Epithermal neutron energy; neutron radiography; nondestructive assay; position-sensitive proportional counter; uranium; *SP582*, pp. 86-92 (June 1980).
- Epithermal neutrons; neutron radiography; nondestructive assay; nondestructive evaluation; position-sensitive proportional counter; 19847.
- Equation of state; ethylene; impurities; isochores; scaling laws; Burnett method; coexistence curve; critical exponents; critical isochore; critical parameters; 19894.
- Equation of state; extended corresponding states; extended critical region; mathematical model; natural gas components; nitrogen-methane mixtures; PVTx properties measurements; 19782.
- Equation of state; fluids; orthobaric densities; propane; specific heats; thermodynamic properties; vapor pressures; coexistence boundary; critical point; densities; 19204.
- Equation of state; heat capacity at constant pressure; heat capacity at constant volume; helium; hydrogen; methane; neon; nitrogen; oxygen; thermal conductivity; velocity of sound; viscosity; argon; computer programs; density; enthalpy; entropy; *TN1025*.



Equation of state; helium II; mathematical model; superfluid; thermodynamic properties; computer program; deviation plots; *TN1029*.

Equation of state; ideal gas; Van der Waals equation; virial coefficient; virial equation; Debye theory; *19772*.

Equation of state; inhomogeneous fluid; lattice fluid; long-range interactions; surface entropy; Cahn-Hilliard theory; chemical potential; density gradient; *19653*.

Equation of state; interfacial tension; lattice fluid; miscibility; spinodal; chemical potential; combinatorial entropy; *19652*.

Equilibrium; game theory; mathematical economics; noncooperative games; aggregation; *J. Res.* **85**, No. 5, 391-428 (Sept.-Oct. 1980).

Equilibrium; incoherent interfaces; solid-fluid interface; stressed solid; thermodynamics; vacancies; coherent interfaces; *19949*.

Equilibrium partitioning; Fickian diffusion; food package; interaction parameter; migration; partition coefficient; radiolabeled additive; solubility; *19651*.

Equipment; evaluation; laboratory; manual; personnel; quality assurance; quality control; systems; calibration; *SP591*, pp. 99-103 (Aug. 1980).

Equipment; International Atomic Energy Agency; international safeguards; *SP582*, pp. 169-177 (June 1980).

Equivalency; housing standards; minimum standards; space standards; *SP586*, pp. 103-115 (June 1980).

Equivalent life safety; municipal attorney; product endorsement; professional liability; variances; appeals process; architect; certification; checklists; code official; consultant; engineer; *SP586*, pp. 45-57 (June 1980).

Erosion; fracture mechanics; thermal fracture; ceramic strength; crack propagation; *19728*.

Erosion; germanium; hardness measurements; plastic deformation; silicon; silicon carbide; aluminum oxide; brittle fracture; dislocations; electron microscopy; *19731*.

Erosion; glass; impact; indentation fracture; strength; ceramics; *19594*.

Erosion; impact; metals; surfaces; deformation; *19936*.

Erosion; impingement erosion; metal erosion; wear; copper; electron microscopy; *19941*.

Erosion; instrument landing; measurements; radio frequency; surface science; tetrafluoroethylene powder; water conservation; alternate fuels; data communications; energy; *DIM/NBS* **64**, No. 5, 1-28 (1980).

Erosion; metals; pumps; valves; wear; cyclones; energy; *NBSIR 80-2045 (DOE)*.

Erosive wear; impact; steel; wear; wear debris; abrasive particles; electron microscopy; *19874*.

Erosive wear; scanning electron microscopy; transmission electron microscopy; wear; abrasive wear; copper; *19958*.

Error analysis; exponential function; multiprecision calculations; relative precision; unrestricted arguments; unrestricted ranges; *19380*.

Error analysis; MHD; plasma conductivity; electron scattering cross section; *19090*.

Error bounds; parabolic cylinder functions; turning points; Whittaker functions; asymptotic expansions; confluent hypergeometric functions; *19773*.

Error checking; FORTRAN program; least squares solution; mass calibration; mass measurement; calibration report; correction to mass measurements; *TN1127*.

Error estimates; higher order finite difference methods; numerical experiments; parabolic equations; singular perturbation problems; cell Reynolds number; diffusion convection equations; *19490*.

Errors; isotope ratios; mass spectroscopy; pulse counting; resin beads; thermal ionization; uranium; *19816*.

ESCA; gold; relative intensities; round robin; x-ray photoelectron spectroscopy; binding energies; copper; *19202*.

ESCA; oxygen; ruthenium; ruthenium oxide; surface reactions; chemisorption; *19254*.

ESDIAD; ion energy distributions; ion yield; oxygen; photon stimulated desorption; synchrotron radiation; tungsten; angular distribution of ions; chemisorption; electron stimulated desorption; *19533*.

Escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; *SP585*.

Escape; evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; *NBSIR 80-1965*.

Escape behavior; HUD; mobile home; safety; standard; window; anthropometry; emergency egress; *NBSIR 80-2049*.

Estimates; gamma rays; neutrons; nondestructive assay; plutonium waste; safeguards; uranium waste; verification; counter; *SP582*, pp. 622-632 (June 1980).

ETIP; financial projections; regulatory commissions; regulatory process; technological innovation; computer program; electric utilities; *NBS-GCR-ETIP 79-73*.

Etchant bath; light absorption; microscopic pores; nickel-phosphorus alloy; solar collector; surface morphology; ultra-black surface coating; *U.S. Patent 4,233,107*.

Ethane; adsorption; angular distribution; cyclohexane; cyclooctane; cyclopropane; desorption; electron stimulated desorption; *19922*.

Ethane; group theory; internal rotation; perturbations; torsion; vibration-rotation; *19412*.

Ethernet; local; network; terminal; area; computer; data; digital; *19126*.

Ethyl chloride; halocarbons; photochemistry; *19931*.

Ethylene; impurities; isochores; scaling laws; Burnett method; coexistence curve; critical exponents; critical isochore; critical parameters; equation of state; *19894*.

Ethylene; melting pressures; PVT; vapor pressure; compressibility; density; *19682*.

Ethylene; physisorption; surface; tungsten; acetylene; chemisorption; electron energy loss spectroscopy; *19390*.

Ethylene; second virial; state-of-the-art; temperature; Burnett PVT measurements; coefficient; *19115*.

Ethylidenimine; hyperfine and internal rotations; microwave spectra; pyrolysis of ethylamine; Stark effects; synthesis and microwave spectrum of; *19447*.

[Et<sub>3</sub>P]<sub>2</sub>PtWS<sub>4</sub>; molecular structure; Pt-W complex; single crystal; ternary metal sulfide; x-ray diffraction; *19172*.

Eu isotopes; integral cross sections; Nd; Sm; dosimetry; EBR-II; *SP594*, pp. 557-562 (Sept. 1980).

Euratom safeguards; MUF simulation; MUF statistical inference; *SP582*, pp. 677-689 (June 1980).

Europium lithium borate glass; fluorescence line narrowing; glass; laser; laser glass; laser-induced fluorescence; *19545*.

Eutectics; Rayleigh waves; stability; surface anisotropy; composites; durability; *19153*.

Eutectic solidification; metallic glasses; palladium-copper-silicon alloys; rapid solidification; amorphous alloys; coupled growth; *19891*.

EV neutron energy; neutron imaging techniques; pinhole camera; position-sensitive proportional counter; *19383*.

EV neutrons; ratio; standards; cross sections; *SP594*, pp. 97-100 (Sept. 1980).

Evacuation; fire alarms; fire safety; human behavior; human factors; panic; safety; smoke; symbols; communications; *NBSIR 80-2070*.

Evacuation; fire alarm systems; fire departments; fire extinguishers; fire investigations; nursing homes; patients; *NBS-GCR-80-218*.

Evacuation; fire alarm systems; fire departments; fire fighters; flashover; nursing homes; nursing staff; patients; room fires; smoke detectors; death; doors; egress; *NBS-GCR-80-191*.

Evacuation; fire alarm systems; fire departments; fire fighters; hospitals; nursing staff; patients; smoke; egress; *NBS-GCR-80-192*.



- Evacuation; fire alarm systems; fire departments; fire investigations; smoke; *NBS-GCR-80-272*.
- Evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; *SP585*.
- Evacuation; fire alarm systems; fire departments; fire safety; handicapped; life safety; refuge; building codes; building design; building fires; building management; egress; emergencies; escape; *NBSIR 80-1965*.
- Evacuation; fire department; fire investigations; mattresses; smoke; *NBS-GCR-80-262*.
- Evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients; *NBS-GCR-80-240*.
- Evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients; smoke; sprinkler systems; *NBS-GCR-80-233*.
- Evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients; beds (furniture); *NBS-GCR-80-241*.
- Evacuation; fire departments; fire extinguishers; fire investigations; mattresses; nursing homes; nursing staff; *NBS-GCR-80-216*.
- Evacuation; fire departments; fire extinguishers; fire investigations; nursing homes; nursing staff; smoke; *NBS-GCR-80-223*.
- Evacuation; fire departments; fire extinguishers; fire investigations; patients; smoke; *NBS-GCR-80-273*.
- Evacuation; fire departments; fire fatalities; fire fighters; flashover; ladders; room fires; smoke; students; doors; dormitories; *NBS-GCR-80-193*.
- Evacuation; fire departments; fire fatalities; fire investigations; flashover; group homes; halfway houses; mental disorders; smoke; upholstered furniture; *NBS-GCR-80-200*.
- Evacuation; fire departments; fire fatalities; flashover; hotels; room fires; senior citizens; smoke; breathing apparatus; *NBS-GCR-80-253*.
- Evacuation; fire departments; fire fighters; fire investigations; mattresses; smoke; apartments; building fires; doors; egress; *NBS-GCR-79-187*.
- Evacuation; fire departments; fire investigations; flashover; schools; smoke; *NBS-GCR-80-237*.
- Evacuation; fire departments; fire investigations; hospitals; nursing staff; patients; *NBS-GCR-80-217*.
- Evacuation; fire departments; fire investigations; hospitals; smoke; *NBS-GCR-80-230*.
- Evacuation; fire departments; fire investigations; mattresses; patients; smoke; *NBS-GCR-80-266*.
- Evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; room fires; sprinkler systems; *NBS-GCR-80-206*.
- Evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; smoke; *NBS-GCR-80-205*.
- Evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; smoke; *NBS-GCR-80-214*.
- Evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; smoke; *NBS-GCR-80-242*.
- Evacuation; fire departments; fire investigations; nursing homes; patients; *NBS-GCR-80-208*.
- Evacuation; fire departments; fire investigations; nursing staff; patients; smoke; smoke detectors; *NBS-GCR-80-238*.
- Evacuation; fire extinguishers; fire investigations; hospitals; nursing staff; patients; smoke; doors; *NBS-GCR-80-231*.
- Evacuation; fire extinguishers; fire investigations; smoke; *NBS-GCR-80-276*.
- Evacuation; fire investigations; doors; *NBS-GCR-80-264*.
- Evacuation; fire investigations; smoke; *NBS-GCR-80-271*.
- Evacuations; fire alarm systems; fire departments; fire investigations; mattresses; nursing staff; smoke; *NBS-GCR-80-268*.
- Evacuations; fire alarm systems; fire extinguishers; fire investigations; nursing homes; nursing staff; patients; room fires; doors; *NBS-GCR-80-219*.
- Evacuations; fire departments; fire extinguishers; nursing staff; patients; room fires; smoke; upholstered furniture; doors; *NBS-GCR-80-220*.
- Evaluability assessment; evaluation; Experimental Technology Incentives Program; experimental variance; Occupational Safety and Health Administration; regulatory experimentation; regulatory policy; standards; technological innovation; administrative experimentation; *TN1114*.
- Evaluability assessment; evaluation; Experimental Technology Incentives Program; intermodal freight transportation; Interstate Commerce Commission; rail freight transportation; regulatory experimentation; regulatory policy; technological innovation; *NBS-GCR-ETIP 80-85*.
- Evaluated fusion cross sections; multichannel R-matrix analyses; nucleon systems; charged-particle reactions; *SP594*, pp. 650-658 (Sept. 1980).
- Evaluation; covariance; cross section; *SP594*, pp. 221-223 (Sept. 1980).
- Evaluation; Experimental Technology Incentives Program; experimental variance; Occupational Safety and Health Administration; regulatory experimentation; regulatory policy; standards; technological innovation; administrative experimentation; evaluability assessment; *TN1114*.
- Evaluation; Experimental Technology Incentives Program; intermodal freight transportation; Interstate Commerce Commission; rail freight transportation; regulatory experimentation; regulatory policy; technological innovation; administrative experimentation; *NBS-GCR-ETIP 80-85*.
- Evaluation; Experimental Technology Incentives Program; nuclear regulatory standards; regulatory experimentation; administrative experimentation; *NBSIR 80-2086*.
- Evaluation; Federal Information Processing Standards Publication; measurement; performance; remote batch; selection; service; analysis; computer; *FIPS PUB 72*.
- Evaluation; fission-products; decay heat; *SP594*, pp. 667-671 (Sept. 1980).
- Evaluation; hospitals; inspectors; marketing; qualification; re-examination; technicians; accreditation; certification; colleges; confidence; criteria; *SP591*, pp. 3-5 (Aug. 1980).
- Evaluation; inspection; audit; calibration; calibration laboratory; certification; *SP591*, pp. 41-44 (Aug. 1980).
- Evaluation; laboratory; manual; personnel; quality assurance; quality control; systems; calibration; equipment; *SP591*, pp. 99-103 (Aug. 1980).
- Evaluation; literature search; regulation; standardization; standards; benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; economics; *NBSIR 80-2015*.
- Evaluation; mathematical models; model access; model management; sensitivity analysis; validation; assessment; documentation; econometric models; energy modeling forum; energy models; *SP569*.
- Evaluation; neutron cross-sections; optical model; resonances; statistical model; *SP594*, pp. 872-876 (Sept. 1980).
- Evaluation; neutrons; sodium; cross sections; *SP594*, pp. 58-62 (Sept. 1980).
- Evaluation; nuclear levels; nuclear reactions; nuclear structure data; radioactivity; reaction gamma rays; ENSDF; *SP594*, pp. 659-661 (Sept. 1980).
- Evaluation; organic coating; pullout tests; reinforcing steels; structural engineering; concrete (reinforced); creep tests; *19077*.
- Evaluation; toxicology laboratories; accreditation; certification criteria; *SP591*, pp. 75-76 (Aug. 1980).
- Evaluation; 14.73 MeV;  $^{56}\text{Fe}(n,p)$  cross section; *SP594*, pp. 980-984 (Sept. 1980).
- Evaluation criteria; laboratory accreditation; standards committees; *19848*.
- Evaluation environments; statistical pattern recognition; test environments; test workload generation; benchmark; *19059*.
- Evaluation, internal quality control; evaluation, performance; evaluation, qualifications of laboratory personnel; improvement; proficiency testing; checklist; CLIA '67; Clinical Labo-



- ratories Improvement Act of 1967; clinical laboratory evaluation; *SP591*, pp. 53-62 (Aug. 1980).
- Evaluation of inspection organizations; evaluation of testing organizations; inspection standards; laboratory accreditation; laboratory evaluation; regulatory liability; test standards; voluntary consensus standards; accreditation systems; *SP591*, pp. 11-14 (Aug. 1980).
- Evaluation of safeguards effectiveness; waste management; back-end facilities; containment and surveillance; detection probability; *SP582*, pp. 740-749 (June 1980).
- Evaluation of testing organizations; inspection standards; laboratory accreditation; laboratory evaluation; regulatory liability; test standards; voluntary consensus standards; accreditation systems; certification; *SP591*, pp. 11-14 (Aug. 1980).
- Evaluation, performance; evaluation, qualifications of laboratory personnel; improvement; proficiency testing; checklist; CLIA '67; Clinical Laboratories Improvement Act of 1967; clinical laboratory evaluation; evaluation, internal quality control; *SP591*, pp. 53-62 (Aug. 1980).
- Evaluation, qualifications of laboratory personnel; improvement; proficiency testing; checklist; CLIA '67; Clinical Laboratories Improvement Act of 1967; clinical laboratory evaluation; evaluation, internal quality control; evaluation, performance; *SP591*, pp. 53-62 (Aug. 1980).
- Evaluations; reviews; solutions; thermodynamic properties; aqueous electrolytes; electrolyte data center; *19920*.
- Evaporation; fission; high energy proton; neutron yield analysis; spallation; *SP594*, pp. 417-421 (Sept. 1980).
- Evaporation rate; fabric; flammability; garments; gasoline; heat output; ignition; burn injury; *19114*.
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- Field ion microscopy; photoillumination effect; silicon; 19210.
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- Field-ion microscopy; surface physics; surface reconstruction; atomic surface structure; 19940.
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Fire departments; fire extinguishers; fire investigations; nursing homes; smoke; *NBS-GCR-80-226.*

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Fire departments; frequency distribution; noise (sound); sleep; smoke detectors; wakefulness; adults; alarm responses; auditory perception; decibal levels; *NBS-GCR-80-284.*

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Fire fighters; flashover; ladders; room fires; smoke; students; doors; dormitories; evacuation; fire departments; fire fatalities; *NBS-GCR-80-193*.

Fire fighters; flashover; nursing homes; nursing staff; patients; room fires; smoke detectors; death; doors; egress; evacuation; fire alarm systems; fire departments; *NBS-GCR-80-191*.

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Fire incident; nursing homes; nursing staff; patients; smoke; fire departments; *NBS-GCR-80-211*.

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Fire investigations; hospitals; patients; beds (furniture); evacuation; fire departments; fire extinguishers; *NBS-GCR-80-241*.

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- Fire investigations; nursing homes; fire departments; *NBS-GCR-80-236*.
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- Fire investigations; nursing homes; nursing staff; patients; smoke; evacuation; fire departments; *NBS-GCR-80-214*.
- Fire investigations; nursing homes; nursing staff; patients; smoke; evacuation; fire departments; *NBS-GCR-80-205*.
- Fire investigations; nursing homes; nursing staff; smoke; evacuation; fire departments; fire extinguishers; *NBS-GCR-80-223*.
- Fire investigations; nursing homes; patients; evacuation; fire alarm systems; fire departments; fire extinguishers; *NBS-GCR-80-218*.
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- Fire investigations; smoke; doors; fire departments; *NBS-GCR-80-221*.
- Fire investigations; smoke; evacuation; fire alarm systems; fire departments; *NBS-GCR-80-272*.
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- Fire investigations; smoke; fabric flammability; fire departments; *NBS-GCR-80-270*.
- Fire investigations; smoke; fire alarm systems; fire departments; *NBS-GCR-80-275*.
- Fire investigations; smoke; sprinkler systems; fire alarm systems; fire departments; *NBS-GCR-80-263*.
- Fire investigators; hydrocarbons; photography; accelerants; arson; building fires; electrical fires; explosions; fire investigations; *H134*.
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- Fire modeling; fire protection; fire research; fire suppression; human behavior in fires; physics of fire; toxicity of combustion products; chemistry of fire; combustion products; detection; fire hazards; *NBSIR 80-2127*.
- Fire models; fire protection; marine transportation; merchant vessels; shipboard fires; cost benefit analysis; cost effectiveness; fire departments; fire losses; *NBS-GCR-79-173*.
- Fire models; fire safety; fire tests; flues; heating equipment; heat transfer; literature reviews; radiant energy; stoves; wood; chimneys; *NBSIR 80-2140, Vol. 1*.
- Fire prevention; fire tests; flammability; flash point; heat transfer fluids; insulation; leakage; solar collectors; solar energy; *NBSIR 79-1931*.
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- Fire research; fire safety; human behavior in fires; modeling technique; programming; simulation of human behavior; architectural research; building fires; computer-aided design; environmental psychology; *NBSIR 80-1982*.
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- Fire retardants; fire tests; loose fill insulation; smoldering ignition; thermal analysis; thermal insulation; activation energy; borax; boric acid; cellulose; critical radiant flux; fire; *NBSIR 80-2085*.
- Fire safety; fire safety evaluation system; health care facilities; life cycle; cash flow; economic analysis; *NBS-GCR-79-186*.
- Fire safety; fire tests; flues; heating equipment; heat transfer; literature reviews; radiant energy; stoves; wood; chimneys; fire models; *NBSIR 80-2140, Vol. 1*.
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- Franck-Condon factors; ion; photoelectron spectra; photoionization; shape resonance; synchrotron radiation; vibrational intensity distribution; carbon monoxide; CO; *19184*.
- Franck-Condon factors; laser excited fluorescence; radiative life-



time; single vibronic level spectroscopy; CF<sub>2</sub>; difluorocarbene; fluorescence excitation spectroscopy; 19371.

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Free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; NBSIR 80-2118.

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Frequency calibrations; GOES satellite; high frequency; low frequency; satellite time code; standard frequencies; television color subcarrier; time calibrations; time signals; broadcast of standard frequencies; SP432, 1979 Edition.

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Fuel handling; high-level waste management; thorium HTR fuel cycles; cross-section accuracy requirements; SP594, pp. 131-134 (Sept. 1980).

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Fuel pins; inventory tracking system; manufacturing information system; quality status tracking system; fuel pin identification system; SP582, pp. 313-323 (June 1980).

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Fundamental frequencies; infrared spectra; normal vibrations; polyatomic molecules; Raman spectra; vibrational frequencies; force constants; JPCRD 9, No. 4, 1149-1254 (1980).

Furnaces; heat pumps; hybrid heat pumps; hybrid systems; rating procedure; seasonal cost of operation; add-on heat pumps; NBSIR 80-2090.

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Fused silica; laser damage; optical microscopy; total internal reflection; SP568, pp. 333-341 (July 1980).

Fused silica; laser damage; surface finishing; surface polishing; SP568, pp. 229-236 (July 1980).

Fusion; fusion reactivity; charged particle cross section needs; SP594, pp. 254-264 (Sept. 1980).

Fusion; heat transfer; hybrid blanket; tokamak; cross-section data; fission; SP594, pp. 351-359 (Sept. 1980).

Fusion; measured  $\sigma_r$  for O(n,n); calculate deuterium plasma neutron spectrum; SP594, pp. 807-811 (Sept. 1980).

Fusion; neutral beam injection; neutrons; nuclear heating; photon dose rate; photons; shielding; SP594, pp. 239-245 (Sept. 1980).



Fusion; neutron dosimetry; radiation damage; radioactivity; reactors; cross sections; fission; *SP594*, pp. 285-296 (Sept. 1980).  
 Fusion; neutron heating; neutron transport; radiation damage; tritium breeding; activation; dosimetry; *SP594*, pp. 228-238 (Sept. 1980).  
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 Fusion neutronics; LMFBR analysis; LWR shielding and dosimetry; multigroup cross section libraries; weapons applications; ENDF/B-V; *SP594*, pp. 204-208 (Sept. 1980).  
 Fusion pellets; neutron cross sections; neutron spectra; actinide burn-up; *SP594*, pp. 360-363 (Sept. 1980).  
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Gamma-ray spectroscopy; mass spectroscopy; precision; uranium enrichment measurement; accuracy; SP582, pp. 103-110 (June 1980).

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- GCFR; integral experiment; thorium; capture cross section; ENDF/B-5; *SP594*, pp. 127-130 (Sept. 1980).
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- GELINA; HELIOS; KFK; ORELA; PSR; "white" neutron sources; WNR; comparison neutron yields; *SP594*, pp. 920-928 (Sept. 1980).
- Ge; laser damage; optoacoustic spectroscopy; photoacoustic spectroscopy; thin films; absorption; *SP568*, pp. 313-332 (July 1980).
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- Geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering; bridges; buildings; dikes; earthquakes; foreign engineering; *SP592*.
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- Geothermal; process; thermodynamics; transport properties; aeroscience; data accuracy; design; *SP590*.
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- Item-dependent error; measurement error; nuclear material accounting; referee measurement methods; robust statistical methods; systematic error. robust statistical methods; 19332.
- Iteration method; nonlinear differential equation; nonlinear load; time-stepping finite difference equation technique; Auger



function; electrically-short dipole; 19449.

Iterative methods for linear algebraic equations; Neumann boundary conditions; sparse matrices; conjugate gradient algorithm; elliptic partial differential equations; *J. Res.* **85**, No. 5, 367-390 (Sept.-Oct. 1980).

Iterative refinement; least squares solution; linear constraints; overdetermined system of equations; regression; underdetermined system of equations; covariance matrix; curve fitting; 19155.

Iterative refinement; least squares solution; linear constraints; overdetermined system of equations; regression; statistics; covariance matrix; curve fitting; 19154.

*in situ*; oxidation; silicon nitride; yttria-doped silicon nitride; ceramic; high voltage electron microscopy; 19605.

*in situ*; oxidation; silicon nitride; yttria-doped silicon nitride; ceramic; high voltage electron microscopy; *NBSIR* 80-2075.

*in vivo* anticancer activity; molecular structure determination; single crystal x-ray diffraction; synthesis; *cis*-4-phenylcyclophosphamide; cyclophosphamide analogs; 19829.

*in vivo* measurement; neutron activation; body composition; clinical application; elemental analysis; *SP594*, pp. 456-457 (Sept. 1980).

## J

*J*-dependence; transitions;  $\Lambda$ -doublets; calculations; ion-molecule collision; 19462.

JENDL-1; reaction rate distribution; reaction rate ratio; reactivity worth; sodium void coefficient; structural materials; benchmark tests; control rod worth; Doppler coefficient; *SP594*, pp. 581-585 (Sept. 1980).

JENDL-2; nuclear data; optical potential parameter; relative measurement; simultaneous evaluation; absolute measurement; consistency; fission cross section; *SP594*, pp. 715-719 (Sept. 1980).

Jellium; martensite; model; stability; strain; transformation; criteria; finite; 19243.

Jensen's inequality; blood lead levels; concave; geometric mean; *J. Res.* **85**, No. 5, 363-366 (Sept.-Oct. 1980).

Jet flow; light scattering; longitudinal gradient; orientational distribution; rigid spheroid; transient; birefringence; 19409.

Job tracking; security violations; SMF retrieval; audit trails; computer fraud; computer security; *SP500-65*, pp. 33-46 (Oct. 1980).

Johnson noise; process instrumentation; thermocouples; thermometry; coal conversion; high temperatures; 19344.

Joists; room fires; steel; wood; fire endurance; fire tests; flame through; floors; furniture; interior finishes; *NBSIR* 80-2134.

Jordan form; positive definite; square root; field of values; Hermitian part; 19499.

Josephson effect; magnets; superconductivity; aerospace; digital; electronics; gravitational experiments; high-Q cavities; interference; 19054.

Josephson effect; microwave detectors; parametric amplifiers; superconductivity; aerospace; infrared detectors; 19406.

Josephson effect; nonequilibrium superconductivity; quasiparticle injection; superconducting tunnel junction; superconducting weak link; controllable weak link; cryoelectronic; 19416.

Josephson effect; phase locking; superconductivity; voltage standard; 19351.

Josephson effect; quantum interference; superconductivity; aerospace; computers; digital electronics; 19405.

Josephson effect; superconducting electronics; a/d converter; cryogenic electronics; digital instrument; high speed instruments; 19057.

Josephson junction; magnetic gradiometer; magnetometer; quantum interference; superconductivity; aerospace; amplifier; 19203.

Josephson junction; noise thermometry; nuclear orientation; thermometry;  $^{60}\text{CoCo}$   $\gamma$ -ray anisotropy thermometry; cryogenic temperature scale; 19685.

Josephson junction; risetime; sampler; transition duration; amplitude comparator; 19056.

Josephson junctions; microstrip; microwave integrated circuit; stripline transmission line; *U.S. Patent* 4,227,096.

Josephson junctions; superconductivity; threshold curves; interferometers; 19200.

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Journals; library holdings; NBS library; NBS periodicals; periodicals; proceedings; serials; standards; transactions; annual reports; diffusion in metals; fire; *NBSIR* 79-1932.

Jovanovich equation; Langmuir equation; monomolecular adsorption; nonlinear regression analysis; adsorption isotherms; energy distribution functions; 19771.

JPDR-I reactor; resonance integral; resonance interference effect; spent fuel; burnup; fission product; *SP594*, pp. 224-227 (Sept. 1980).

Junction C-V measurements; neutron activation analysis; phosphorus density; photometric technique; silicon; Hall effect; 19431.

Junction resistance; scanning electron microscopy; x-ray microanalysis; aluminum wiring; duplex connectors; high resistance junctions; *J. Res.* **85**, No. 6, 429-440 (Nov.-Dec. 1980).

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Kamerlingh Onnes; liquidons; liquids; mixtures; van der Waals; vapors; Andrews; condensation; critical point; diffusion; gaseous; history of science; 19932.

Karl Fischer titration; moisture content; syringe calibration; telescopic viewer; volumetric dispensing; water calibration; 19277.

Karl Fischer water determination; mass fraction of water; rate constant; saturation; titration curve; dissolution; 19591.

KBr; KCl; laser windows; volume and surface impurities; wavelength modulation spectroscopy; extrinsic infrared absorption; *SP568*, pp. 99-117 (July 1980).

KBr; KCN; libration; translation-rotation coupling; tunnelling; defect; 19612.

KCl; laser damage; laser fusion; NaCl; nanosecond pulse; surface damage; alkali halides;  $\text{CO}_2$  laser; *SP568*, pp. 209-227 (July 1980).

KCl; laser windows; volume and surface impurities; wavelength modulation spectroscopy; extrinsic infrared absorption; KBr; *SP568*, pp. 99-117 (July 1980).

KCl; SRM 1655; standard reference material; thermochemistry; adiabatic calorimeter; calorimetry,  $\Delta C_p$ , endothermic reaction; enthalpy of dilution; enthalpy of solution; *J. Res.* **85**, No. 6, 449-465 (Nov.-Dec. 1980).

KCl; solution calorimetry; standard reference materials; thermochemistry; tris(hydroxymethyl)aminomethane; calorimetry; enthalpy of solution; *J. Res.* **85**, No. 6, 467-481 (Nov.-Dec. 1980).

KCN; libration; translation-rotation coupling; tunnelling; defect; KBr; 19612.

(KCN)(KBr); order parameter; orientational; strain dipole; translation-rotation; dipole glass; 19596.

K edge; lithium; photoabsorption; 19272.

Kelvin; temperature; temperature scale; Celsius; Fahrenheit; IPTS-68; 19169.

Kerma; neutron dosimetry; stopping power ratios; tissue equivalence; ionization chambers; *SP594*, pp. 447-455 (Sept. 1980).

Kerma; neutrons; secondary charged particles; tissue-equivalent gas; dosimetry; energy per ion pair; 19331.

Kerma factors; neutron dosimetry; absorbed dose; biology and medicine; 19599.

Ketene; photochemistry; spectroscopy; transient; vacuum ultraviolet; acetylene; excited state; 19493.

KeV; LINAC; MeV; multigroup calculation; neutron flux spectra; thorium; time-of-flight; cross section; ENDF/B; *SP594*, pp. 545-547 (Sept. 1980).



Key notarization; character set encryption; digital signatures; 19142.

Key words; NBS publications; publications; abstracts; *SP305, Supplement 11*.

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KFK; ORELA; PSR; "white" neutron sources; WNR; comparison neutron yields; GELINA; HELIOS; *SP594*, pp. 920-928 (Sept. 1980).

K<sub>IC</sub>; laser windows; Weibull; yield stress; brittle failure; failure criteria; flaws; fracture; *SP568*, pp. 151-159 (July 1980).

Kinetic equations; photochemistry; photon intensity; photoresist exposure; rate constants; saturation effect; chemical kinetics; exposure; exposure reciprocity; 19418.

Kinetic perturbation theory; kinetic theory; nonequilibrium perturbation theory; perturbation theory; soft spheres; transport coefficients; Boltzmann equation; collision integral; dilute gas; 19866.

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Kinetics; lifetime prediction; polystyrene; polyurethane; pyrolysis; stability; thermal analysis; thermogravimetry; accelerated aging; complex reactions; decomposition; degradation; durability; heating rates; initial rates; 19752.

Kinetics; methanation; nickel; single crystal; carbide; carbon; catalysis; 19480.

Kinetics; methanation; ruthenium; single crystal; carbon; catalysis; hydrogenation; 19492.

Kinetics; microsegregation; rapid solidification; solute trapping; thermodynamics; interface stability; 19946.

Kinetics; nickel; carbon monoxide; catalysis; catalytic methanation; hydrogenation; 19481.

Kinetics; ozone; resonance fluorescence; stratosphere; Cl atoms; formaldehyde; 19704.

Kinetics; ozone; stopped-flow; sulfur dioxide; thiirane; gas; 19427.

Kinetics; ozone O<sub>2</sub>(<sup>1</sup>Δ); vibrational deactivation; atmospheric; flash photolysis; 19618.

Kinetics; photoelectron; photoionization; unimolecular; benzene; benzonitrile ion; coincidence; fragmentation; 19603.

Kinetics; thermal analysis; applications; *SP580*, pp. 1-31 (Aug. 1980).

Kinetics; thermal analysis; chemical complexes; chemical equilibrium; *SP580*, pp. 183-198 (Aug. 1980).

Kinetics; thermal analysis; thermochemical titrations; *SP580*, pp. 149-181 (Aug. 1980).

Kinetics; thermogravimetry; high pressure methods; *SP580*, pp. 235-250 (Aug. 1980).

Kinetics methanation; nickel; ruthenium; single crystal; surface science; carbon monoxide; catalysis; 19482.

Kinetics of surface processes; surface chemical analysis; surface chemistry; surface spectroscopy; alloy catalysts; catalytic reactions; electron diffraction; electron spectroscopy; 19957.

Kinetic theory; nonequilibrium perturbation theory; perturbation theory; soft spheres; transport coefficients; Boltzmann equation; collision integral; dilute gas; kinetic perturbation theory; 19866.

Kitchen fires; fire departments; fire extinguishers; fire investigations; hospitals; *NBS-GCR-80-235*.

Kitchen fires; nursing homes; fire extinguishers; fire investigations; *NBS-GCR-80-207*.

K-matrix; photoionization; rare gases; chlorine; Hartree-Fock; 19304.

Knight shift; scaling theory; solids; Van Vleck susceptibility; anomalous behavior; frequency shifts; hydrostatic pressure; 19925.

Knoop; microhardness; nondestructive testing; brass; copper; hardness testing; 19849.

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Label; product; testing; benefits; consumer; information; *NBSIR 80-2016*.

Labels; standards; sulfuric acid; tools; awards; computers; didymium glass filters; energy efficiency; inventors; innovation; *DIM/NBS 64*, No. 7, 1-28 (1980).

Laboratories; standards; Standards Council of Canada; testing; accreditation; Canada; *SP591*, pp. 88-91 (Aug. 1980).

Laboratory; manual; personnel; quality assurance; quality control; systems; calibration; equipment; evaluation; *SP591*, pp. 99-103 (Aug. 1980).

Laboratory; measurement; metrology; precision; test equipment; calibration; Federal Government; *SP546, 1980 Edition*.

Laboratory; metrology; seminars; State/local; training; inspectors; 19438.

Laboratory; PAT; performance; personnel; proficient; quality control; reaccreditation; site visit; accreditation; accreditation committee; American Industrial Hygiene Association; coordinator; industrial hygiene laboratories; *SP591*, pp. 67-70 (Aug. 1980).

Laboratory; preparation; riffle; sample; standards; heterogeneous; in-house; *SP591*, pp. 45-49 (Aug. 1980).

Laboratory accreditation; building products; certification; *SP591*, pp. 146-155 (Aug. 1980).

Laboratory accreditation; classes of tests; directory of accredited laboratories; discipline; *SP591*, pp. 85-87 (Aug. 1980).

Laboratory accreditation; laboratory evaluation; laboratory performance; proficiency testing; thermal insulation; 19865.

Laboratory accreditation; laboratory evaluation; regulatory liability; test standards; voluntary consensus standards; accreditation systems; certification; evaluation of inspection organizations; evaluation of testing organizations; *SP591*, pp. 11-14 (Aug. 1980).

Laboratory accreditation; laboratory performance evaluation; noncompliance; proficiency; countercheck reference tests; critical control features; feedback; implementation; inspections; *SP591*, pp. 79-84 (Aug. 1980).

Laboratory accreditation; laboratory performance evaluation; quality control; testing laboratories; accreditation; audit certification; *SP591*.

Laboratory accreditation; legal constraints; definitions; directory of accreditation systems; international; *SP591*, pp. 173-178 (Aug. 1980).

Laboratory accreditation; monitoring; quality assurance; standard methods; data; environment; Federal programs; 19715.

Laboratory accreditation; photovoltaics; product certification; solar collectors; solar energy; energy conversion; *NBSIR 80-2028*.

Laboratory accreditation; standards committees; evaluation criteria; 19848.

Laboratory accreditation; state-of-the-art in 1979; *SP591*, pp. 6-10 (Aug. 1980).

Laboratory automation; scientific computation; computer; instrumentation; 19133.

Laboratory capabilities; laboratory performance evaluation; manufacturers response to laws and consumers; pretest quality planning; consumer awareness and legality; customer and laboratory responsibilities; *SP591*, pp. 131-134 (Aug. 1980).

Laboratory criteria; product certification; proficiency testing; quality control; standardization; testing laboratory; accreditation; compliance testing; *NBSIR 79-1956*.

Laboratory evaluation; laboratory performance; proficiency testing; thermal insulation; laboratory accreditation; 19865.

Laboratory evaluation; linear model; measuring process; proficiency testing; Youden two-sample analysis; collaborative reference program, test method; interlaboratory testing; *SP591*, pp. 25-30 (Aug. 1980).

Laboratory evaluation; National Bureau of Standards; paper; paperboard; TAPPI; test methods; Youden graphical analysis; collaborative reference programs; history; interlaboratory testing program; 19321.



- Laboratory evaluation; regulatory liability; test standards; voluntary consensus standards; accreditation systems; certification; evaluation of inspection organizations; evaluation of testing organizations; inspection standards; *SP591*, pp. 11-14 (Aug. 1980).
- Laboratory performance; measurement assurance; measurement evaluation technology; measurement services; physical standards; proficiency testing; standard reference materials; testing; traceability; calibrations; collaborative reference programs; *SP591*, pp. 15-22 (Aug. 1980).
- Laboratory performance; proficiency testing; thermal insulation; laboratory accreditation; laboratory evaluation; 19865.
- Laboratory performance evaluation; manufacturers response to laws and consumers; pretest quality planning; consumer awareness and legality; customer and laboratory responsibilities; Institute of Electrical and Electronic Engineers Specifications; *SP591*, pp. 131-134 (Aug. 1980).
- Laboratory performance evaluation; noncompliance; proficiency; countercheck reference tests; critical control features; feedback; implementation; inspections; laboratory accreditation; *SP591*, pp. 79-84 (Aug. 1980).
- Laboratory performance evaluation; quality control; testing laboratories; accreditation; audit certification; laboratory accreditation; *SP591*.
- Laboratory procedures; reliability of the sample collection; tools for laboratory evaluation; accuracy and precision of the checking authority; *SP591*, pp. 169-170 (Aug. 1980).
- Laboratory-test development; life cycle; performance; reliability; consumer product; 19191.
- Laboratory test procedures; quality assurance lab test; standard test methods; thermal performance test; *SP591*, pp. 124-130 (Aug. 1980).
- Laboratory tests; modifications test procedures; water heaters; energy consumption; energy measurements; heat pump; *NBSIR 79-1951*.
- LaCrO<sub>3</sub>; magnetohydrodynamics; spinels; zirconia; ceramic oxides; electrodes; 19644.
- Ladders; room fires; smoke; students; doors; dormitories; evacuation; fire departments; fire fatalities; fire fighters; flashover; *NBS-GCR-80-193*.
- Lamellar crystallization; lamellar morphology; polymer crystallization; chain folding in polymers; crystal amorphous complex; 19854.
- Lamellar morphology; polymer crystallization; chain folding in polymers; crystal amorphous complex; lamellar crystallization; 19854.
- Laminagraphy; neutrons; radiography; reactor fuel subassemblies; resonance neutrons; thermal neutrons; three-dimensional radiography; fast neutrons; 19214.
- Laminagraphy; nondestructive testing; radiography; three-dimensional radiography; tomography; x-ray laser; computerized axial tomography; Fresnel zone; holographic reconstruction; imaging; 19855.
- Landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering; bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; *SP592*.
- Langmuir equation; monomolecular adsorption; nonlinear regression analysis; adsorption isotherms; energy distribution functions; Jovanovich equation; 19771.
- Language processor testing; minimal basic; programming language standards; software standards; software testing; BASIC; *SP500-70/2*.
- Language processor testing; minimal basic; programming language standards; software standards; software testing; BASIC; *SP500-70/1*.
- Languages; query; conversion; data base; data-description; data-dictionary; data-directory; data-manipulation; DBMS; *SP500-64*.
- Language transformation; language uniformity; user-computer interaction; user-oriented system design; bibliographic retrieval systems; command language; interaction language; *SP500-63*.
- Language translators; maintenance; portability; conversion costs; conversion problems; conversion tools; database management; Federal agencies; *SP500-62*.
- Language uniformity; user-computer interaction; user-oriented system design; bibliographic retrieval systems; command language; interaction language; language transformation; *SP500-63*.
- Laplace's equation; cylindrical coordinates; difference equations; electron optics; fourth-order; 19089.
- Laplace's equation; local slope analysis; multilayer analysis; resistivity; sheet resistance; spreading resistance; correction factor; depth profiling; 19703.
- Laplace's equation; nonlinear differential equations; resistivity; spreading resistance; continuum model; correction factor; 19796.
- La radiation; quasars; 19723.
- Large corporations; productivity; small business; conglomerates; innovation; invention; 19230.
- Large liquid scintillator; neutron multiplicity; proton-recoil detector; fission; *SP594*, pp. 728-732 (Sept. 1980).
- Laser; laser chemistry; radical; chain reaction; 19399.
- Laser; laser glass; laser-induced fluorescence; europium lithium borate glass; fluorescence line narrowing; glass; 19545.
- Laser; magnetic resonance; rotational transitions; CH<sub>2</sub>; 19720.
- Laser; mass spectrometry; photolysis; CF<sub>2</sub>; C<sub>2</sub>F<sub>4</sub>; kinetics; 19722.
- Laser; microwave; relativistic; synchrotron radiation; electron; frequency divider; ion trap; 19529.
- Laser; narrow band laser; Nd:YAG pump; pulsed laser; tunable laser; CW injection; 19266.
- Laser; opto-galvanic effect; transition frequency; analytical flame; discharge tube; *U.S. Patent 4,184,127*.
- Laser; photochemistry; radical; chain reaction; combustion; 19198.
- Laser; photodissociation; quantum yield; quenching; reactive collisions; vibrational excitation; electronic excitation; 19336.
- Laser absorption; molecules; site selection; condensed phase; emission; 19111.
- Laser annealing; silicon; capacitance-voltage profiling; damage effects; electrical activation of implanted impurities; ion implantation; 19724.
- Laser applications; microdensitometry; microlithography; micro-metrology; optical microscopy; partially coherent imaging; coherence; 19164.
- Laser breakdown; polishing; surface damage; diamond turning; infrared windows; *SP568*, pp. 195-197 (July 1980).
- Laser bulk damage; laser surface damage; optical materials; self-focusing; stimulated Brillouin scattering (SBS); damage morphology; damage thresholds; *SP568*, pp. 519-527 (July 1980).
- Laser calibration; molecular spectra; spectra; spectroscopy; absorption; calibration; carbonyl sulfide; infrared; 19368.
- Laser chemistry; chlorine isotopes; isotope separation; 19759.
- Laser chemistry; laser induced fluorescence; molecular spectroscopy; multiphoton chemistry; unimolecular reactions; vibrational energy transfer; 19929.
- Laser chemistry; radical; chain reaction; laser; 19399.
- Laser cooling; laser spectroscopy; microwave spectroscopy; optical pumping; stored ions; atomic spectroscopy; double resonance; high-resolution spectroscopy; 19440.
- Laser cooling; laser spectroscopy; radiation pressure; atomic clocks; atomic spectroscopy; Doppler effects; frequency standards; ion storage; 19799.
- Laser damage; laser fusion; NaCl; nanosecond pulse; surface damage; alkali halides; CO<sub>2</sub> laser; KCl; *SP568*, pp. 209-227 (July 1980).
- Laser damage; laser-induced stress-strain; plastic deformation; surface degradation; Cu mirrors; damage thresholds; *SP568*, pp. 159-173 (July 1980).
- Laser damage; laser interaction; optical components; optical fabrication; optical materials and properties; thin film coatings;



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- Laser damage; Mie absorption coefficient; pulse duration dependence of damage; impurity-induced damage; SP568, pp. 479-496 (July 1980).
- Laser damage; mirror surfaces; corrosion inhibition; ion implantation; SP568, pp. 187-193 (July 1980).
- Laser damage; multiphoton absorption; theory; alkali halides; electron-avalanche breakdown; electron-phonon scattering; Fokker-Planck equation; SP568, pp. 467-478 (July 1980).
- Laser damage; multiphoton induced damage; pulse duration dependence of damage; thin films; wavelength dependence of damage; avalanche ionization; film thickness dependence; impurity damage; SP568, pp. 405-416 (July 1980).
- Laser damage; neodymium:glass; polarizer; pyrophosphate; xenotime; yttrium orthophosphate; yttrium phosphate; absorption spectra; calcite; flux growth; SP568, pp. 137-140 (July 1980).
- Laser damage; optical microscopy; total internal reflection; fused silica; SP568, pp. 333-341 (July 1980).
- Laser damage; optical properties; diamond single-point machining; dielectrics; infrared optical components; SP568, pp. 199-208 (July 1980).
- Laser damage; photoacoustic spectroscopy; photoacoustic spectroscopy; thin films; absorption; Ge; SP568, pp. 313-332 (July 1980).
- Laser damage; pico-second pulses; pulsewidth dependence; UV lasers; damage thresholds; SP568, pp. 417-424 (July 1980).
- Laser damage; plastic flow; sapphire; thermomechanical analysis; compressive failure; SP568, pp. 141-149 (July 1980).
- Laser damage; reflectors; thin film; absorption; calorimetry; damage; electric field; high energy laser; SP568, pp. 377-390 (July 1980).
- Laser damage; self-focusing; spot size dependence; alkali halides; intrinsic damage; IR windows; SP568, pp. 497-517 (July 1980).
- Laser damage; surface finishing; surface polishing; fused silica; SP568, pp. 229-236 (July 1980).
- Laser-damage; ultrapure KBr; Fe; SP568, p. 125 (July 1980).
- Laser damage resistance; materials properties; oxide coatings; reactive sputtering; transparent-conductive coatings; glassy structure; SP568, pp. 359-375 (July 1980).
- Laser diagnostics; reconstruction algorithm; tomography; absorption measurement; combustion measurements; convolution algorithm; diffusion jet; 19822.
- Laser diodes; material dispersion; mode scramblers; optical detectors; optical fibers; transfer function; bandwidth; TN1019.
- Laser diodes; material dispersion; optical fibers; bandwidth; 19458.
- Laser enhanced ionization; laser spectrometry; opto-galvanic effect; trace metal analysis; atomic spectrometry; flame spectrometry; 19918.
- Laser enhanced ionization; laser spectrometry; tunable laser; atomic absorption; atomic detection limits; flame spectrometry; 19916.
- Laser enhanced ionization; opto-galvanic effect; photodissociation laser; atomic resonance laser; atomic resonance-line laser; flame spectrometry; 19836.
- Laser excitation; multi-photon processes; non-stationary processes; resonance fluorescence; strong laser field; time-dependent spectrum; transient spectrum; fluorescence spectrum; 19220.
- Laser-excited fluorescence; laser-induced chemistry; mass transport; multiphoton processes; vibrational relaxation; diffusion; energy transfer; 19179.
- Laser excited fluorescence; radiative lifetime; single vibronic level spectroscopy; CF<sub>2</sub>; difluorocarbene; fluorescence excitation spectroscopy; Franck-Condon factors; 19371.
- Laser frequency measurement; new laser lines; relative intensity; relative polarization; CH<sub>2</sub>DOH; CO<sub>2</sub> laser; FIR laser; 19460.
- Laser frequency measurement; optically pumped FIR laser; stabilized CO<sub>2</sub> lasers; CH<sub>2</sub>F<sub>2</sub>; difluoromethane; FIR frequency synthesis; 19452.
- Laser frequency measurements; new <sup>13</sup>CH<sub>3</sub>OH laser lines; optically pumped FIR lasers; relative power output of CH<sub>3</sub>OH laser lines; carbon dioxide laser; 19719.
- Laser fusion; NaCl; nanosecond pulse; surface damage; alkali halides; CO<sub>2</sub> laser; KCl; laser damage; SP568, pp. 209-227 (July 1980).
- Laser glass; laser-induced fluorescence; europium lithium borate glass; fluorescence line narrowing; glass; laser; 19545.
- Laser glass; low-dispersion glass; optical glass; Al(PO<sub>3</sub>)<sub>3</sub>-AlF<sub>3</sub>-MF-RF<sub>1</sub> system; fluoride glass; fluorophosphate glass; 19216.
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- Laser-induced effects; light scattering; microanalysis; particle analysis; Raman microprobe; Raman spectroscopy; 19650.
- Laser induced excitation; population trapping; vibrational-rotational states; 19317.
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- Laser-induced fluorescence; low-level analysis; nuclear safeguards; trace levels; uranium determination; waste solution analysis; analyses; fluorometry; SP582, pp. 147-155 (June 1980).
- Laser induced fluorescence; molecular spectroscopy; multiphoton chemistry; unimolecular reactions; vibrational energy transfer; laser chemistry; 19929.
- Laser-induced slip; polishing; ripples; SiC substrates; surface defects; thermal diffusivity; vapor-deposited mirrors; crystalline disorder; Cu mirrors; diamond turning; SP568, pp. 175-186 (July 1980).
- Laser-induced stress-strain; plastic deformation; surface degradation; Cu mirrors; damage thresholds; laser damage; SP568, pp. 159-173 (July 1980).
- Laser interaction; optical components; optical fabrication; optical materials and properties; thin film coatings; laser damage; SP568.
- Laser ionization; Na; superelastic; electron heating; electron seeding; gas breakdown; 19779.
- Laser measurements; laser metrology; laser standards; transfer standards; calibration; 19211.
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- Laser power measurement; photodetector; radiant power measurement; radiometry; silicon photodiode; spectroradiometry; absolute spectral response; 19354.
- Laser-produced-plasma; molybdenum; vacuum-ultraviolet; wavelengths; ion; 19610.
- Laser-produced plasma; spectrum; ultraviolet; highly ionized atoms; 19608.
- Laser pulses; monochromatic; multiphoton ionization; Rabi oscillation; sodium; AC Stark shifts; AC Stark widths; cesium; hydrogen; intermediate resonances; 19159.
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- Lasers; calcium; collision physics; dimer lasers; energy transfer; 19775.
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- Lasers; photoelasticity; piezoelectric; refractive index; glass; 19842.
- Lasers; station positions; artificial satellites; distance measurements; geodesy; geodynamics; 19742.
- Laser scanning; light biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cells; cell cracks; device measurements; 19435.



- Laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cell; solar cell measurements; solar cell stability; device measurements; *NBSIR 80-2027*.
- Laser scattering; laser spectroscopy; Mossbauer effect; optical pumping; radiation pressure; radiative cooling; Raman scattering; spectroscopy; anti-Stokes Raman scattering; atomic physics; 19055.
- Laser spectrometry; opto-galvanic effect; trace metal analysis; atomic spectrometry; flame spectrometry; laser enhanced ionization; 19918.
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- Laser spectroscopy; microwave spectroscopy; optical pumping; stored ions; atomic spectroscopy; double resonance; high-resolution spectroscopy; laser cooling; 19440.
- Laser spectroscopy; molecular spectroscopy;  $\text{HeH}^+$ ; infrared spectra; ion beams; 19463.
- Laser spectroscopy; non-linear spectroscopy; saturated absorption; saturation spectroscopy; Doppler-free spectroscopy; high-resolution spectroscopy; 19288.
- Laser spectroscopy; radiation pressure; atomic clocks; atomic spectroscopy; Doppler effects; frequency standards; ion storage; laser cooling; 19799.
- Laser standards; transfer standards; calibration; laser measurements; laser metrology; 19211.
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- Laser windows; lithium fluoride; mechanical properties; optical properties; ultraviolet transmission; fluorides; forging; *SP568*, pp. 39-46 (July 1980).
- Laser windows; optical absorption; optical homogeneity; optical scattering; stress birefringence; calcium fluoride; hot isostatic forging; hot isostatic pressing; *SP568*, pp. 47-63 (July 1980).
- Laser windows; volume and surface impurities; wavelength modulation spectroscopy; extrinsic infrared absorption; KBr; KCl; *SP568*, pp. 99-117 (July 1980).
- Laser windows; Weibull; yield stress; brittle failure; failure criteria; flaws; fracture;  $K_{Ic}$ ; *SP568*, pp. 151-159 (July 1980).
- Latent heat storage; pebble-bed; phase-change unit; solar energy storage; thermal storage device; ASHRAE standard 94-77; Glauber's salt; 19175.
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- Late type, stars; CaII emission, stars; chromospheres, stars; circumstellar shells; 19119.
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- Late-type stars; stellar atmospheres; stellar chromospheres; ultraviolet spectra; 19357.
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- Mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; economic analysis; fire safety; health care facilities; hospitals; life safety; *NBSIR 79-1929*.
- Mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; building economics; cost estimation; economic analysis; engineering economics; housing; *BSS129*.
- Matrix isolation; NF<sub>3</sub>; normal coordinate analysis; photodissociation; ultraviolet spectrum; CO; discharge sampling; F-atom reactions; FCO; F<sub>2</sub>CO; infrared spectrum; 19393.
- Matrix isolation; PO; PO<sub>2</sub>; (PO)<sub>2</sub>; ultraviolet spectrum; vacuum ultraviolet photolysis; discharge sampling; HPO; infrared spectrum; 19082.
- Matrix isolation; photodecomposition; CF<sub>3</sub>Br; CF<sub>4</sub>Br; CF<sub>3</sub>Cl; CF<sub>4</sub>Cl; CF<sub>3</sub>I; CF<sub>4</sub>I; F-atom reactions; infrared spectrum; 19760.
- Matrix isolation; S atom reaction; CF<sub>2</sub> reaction; CF<sub>2</sub>I; CF<sub>2</sub>S; H atom reaction; HCF<sub>2</sub>; I atom reaction; infrared spectrum; 19410.
- Mattresses; nursing homes; nursing staff; evacuation; fire departments; fire extinguishers; fire investigations; *NBS-GCR-80-216*.
- Mattresses; nursing homes; nursing staff; room fires; sprinkler systems; fire departments; fire extinguishers; fire investigations; *NBS-GCR-80-277*.
- Mattresses; nursing staff; patients; fire departments; fire investigations; *NBS-GCR-80-228*.
- Mattresses; nursing staff; room fires; doors; fire alarm systems; fire departments; fire investigations; hospitals; *NBS-GCR-80-260*.
- Mattresses; nursing staff; smoke; evacuations; fire alarm systems; fire departments; fire investigations; *NBS-GCR-80-268*.
- Mattresses; patients; smoke; evacuation; fire departments; fire investigations; *NBS-GCR-80-266*.
- Mattresses; smoke; apartments; building fires; doors; egress; evacuation; fire departments; fire fighters; fire investigations; *NBS-GCR-79-187*.
- Mattresses; smoke; evacuation; fire department; fire investigations; *NBS-GCR-80-262*.
- Mattresses; smoke movement; sprinkler systems; clothing wardrobes; health care facilities; hospitals; *NBSIR 80-2097*.
- Mattresses; sprinkler systems; intermediate care facilities; *NBS-GCR-80-267*.
- Maunder minimum, models; simulation; statistics; sunspots; ARMA models; forecasts; *TN1022*.
- Maxwell's velocity distribution; rate coefficients; cross sections; high electron energy; 19356.
- M-centers; megared dosimetry; N-centers; radiation darkening; radiation processing; R-centers; absorption spectroscopy; alkali halides; color centers; darkening of crystals; dosimetry; electron dosimetry; F-centers; gamma-ray dosimetry; lithium fluoride; 19352.
- Mean field; sum rule; susceptibility; three coexistence phases; tricritical point; correlation length; 19135.
- Mean free path; exchange and correlation; low energy electrons; 19858.
- Mean-square radius of gyration; Monte-Carlo; reduced moments; star-branched polymers; branched polymers; expansion factor; 19656.
- Mean-value theorem; Taylor's theorem; convexity; derivatives; inequalities; intermediate point; 19421.
- Measured asymmetry; calculated scattering phase shifts; *SP594*, pp. 985-987 (Sept. 1980).
- Measured course; odometer; taximeter; test procedure; tire pressure; tolerances; calibration; distance; fifth wheel; inspection; *H137*.
- Measured cross section; activation method; *SP594*, pp. 433-435 (Sept. 1980).
- Measured performance; optical path difference; temperature profile; thermal distortion; thermal lensing; ZnSe; absorption; calculated performance; CO<sub>2</sub> laser; holographic interferometry; *SP568*, pp. 73-89 (July 1980).
- Measured  $\sigma(E)$  at 110° and 128° up to 8.6 MeV in excitation energy; nuclear reactions; <sup>22</sup>Ne(*e,e'*); deduced *J*,  $\pi$ , *B*(CL); enriched <sup>22</sup>Ne target; 19691.
- Measured  $\sigma(E_n, 0^\circ)$ ; nuclear reactions; gas target; *SP594*, pp. 542-544 (Sept. 1980).
- Measured  $\sigma_g(E_n, 125^\circ)$ ; nuclear reactions, <sup>232</sup>Th(*n,n'* $\gamma$ ); time-of-flight; comparison with calculated excitation functions; inferred level cross sections for 22 states; *SP594*, pp. 685-689 (Sept. 1980).
- Measured  $\sigma_g(E_n, 125^\circ)$ ; nuclear reactions <sup>238</sup>U(*n,n'* $\gamma$ ); time-of-



flight; inferred level cross sections for 20 states; *SP594*, pp. 680-684 (Sept. 1980).

Measured  $\sigma_T$  for O(n,n); calculate deuterium plasma neutron spectrum; fusion; *SP594*, pp. 807-811 (Sept. 1980).

Measured  $\sigma_T$  for  $^{233}\text{U}$ ; resonance at 0.15 eV; *SP594*, pp. 690-691 (Sept. 1980).

Measured 0.02 eV to 30 keV; fission integrals; *SP594*, pp. 961-965 (Sept. 1980).

Measurement; color; colorimetry; fluorescent; fluorescent specimens; *NBS-GCR-79-185*.

Measurement; metrology; on-site calibration; PMTE; calibration labs; calibration, out-of-service; central calibration; in situ calibration; *NBS-GCR-80-282*.

Measurement; metrology; PMTE; recall intervals; calibration interval; calibration interval algorithms; calibration requirements; decision table; interval adjustment; *NBS-GCR-80-283*.

Measurement; metrology; precision; test equipment; calibration; Federal Government; laboratory; *SP546, 1980 Edition*.

Measurement; modeling; solar; testing; computer; energy; heat transfer; hot water; *19375*.

Measurement; modeling; solar; testing; computer; energy; heat transfer; hot water; *19459*.

Measurement; modeling; solar; testing; computer; energy; heat transfer; hot water; *19498*.

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Measurement; polarized electrons; secondary standards; signs; symbols; antifouling coating; communication; gamma-ray measurement; human serum; industrial development; industrial furnace; *DIM/NBS 64*, No. 2, 1-36 (1980).

Measurement; precision; accuracy; bias; *19284*.

Measurement assurance; measurement evaluation technology; measurement services; physical standards; proficiency testing; standard reference materials; testing; traceability; calibrations; collaborative reference programs; laboratory performance; *SP591*, pp. 15-22 (Aug. 1980).

Measurement assurance; metrication; model laws and regulations; moisture loss; packaging and labeling; specifications and tolerances; weights and measures; consumer affairs; education; electronic devices; International Organization of Legal Metrology; legal metrology; *SP566*.

Measurement assurance; random errors; standard deviation; systematic errors; uncertainty; check standard; gage blocks; *NBSIR 80-2078*.

Measurement assurance program; platinum resistance thermometer; reference thermometer; thermometer; calibration; check thermometers; fixed points; International Practical Temperature Scale of 1968; *SP591*, pp. 137-145 (Aug. 1980).

Measurement compatibility; protocol; reference methods; SI units; standard reference materials; traceability; definitive methods; *SP582*, pp. 15-24 (June 1980).

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Measurement error; nuclear material accounting; referee measurement methods; robust statistical methods; systematic error; robust statistical methods; item-dependent error; *19332*.

Measurement errors; noise; noise exposure; sampling (temporal); statistics; time-varying signals; community noise; *19116*.

Measurement error sources; sensitivity analysis; material balance declaration; *SP582*, pp. 690-701 (June 1980).

Measurement evaluation technology; measurement services; physical standards; proficiency testing; standard reference materials; testing; traceability; calibrations; collaborative reference programs; laboratory performance; measurement assurance; *SP591*, pp. 15-22 (Aug. 1980).

Measurement interferences; mobile ions; MOS capacitor; silicon; thermally stimulated measurements; interface states; *19166*.

Measurement methods; microelectronics; microstructures; semiconductors; dimensional metrology; electronics; integrated circuits; materials characterization; *SP400-61*.

Measurement methods; neutron transmutation doped silicon; power-device grade silicon; resistivity variations; silicon; spreading resistance measurements; thermally stimulated measurements; thyristor materials measurements; thyristor measurements; zinc oxide varistors; *NBSIR 80-2061*.

Measurement, nondestructive; second breakdown, reverse-bias; transistor, power; turn-off, transistor; focusing, current; *19161*.

Measurement of controlled environments; agricultural engineering; growth chambers; horticulture; *19112*.

Measurement of inventory; nuclear materials; safeguards; inventory verification; *SP582*, pp. 178-188 (June 1980).

Measurement process; omnifariousness; precision; round robin; routine conditions; variance model; within-laboratory precision; accuracy; between-laboratory precision; components of variance; duplicity; ideal conditions; *SP591*, pp. 31-40 (Aug. 1980).

Measurements; attenuation; bandwidth; fiber optic joints; fiber optics; fiber optics-single mode; index profile; *SP597*.

Measurements; measurement standards; radiation; radiation hazards; radiation safety; radiation standards; standardization; standards; history; ionizing radiation; *19551*.

Measurements; metals; standards; wear; corrosion; *19950*.

Measurements; metric; metrology; SI; standards; units; *19628*.

Measurements; metric; metrology; SI; standards; units; *19868*.

Measurements; neutron interrogation; nondestructive assay; nuclear fuel subassembly; nuclear safeguards; process control; spent nuclear fuel; assay accuracy; calculations; criticality control; material accountability; *SP582*, pp. 447-456 (June 1980).

Measurements; number of nuclei; samples; spectrometric analysis; transmission; *SP594*, pp. 903-906 (Sept. 1980).

Measurements; operations; performance; *SP500-65*, pp. 279-287 (Oct. 1980).

Measurements; optical communications; quality control; attenuation; fiber optics; interlaboratory comparisons; *19461*.

Measurements; radiation; radon; radon daughters; ventilation; buildings; environment; health; *SP581*.

Measurements; radiation; random uncertainty; systematic uncertainty; data reporting; environmental; *19301*.

Measurements; radio frequency; surface science; tetrafluoroethylene powder; water conservation; alternate fuels; data communications; energy; erosion; instrument landing; *DIM/NBS 64*, No. 5, 1-28 (1980).

Measurement seminars; photon-recoil components; SRM's; atomic properties; computers; emissions testing; energy; fundamental constants; gas; grants; marketplace; *DIM/NBS 64*, No. 1, 1-24 (1980).

Measurement services; molecular science; National Measurement Laboratory; nondestructive evaluation; nuclear measurement technology; physics research; radiation research; recycled materials; standard reference data; standard reference materials; technical activities; *SP572*.

Measurement services; physical standards; proficiency testing; standard reference materials; testing; traceability; calibrations; collaborative reference programs; laboratory performance; measurement assurance; measurement evaluation technology; *SP591*, pp. 15-22 (Aug. 1980).

Measurement services; standardization; AID; assistance; developing economies; foreign relations; industrializing nations; international relations; LDC's; *NBSIR 80-2021*.

Measurement standards; radiation; radiation hazards; radiation safety; radiation standards; standardization; standards; history; ionizing radiation; measurements; *19551*.

Measurement system; metric system; SI; base units; convention of the meter; economic benefits; epistemology; *19639*.

Measurement systems; product standards; standard reference data; standard reference materials; engineering standards; information interchange; *19905*.

Measurement technology; microelectronics; phosphorus pileup; photolithography; pull test; random fault test structures; resistivity; scanning acoustic microscope; scanning electron micro-



- scope; semiconductor devices; semiconductor materials; semiconductor process control; *SP400-45*.
- Measurement technology; microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; silicon; electronics; integrated circuits; *NBSIR 80-2006*.
- Measurement technology; moisture accumulation; nondestructive tests; thermal resistance; built-up roofs; *NBSIR 80-2100*.
- Measurement technology; Pakistan; standardization; Agency for International Development; development assistance; industrialization; less developed countries; *NBSIR 80-2051*.
- Measurement technology; photovoltaic energy conversion; photovoltaics; solar cells; test method preparation; consensus standards; *NBSIR 80-2060*.
- Measurement uncertainties; microwave mixer diodes; modulation; point-contact diodes; reflectometer; return loss; Schottky-barrier diodes; semiconductor diodes; standing-wave ratio (SWR); conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; *SP400-16*.
- Measures; scales; specifications; taximeters; tolerances; volume-measuring devices; weighing devices; weights; length-measuring devices; liquid-measuring devices; *H44, 1980 Edition*.
- Measures; weights; weights and measures; AID; assistance; developing economies; foreign relations; industrializing nations; international relations; *NBSIR 80-2022*.
- Measure time-of-flight spectra; Fe, Cu, Ni, Pb; *SP594*, pp. 139-142 (Sept. 1980).
- Measuring process; proficiency testing; Youden two-sample analysis; collaborative reference program, test method; interlaboratory testing; laboratory evaluation; linear model; *SP591*, pp. 25-30 (Aug. 1980).
- Mechanical conditioning; nonlinear viscoelasticity; normal stresses; poly(methyl methacrylate); shear stresses; BKZ theory; *19707*.
- Mechanical engineering; nuclear reactors; piping; pressure vessel; pump; reliability; risk analysis; valves; failure data; fatigue; fracture; inservice data; *19085*.
- Mechanical insulation; industrial/commercial thermal insulation; insulation program plan; *19725*.
- Mechanical integrity; nondestructive evaluation; normal modes; orthopedic implants; piezoelectric polymer; plastics; vibrations; *19952*.
- Mechanical properties; nickel alloys; steels; fatigue (materials); fracture (materials); low temperature tests; *19550*.
- Mechanical properties; niobium-tin; niobium-titanium; strain; superconducting coil composite; superconducting wire; critical current; fiberglass/epoxy composite; *NBSIR 80-1633*.
- Mechanical properties; optical properties; ultraviolet transmission; fluorides; forging; laser windows; lithium fluoride; *SP568*, pp. 39-46 (July 1980).
- Mechanical properties; PMMA; polyethylene; poly(methyl methacrylate); time-dependent behavior; additivity of damage; Bailey criterion; damage accumulation; failure; fatigue; *19690*.
- Mechanical properties; specific heat; thermal expansion; hardness; homogeneity; infrared laser absorption properties; *SP568*, pp. 65-72 (July 1980).
- Mechanical properties; stainless steel; strength; toughness; welds; cryogenic; delta ferrite; ferrite content; fracture; *19673*.
- Mechanical reliability; mechanics; strength; ceramics; crack growth; delayed failure; fracture; *19636*.
- Mechanics; strength; ceramics; crack growth; delayed failure; fracture; mechanical reliability; *19636*.
- Medical physics; spectroscopy; Broida; combustion; flames; free radicals; *19680*.
- Medical x-ray image; x-ray image storage; digital image requirement; image information; information content; *19134*.
- Medium temperature collector; solar energy; special collectors; energy estimates; geographical distribution; low temperature collectors; manufacturing activity; *19527*.
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- Megarad dosimetry; nylon polycarbonate; polyethylene terephthalate; polymethyl methacrylate; polyvinyl chloride; polyvinyl fluoride; polyvinyl pyrrolidone radiochromic dyes; temperature dependence; absorption spectroscopy; blue cellophane; cellulose triacetate; dosimetry; *19326*.
- Melting; niobium; dynamic techniques; heat of fusion; high temperatures; *19745*.
- Melting; normal spectral emittance; palladium; radiance temperature; dynamic measurements; high temperature; *19063*.
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- Melting curves; metastability; phase diagram; plastic crystal; pressure; carbon tetrachloride; *19470*.
- Melting line; mercury; pressure; pressure fixed points; pressure metrology; pressure scale; *19286*.
- Melting point; stainless steel; thermodynamics; dynamic measurements; electrical resistivity; emittance; heat capacity; high temperature; *19541*.
- Melting pressures; PVT; vapor pressure; compressibility; density; ethylene; *19682*.
- Melting temperature; row nucleation; stirred solution; strained melt; crystallization temperature; *19904*.
- Meniscus; silicon; stability; crystal; Czochralski; edge-defined film-fed growth (EFG); floating zone; *19945*.
- Mental disorders; smoke; upholstered furniture; evacuation; fire departments; fire fatalities; fire investigations; flashover; group homes; halfway houses; *NBS-GCR-80-200*.
- Merchant vessels; shipboard fires; cost benefit analysis; cost effectiveness; fire departments; fire losses; fire models; fire protection; marine transportation; *NBS-GCR-79-173*.
- Mercury; pressure; pressure fixed points; pressure metrology; pressure scale; melting line; *19286*.
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- Mercury (I) chloride; solubility; solubility product; standard electrode potentials; standard thermodynamic functions; compilation of solubility data; disproportionation of mercury (I); electromotive force measurements; *JPCRD 9*, No. 4, 1307-1330 (1980).
- Message overhead; modular design; system tuning; capabilities; *SP500-65*, pp. 319-330 (Oct. 1980).
- Metal atoms; discharges; excimer laser; *19334*.
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- Metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cell; solar cell measurements; solar cell stability; device measurements; laser scanning; light-biasing; *NBSIR 80-2027*.
- Metalloenzymes, single crystal; 12-membered cage, x-ray diffraction;  $((C_7H_7)_3P)_4Cu_4W_2O_{28}S_6$ ; coordination complex; 19173.
- Metal-on-fused silica filters; optical transmittance accuracy; polarization; reflections; spectral bandpass; standard reference materials in spectrophotometry; stray radiation; transmittance stability; filters for spectrophotometry; *SP260-68*.
- Metal-oxide-semiconductor device; process-induced radiation damage; radiation damage; semiconductor devices; very large scale integration; x-ray lithography; electron-beam lithography; 19162.
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- Metals; standards; wear; corrosion; measurements; 19950.
- Metals; surfaces; deformation; erosion; impact; 19936.
- Metals fatigue; plastics fatigue; quantitative microscopy; statistical aspects of fatigue; composite materials; corrosion fatigue; durability; fatigue; fatigue mechanism; fatigue research; fracture mechanics; mathematical modeling; 19448.
- Metal surface effects; nitrogen dioxide; oxidation; recycled base stocks; thermal analysis; virgin base stocks; differential scanning calorimeter; lubricating oil; 19788.
- Metaphosphates; molten salts; molybdates; sulfates; sulfides; surface tension; tungstates; viscosity; carbonates; density; electrical conductance; hexafluoroaluminates; *JPCRD 9*, No. 4, 831-1022 (1980).
- Metaprogramming; operationalism; programmer measurement; programmer productivity; *SP500-65*, pp. 49-52 (Oct. 1980).
- Metastability; phase diagram; plastic crystal; pressure; carbon tetrachloride; melting curves; 19470.
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- Methanol; phase transition; surface; surface tension; wetting; contact angle; critical point; cyclohexane; interface; 19306.
- Method accuracy; multielement analyses; NBS standard reference materials; spectrophotometry; systematic errors; transmittance accuracy; absorbance accuracy; instrumental standards; 19818.
- Method approximations; multigroup data; neutron propagation; *SP594*, pp. 190-193 (Sept. 1980).
- Method of sale of commodities; open dating; packaging and labeling; registration of servicemen; unit pricing; weighmaster law; basic weights and measures law; *H130*, 1979 Edition.
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- Methodology; reliability; terminology; testing; useful life; consumer products; life-cycle performance; *NBSIR 76-1157*.
- Methods; thermal analysis; instrumentation review; *SP580*, pp. 219-233 (Aug. 1980).
- Methyl chloroform; OH radicals; rate constant; resonance fluorescence; stratospheric ozone; atmospheric chemistry; 19092.
- Methyl cyanide; microwave spectra; molecular constants; radio astronomy; rotational transitions; interstellar molecules; line strengths; *JPCRD 9*, No. 3, 659-720 (1980).
- Methyl group; molecular reorientation; neutron scattering; nitromethane; quantum tunnelling; x-ray scattering; 19810.
- Methyl group; molecular reorientation; neutron scattering; nitromethane; quantum tunnelling; x-ray scattering; 19809.
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- Metrication; model laws and regulations; moisture loss; packaging and labeling; specifications and tolerances; weights and measures; consumer affairs; education; electronic devices; International Organization of Legal Metrology; legal metrology; measurement assurance; *SP566*.
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- Metric products and non-metric buildings; repair and maintenance; adaptation of building materials; metric familiarization; 19520.
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- Metrology; PMTE; recall intervals; calibration interval; calibration interval algorithms; calibration requirements; decision table; interval adjustment; measurement; NBS-GCR-80-283.
- Metrology; precision; test equipment; calibration; Federal Government; laboratory; measurement; SP546, 1980 Edition.
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- MeV; multigroup calculation; neutron flux spectra; thorium; time-of-flight; cross section; ENDF/B; keV; LINAC; SP594, pp. 545-547 (Sept. 1980).
- MeV neutrons; neptunium-237; standard; uranium-235; cross section; fission; SP594, pp. 971-975 (Sept. 1980).
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- Microchannel plate; portable; rare-earth scintillator; small-format; x-ray imaging system; <sup>125</sup>I x-ray source; 19402.
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- Microcomputer; minicomputer; analytical chemistry; automation; instrumentation; 19411.
- Microcomputer; track counting; fission rate; fused quartz track recorder; SP594, pp. 512-515 (Sept. 1980).
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- Microcreep; optical mirrors; beryllium; creep; dimensional instability; inertial guidance; 19896.
- Microdensitometry; microlithography; micrometrology; optical microscopy; partially coherent imaging; coherence; laser applications; 19164.
- Microdroplets; particles; particulate matter; biological fluids; electron microprobe; electron microscopy; ion probe; light microscopy; microanalysis; SP533.
- Microelectrodes; microvolume; analysis; biophysics; chloride; fluorides; 19280.
- Microelectronics; micrometrology; optical microscope; photoelectric microscope; photomask; scanning electron microscope; semiconductor technology; filar eyepiece; image-shearing eyepiece; integrated circuits; linewidth measurements; SP400-43.
- Microelectronics; microstructures; semiconductors; dimensional metrology; electronics; integrated circuits; materials charac-



- terization; measurement methods; *SP400-61*.
- Microelectronics; phosphorus pileup; photolithography; pull test; random fault test structures; resistivity; scanning acoustic microscope; scanning electron microscope; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; *SP400-45*.
- Microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; silicon; electronics; integrated circuits; measurement technology; *NBSIR 80-2006*.
- Microelectronics; semiconductors; dimensional metrology; electronics; integrated circuits; materials characterization; *19109*.
- Microelectronic test structure; process validation wafer; random fault test structure; sheet resistor; test methods; test pattern; test structure; circuit characterization; cross-bridge sheet resistor; electrical alignment test structure; gated diode; integrated test structure; *19165*.
- Microfibril; microfibrillar; tie molecules; annealing; drawing; fibril; fibrous structure; high elastic modulus material; *19688*.
- Microfibril; necking; plastic deformation; spherulitic structure; tie molecule; crystalline polymer; cylindritic structure; fibril; fibrous structure; *19674*.
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- Microfibrils; point defects of microfibrillar structure; ruptured chains; strength; tie molecules; crystalline polymer; elastic modulus; fibrils; fibrous structure; fracture; load-elongation curve; *19901*.
- Microfibrils; superdrawing; Taut tie molecules; annealing; crystallization; elastic modulus; fibrils; fibrous structure; *19903*.
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- Microhardness; nondestructive testing; brass; copper; hardness testing; Knoop; *19849*.
- Microolithography; micrometrology; microscopy; linewidth measurement; *19546*.
- Microolithography; micrometrology; optical microscopy; partially coherent imaging; coherence; laser applications; microdensitometry; *19164*.
- Micromechanics; microstructure; nuclear fuel element; paper; quantitative microscopy; size effect; solid mechanics; statistical methods; steel; fatigue; fracture; mathematical modeling; *19086*.
- Micromechanics; polymers; quantitative microscopy; slip bands; statistical aspects of fatigue; striations; composite materials; corrosion fatigue; dislocations; fatigue mechanism; fracture mechanics; mathematical modeling; *19087*.
- Micrometer scale; scanning electron microscope; electroforming; electroplating; *19833*.
- Micrometrology; microscopy; linewidth measurement; microolithography; *19546*.
- Micrometrology; microscopy; optical imaging; critical dimensions; linewidth; metrology; *19802*.
- Micrometrology; optical microscope; photoelectric microscope; photomask; scanning electron microscope; semiconductor technology; filar eyepiece; image-shearing eyepiece; integrated circuits; linewidth measurements; microelectronics; *SP400-43*.
- Micrometrology; optical microscopy; partially coherent imaging; coherence; laser applications; microdensitometry; microolithography; *19164*.
- Microphone cable; microphone connector; mobile FM transceiver; communications equipment standard; compatibility; interchangeability; law enforcement; *19701*.
- Microphone connector; mobile FM transceiver; communications equipment standard; compatibility; interchangeability; law enforcement; microphone cable; *19701*.
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- Microradiography; monochromatic radiography; real-time radiography; x-ray image magnifier; background scattering; collimation; high resolution; image intensifier; image signals; *19863*.
- Microsampling; molecular microanalysis; particle microanalysis; Raman microprobe; Raman spectra; Raman spectroscopy; South Pole atmosphere; airborne particles; atmospheric aerosol; atmospheric sulfate environmental pollution; *19883*.
- Microscopic data analysis; complete damping; consistency; coupled channels; integral data; *SP594*, pp. 862-866 (Sept. 1980).
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- Microscopy; optical imaging; critical dimensions; linewidth; metrology; micrometrology; *19802*.
- Microsecond pulses; temperature depending absorption; unstable resonator; absorption edge; damage temperature; damage threshold; *SP568*, pp. 269-279 (July 1980).
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- Microstrip; microwave integrated circuit; stripline transmission line; Josephson junctions; *U.S. Patent 4,227,096*.
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- Microstructure; sliding wear; wear; wear models; copper alloys; friction; metallic materials; *19826*.
- Microstructure; solid contact; wear; copper; copper alloys; friction; *19708*.
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- Microtron; recirculating accelerators; room-temperature rf systems; cw accelerators; electron accelerators; *19494*.
- Microvolume; analysis; biophysics; chloride; fluorides; microelectrodes; *19280*.
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- Microwave; microwave measurements; six-port; automatic net-



- work analyzer; calibration; 19303.
- Microwave; relativistic; synchrotron radiation; electron; frequency divider; ion trap; laser; 19529.
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- Microwave induced plasma detector; hydrogen emission; 19934.
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- Microwave power dependence; optical pumping; Rb frequency standards; wall coating; cavity pulling; frequency stability; 19777.
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- Microwave spectrum; rotational constants; structure; amino acid; centrifugal distortion; glycine; 19365.
- Microwave systems; transmission-line theory; signal processing; waves; 19367.
- Microwave temperature sensor; temperature transducer; thermometer; tunnel diode oscillators; gas thermometers; low temperature; 19236.
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- Mineralogy; Raman spectroscopy; chemical analysis; fluid inclusions; gemmology; microanalysis; 19577.
- Mineral particles; Monte Carlo methods; particle; peak-to-background ratios; quantitative analysis; x-ray microanalysis; electron probe microanalysis; glass particles; 19921.
- Mine safety; bibliography; coal mines; electrical equipment; enclosures; explosion; explosion containment; *NBSIR 80-2112*.
- Minicomputer; analytical chemistry; automation; instrumentation; microcomputer; 19411.
- Minicomputers; protocols; user interfaces; command languages; communications; computer access; computer networks; *SP500-68*.
- Minimal basic; programming language standards; software standards; software testing; BASIC; language processor testing; *SP500-70/2*.
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- MOS capacitor; silicon; thermally stimulated measurements; interface states; measurement interferences; mobile ions; 19166.
- MOSFET, d-c; d-c MOSFET dopant profile method; dopant profile method; 19425.
- Mobile FM transceiver; communications equipment standard; compatibility; interchangeability; law enforcement; microphone cable; microphone connector; 19701.
- Mobile home; safety; standard; window; anthropometry; emer-



agency egress; escape behavior; HUD; *NBSIR 80-2049*.

Mobile home; sulfur hexafluoride; tracer gas; air leakage measurements; environmental chamber; fan depressurization; *NBSIR 80-2105*.

Mobile ions; MOS capacitor; silicon; thermally stimulated measurements; interface states; measurement interferences; *19166*.

Mobility; resistivity; semiconductors; silicon; dopant density; electrical measurements; *19783*.

Mobility; resistivity; semiconductors; silicon; dopant density; electrical measurements; *19806*.

Mobility; resistivity; silicon; carrier density; computer program; electrical properties of silicon; Hall effect; *SP400-63*.

Mobility aids; room use; accidents; anthropometry; biomechanics; disability; disability organizations; home safety; household activities; household design; *NBSIR 80-2014*.

Modacrylics; polyesters; protective clothing; radiant energy; wool fabrics; aramids; burns (injuries); char strength; convective energy; cotton fabrics; fabrics; heat flux; insulative properties; *19120*.

Modal split; network analysis; benefit-cost analysis; combinatorial optimization; high-speed rail; mathematical models; *NBSIR 79-1724*.

Model; nebulosity; R Aquarii; spectrum; temperature; density; long-period variable; *19507*.

Model; stability; strain; transformation; criteria; finite; jellium; martensite; *19243*.

Model access; model management; sensitivity analysis; validation; assessment; documentation; econometric models; energy modeling forum; energy models; evaluation; mathematical models; *SP569*.

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Modeling; oxidation; oxygen; rate constant; atmospheric reactions; combustion; methyl radicals; *19149*.

Modeling; regulatory process; simulation; building codes; building fires; computer-aided design; computer simulation; fire research; human performance; *SP586*, pp. 205-224 (June 1980).

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Modeling; solar; testing; computer; energy; heat transfer; hot water; measurement; *19498*.

Modeling; standards; standards-writers; systems analysis; building standards; classification; decision tables; information networks; *NBSIR 80-1979*.

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Modelling; scientific uncertainty; societal decisions; socioscientific problems; theory; time constants; basic research; challenge to the analytical chemist; chemical measurement process; energy; environment; health; *19666*.

Model management; sensitivity analysis; validation; assessment; documentation; econometric models; energy modeling forum; energy models; evaluation; mathematical models; model access; *SP569*.

Model potential; collisions; electron-molecule; exchange potentials; *19747*.

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Models; osmotic coefficient; polyvalent electrolytes; solutions; thermodynamic properties; activity coefficient; correlation; critical evaluation; electrolyte theories; excess Gibbs energy; *19919*.

Models; regulations; additives; diffusion; food additives; indirect additives; migration; *NBSIR 80-1999*.

Model studies; research summaries; fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; *SP583*.

Model validation; queue; scheduling policies; simulation model; system performance; workloads; cumulative distribution function; events; hardware configuration; *SP500-65*, pp. 111-128 (Oct. 1980).

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Modifications test procedures; water heaters; energy consumption; energy measurements; heat pump; laboratory tests; *NBSIR 79-1951*.

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Modular coordination; building module; controlling dimensions; coordinating sizes; dimensional coordination; metric building design; metric building products; *19516*.

Modular coordination; standards; building module; dimensional coordination; metric design and construction; *SP595*.

Modular design; system tuning; capabilities; message overhead; *SP500-65*, pp. 319-330 (Oct. 1980).

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Modulation; point-contact diodes; reflectometer; return loss; Schottky-barrier diodes; semiconductor diodes; standing-wave ratio (SWR); conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; measurement uncertainties; microwave mixer diodes; *SP400-16*.

Modulus; rubber; shear; bulk modulus; compressibility; finite elasticity; *19886*.

Moisture; roofing; thermal conductance; thermal conductivity; thermal resistance; built-up roofing; insulation; *BSS123*.

Moisture accumulation; nondestructive tests; thermal resistance; built-up roofs; measurement technology; *NBSIR 80-2100*.

Moisture content; residences; retrofit; thermal resistivity; conservation; energy; field survey; insulation; *TN1131*.

Moisture content; syringe calibration; telescopic viewer; volumetric dispensing; water calibration; Karl Fischer titration; *19277*.

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Molar absorptivity (molar absorption coefficient); enzyme activity; *19561*.

Molar intensity ratios; natural gas components; Raman spectroscopic method; spectral line intensity measurements; gas mixture composition; gravimetrically prepared gas mixtures; *19540*.

Mole; precision measurement; atomic masses; fundamental con-



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- Molecular charge density; diatomic nitrogen; LCAO  $X\alpha$ ; 19328.
- Molecular clouds; star formation; supernovae; supernova remnants; x rays; dust grains; 19384.
- Molecular constance; spectral shape; coefficient induced dipoles; collision-induced spectra; dielectric virial; intermolecular transactions; 19413.
- Molecular constants; radioastronomy; rotational transitions; formic acid; interstellar molecules; line strengths; microwave spectra; *JPCRD 9*, No. 1, 59-160 (1980).
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- Molecular orientation; palladium (210); surface science; carbon monoxide; chemisorption; electron stimulated desorption; 19195.
- Molecular processes; reaction dynamics; surface reactions; 19880.
- Molecular processes; surface reactions; x-ray edge; electron-hole pairs; 19837.
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- Monochromatic incident x-ray beam; multiphase structure; x-ray fluorescence; chemical profiling; energy dispersive; macrosegregation; 19959.
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- Monte Carlo; particulate; quantitative analysis; analytical standards; electron probe microanalysis; fiber; glass; microsphere; 19732.
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- Mossbauer effect; Schladitz whiskers; carbon; cementite; hyperfine fields; iron fibers; magnetism; 19253.
- Mossbauer isomer shifts; transition metals; alloy phase formation; charge transfer; Coulomb energy; d-electrons; 19567.
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- Pattern recognition; robotics; vision systems; automation; image processing; inspection; manufacturing; 19093.
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- PdI sequence; tokamak; tungsten; AgI sequence; 19485.
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- Peak shape; powder diffraction; profile fitting; x-ray neutron; applications; lattice parameters; *SP567*.
- Peak-to-background ratios; quantitative analysis; x-ray microanalysis; electron probe microanalysis; glass particles; mineral particles; Monte Carlo methods; particle; 19921.
- Pebble-bed; phase-change unit; solar energy storage; thermal storage device; ASHRAE standard 94-77; Glauber's salt; latent heat storage; 19175.
- Pedestrian comfort; wind; wind environment; cool environments; microclimatic prediction; 19106.
- Penetrants; radiography; ultrasonics; acoustic emission; eddy currents; imaging; leakage testing; magnetics; material parameters; nondestructive evaluation; optics; *NBSIR 80-2162*.
- Penning collisions; polarized emission; strontium ions; 19103.
- Peptide hormones; angiotensin I; high resolution liquid chromatography; non-peptide impurities; 19496.
- Perception; questionnaires; research methodology; sensory environment; social sciences; thermal environment; architecture; audition; built environment; color; environmental psychology; illumination; *SP474*.
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- Perfect crystal; perturbation theory; rubidium; vacancies; anharmonicity; anomalous specific heat; atomic migration; high temperature; lattice dynamics; Monte Carlo calculations; 19123.
- Perfluoroethane; photoelectron spectroscopy; quasiequilibrium theory; threshold photoelectron spectroscopy;  $C_2F_6$ ; coincidence mass spectrometry; field ionization mass spectrometry; ion fragmentation; mass spectrometry; 19291.
- Perfluoro n-alkanes; phase transition; polytetrafluoroethylene; Raman spectroscopy; diamond anvil cell; high pressure physics; 19893.
- Perfluoro n-alkanes; polarization; polytetrafluoroethylene; Raman spectroscopy; tetrafluoroethylene-hexafluoroethylene copolymer; orientation; 19633.
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- Performance criteria; solar heating system; standards; codes; 19377.
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- Performance criteria; statistical evaluation; thermal analysis; depletable energy; HUD Demonstration Program; passive solar buildings; 19823.
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- Performance testing; contact resistance; electrical codes; fire safety; glowing electrical connections; house wiring; innovative electrical connections; BSS128.
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- Permeability; plastic deformation; semicrystalline polymers; sorption; diffusivity; elastic deformation; fractional free volume; 19662.
- Permeability; shear-bond strength; simulated geothermal fluids; geothermal-well cements; high pressure vessel; high temperature furnace; NBSIR 80-2099-3.
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- Personnel; budgets; economic analysis; enforcement; housing codes; SP586, pp. 135-148 (June 1980).
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- Perturbations; quantum defect theory; Rydberg states; spectra; atomic spectroscopy; Cd; configuration interaction theory; 19369.
- Perturbations; torsion; vibration-rotation; ethane; group theory; internal rotation; 19412.
- Perturbation theory; rubidium; vacancies; anharmonicity; anomalous specific heat; atomic migration; high temperature; lattice dynamics; Monte Carlo calculations; perfect crystal; 19123.
- Perturbation theory; softness expansion; dilute gas transport properties; inverse power potential; logarithmic terms; 19389.
- Perturbation theory; soft spheres; transport coefficients; Boltzmann equation; collision integral; dilute gas; kinetic perturbation theory; kinetic theory; nonequilibrium perturbation theory; 19866.
- Petri net; state diagram; action table; computer program; finite automata; formal description technique; graphs; natural language; NBS-GCR-80-247.
- Petroleum standards; petroleum test methods; recycled burner fuel oil; substantial equivalency; used oil; waste oil; fuel oil; TN1130.
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- Phase conjugate spectroscopy; saturation spectroscopy; four-wave mixing; heterodyne spectroscopy; iodine spectroscopy; non-linear spectroscopy; 19287.
- Phase diagram; phase transformations; tantalum alloys; constitution diagram; intermetallic compounds; palladium alloys; 19595.
- Phase diagram; plastic crystal; pressure; carbon tetrachloride; melting curves; metastability; 19470.
- Phase diagram; potassium-iron-silicon oxides; solidification; surface tension; thermodynamic properties; Auger measurements on liquids; convection; gallium; heat capacity; lead-tin alloys; magnetic field effect; *NBSIR 80-2082*.
- Phase diagrams; constitution diagrams; crystal chemistry; intermetallic compounds; niobium alloys; palladium alloys; 19330.
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- Phase equilibria; potassium ceria-zirconia system; pyrochlore; ceria-zirconia system; magnetohydrodynamics; oxidation-reduction; perovskite; 19637.
- Phase equilibria; solid solutions; alloy theory; crystal chemistry; intermediate phases; phase diagrams; *SP564*.
- Phase II; polytetrafluoroethylene; units per turn; conformation; crystal; electron; helix; irrational; 19797.
- Phase locking; superconductivity; voltage standard; Josephson effect; 19351.
- Phase spectrum transformation; spectrum; VOR aircraft navigation system; white noise; Fourier coefficients; linear model; nonlinear model; *TN1021*.
- Phase transformations; tantalum alloys; constitution diagram; intermetallic compounds; palladium alloys; phase diagram; 19595.
- Phase transition; polytetrafluoroethylene; Raman spectroscopy; diamond anvil cell; high pressure physics; perfluoro n-alkanes; 19893.
- Phase transition; resistivity; x-ray diffraction; cuprous chloride; diamond cell; optical microscopy; 19687.
- Phase transition; surface; surface tension; wetting; contact angle; critical point; cyclohexane; interface; methanol; 19306.
- Phase transitions; surface melting; adsorbed layers; antiphase boundaries; grain boundaries; lattice gas; 19468.
- Phase transitions; virial coefficients; virial series; Bose gas; fugacity expansion; Pade approximants; 19907.
- Phase transitions; x-ray diffraction; ammonium nitrate; crystal structure; hydrogen bonding; neutron diffraction; 19897.
- Phenols; polynuclear aromatic hydrocarbons; priority pollutants; alternate fuels; gas chromatography; high performance liquid chromatography; N-heterocyclic compounds; 19097.
- Phenyl ion; photoionization; chlorobenzene; coincidence; fragmentation; ion energetics; 19177.
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- Phonon; strong scattering; transport anomalies; conductivity; disordered alloy; localization; 19755.
- Phonon distribution;  $U_3O_8$ ;  $UO_2$ ; chemical state; delayed neutron; fission; 19683.
- Phonons; cross sections; molecular binding; neutron reactions; neutron standards; *SP594*, pp. 89-92 (Sept. 1980).
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- Phosphorus density; photometric technique; silicon; Hall effect; junction C-V measurements; neutron activation analysis; 19431.
- Phosphorus pileup; photolithography; pull test; random fault test structures; resistivity; scanning acoustic microscope; scanning electron microscope; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; *SP400-45*.
- Photoabsorption; K edge; lithium; 19272.
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- Photoabsorption cross sections; photocathodes; plasma diagnostic detectors; radiometry; soft x-ray diagnostics; CsI; CuI; 19602.
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- Photochemistry; ethyl chloride; halocarbons; 19931.
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- Photochemistry; radical; chain reaction; combustion; laser; 19198.
- Photochemistry; sand; surface reactions; tropospheric sink; catalysis; nitrous oxide; 19953.
- Photochemistry; spectroscopy; transient; vacuum ultraviolet; acetylene; excited state; ketene; 19493.
- Photoconductivity variations; photovoltaic technique; resistivity gradients; resistivity variations; wafer scanning; 19764.
- Photodecomposition;  $CF_3Br$ ;  $CF_4Br$ ;  $CF_3Cl$ ;  $CF_4Cl$ ;  $CF_3I$ ;  $CF_4I$ ; F-atom reactions; infrared spectrum; matrix isolation; 19760.
- Photodetachment; space charge; sulfur hexafluoride ( $SF_6$ ); uv radiation; 60 Hz ac and dc; compressed gas; corona; electron avalanche; inception voltage; ionization; ion mobilities; partial discharge; 19786.
- Photodetector; photometry; radiometry; absolute spectral response; detector intercomparison; optical radiation measurements; 19908.
- Photodetector; radiant power measurement; radiometry; silicon photodiode; spectroradiometry; absolute spectral response; laser power measurement; 19354.
- Photodiode; radiometry; calibration; detectors; irradiance; light source; 19592.
- Photodissociation; quantum yield; quenching; reactive collisions;



- vibrational excitation; electronic excitation; laser; 19336.
- Photodissociation; ultraviolet spectrum; CO; discharge sampling; F-atom reactions; FCO;  $F_2CO$ ; infrared spectrum; matrix isolation; NF<sub>3</sub>; normal coordinate analysis; 19393.
- Photodissociation laser; atomic resonance laser; atomic resonance-line laser; flame spectrometry; laser enhanced ionization; opto-galvanic effect; 19836.
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- Photoelastic; piezo-optic; refractive index; relative dielectric impermeability; absorption coefficient; birefringence; crystal optics; dielectric constant; elasto-optic; electro-optic; 19257.
- Photoelastic constants; refractive index; thermal coefficient of refractive index; ultraviolet; alkali halides; crystalline materials; glasses; 19275.
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- Photoelectron; photoionization; unimolecular; benzene; benzonitrile ion; coincidence; fragmentation; kinetics; 19603.
- Photoelectron; ultraviolet photoelectron spectroscopy; UPS; alloys; alloy stability; amorphous alloys; electron density of states; palladium-silicon alloys; 19263.
- Photoelectron emission; spin and energy analysis; spin polarized electron; electron optics; 19342.
- Photoelectrons; resonance; lasers; multiphoton ionization; 19305.
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- Photoelectron spectra; photoionization; threshold photoelectron spectra; allene; ionization potential; low temperature photoionization; mass spectrometry; 19182.
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- Photoelectron spectra; synchrotron radiation; electron spectrometer; 19614.
- Photoelectron spectroscopy; hole dynamics; lineshapes; 19828.
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- Photoemission; polarization; source of polarized electrons; spin polarization; electron optics; electron spin polarization; GaAs; negative electron affinity; 19310.
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- Photographic equipment; cameras; exposure meters; film; filters; law enforcement photography; lenses; lighting equipment; *SP480-23*.
- Photography; accelerants; arson; building fires; electrical fires; explosions; fire investigations; fire investigators; hydrocarbons; *H134*.
- Photoillumination effect; silicon; field ion microscopy; 19210.
- Photoionization; analysis; chemical ionization; hydrocarbons; ion-molecule reactions; mass spectrometry; 19930.
- Photoionization; breakdown curve; cyclopropene; 19942.
- Photoionization; chlorobenzene; coincidence; fragmentation; ion energetics; phenyl ion; 19177.
- Photoionization; propyne; threshold photoelectron spectroscopy; allene; coincidence; cyclopropene; fragmentation; 19803.
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- Photoionization; threshold photoelectron spectra; allene; ionization potential; low temperature photoionization; mass spectrometry; photoelectron spectra; 19182.
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- Photoionization; unimolecular; benzene; benzonitrile ion; coincidence; fragmentation; kinetics; photoelectron; 19603.
- Photoionization quantum beats; sodium; angular distribution; atomic; hyperfine structure; multiphoton; 19388.
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- Photolysis;  $CF_2$ ;  $C_2F_4$ ; kinetics; laser; mass spectrometry; 19722.
- Photolysis kinetics; photoresist; sensitometry; Van Kreveland's law; exposure; exposure modeling; 19801.
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- Photomask; scanning electron microscope; semiconductor technology; filar eyepiece; image-shearing eyepiece; integrated circuits; linewidth measurements; microelectronics; micrometrology; optical microscope; photoelectric microscope; *SP400-43*.
- Photomasking; resistivity; second breakdown; semiconductors; test structures; thermal resistance; very large scale integration; VLSI; wire bonds; Department of Commerce; integrated circuits; metrology for semiconductors; National Bureau of Standards; *NBSIR 80-2057*.
- Photometric technique; silicon; Hall effect; junction C-V measurements; neutron activation analysis; phosphorus density; *19431*.
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- Photon dose rate; photons; shielding; fusion; neutral beam injection; neutrons; nuclear heating; *SP594*, pp. 239-245 (Sept. 1980).
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- Photovoltaic technique; resistivity gradients; resistivity variations; wafer scanning; photoconductivity variations; *19764*.
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- Physisorption; surface; tungsten; acetylene; chemisorption; electron energy loss spectroscopy; ethylene; *19390*.
- PIB; PMMA; poly(isobutylene); poly(methyl methacrylate); time dependent behavior; BKZ theory; non-linear viscoelasticity; normal stresses; *19672*.
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- Piezoelectricity; plasma; polarization; poly(vinylidene fluoride); pyroelectricity; thermal expansion; charge; compressibility; *19324*.
- Piezoelectric polymer; plastics; vibrations; mechanical integrity; nondestructive evaluation; normal modes; orthopedic implants; *19952*.



- Piezoelectric polymers; polarization; poly(vinyl chloride); poly(vinyl fluoride); poly(vinylidene fluoride); pyroelectric polymers; space charge; crystal relaxations; electrets; ferroelectricity; 19734.
- Piezooptic; refractive index; glass; lasers; photoelasticity; 19842.
- Piezo-optic; refractive index; relative dielectric impermeability; absorption coefficient; birefringence; crystal optics; dielectric constant; elasto-optic; electro-optic; photoelastic; 19257.
- Piezo-optic;  $\text{SrF}_2$ ; strain; stress; transverse optic-phonon; anisotropy;  $\text{BaF}_2$ ;  $\text{CaF}_2$ ; effective charge; oscillator strength; photoelastic; piezo-birefringence; 19579.
- Piezo-optics; planar waveguides; thermo-optics; thin films; ultraviolet; fiber optics; graded index materials; infrared; magneto-optics; nonlinear optics; SP574.
- Pile oscillator; small-angle scattering; sulfur; absorption cross section; manganese bath; SP594, pp. 738-742 (Sept. 1980).
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- Pion scattering; baryon resonances; delta-nucleus interaction; nuclear structure; pion absorption; pion nucleus interaction; 19221.
- Pipe flow; fringing fields; magnetohydrodynamics, MHD; non-uniform fields; 19050.
- Piping; pressure vessel; pump; reliability; risk analysis; valves; failure data; fatigue; fracture; inservice data; mechanical engineering; nuclear reactors; 19085.
- Piping; pressure vessels; product liability; pumps and valves; standards; statistical modeling; welding; ASME Boiler Code; data; fabrication; failure analysis; fatigue; fracture; materials science; nondestructive evaluation; SP588.
- Pitting; potentiostat; aluminum; copper; impedance measurements; noise measurements; 19572.
- PLEED; polarized electrons; polarized LEED; surface magnetism; surface magnetization; magnetism; Ni; nickel; 19341.
- PLEED; polarized LEED; surface magnetism; ferromagnetism; LEED; magnetism; nickel; 19104.
- PL/1; benchmark; COBOL; SP500-65, pp. 53-59 (Oct. 1980).
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- Plane of light; real time; robot; sensory feedback; vision system; line following; part acquisition; 19096.
- Plane-polarized radiation; Raman spectra; attenuated total reflection; determination of structure of carbohydrates; infrared spectra of carbohydrates; interpretation of infrared spectra; 19875.
- Planetary nebulae; red giants; abundances; evolution; 19845.
- Planning; queueing models; capacity; SP500-65, pp. 139-156 (Oct. 1980).
- Planning cost; Proposition 13; affordable housing; development fee; SP586, pp. 13-16 (June 1980).
- Plant tissue analysis; standard reference material; trace analysis; agriculture; environmental analysis; foliar analysis; food analysis; nutrition; 19423.
- Plasma; polarization; poly(vinylidene fluoride); pyroelectricity; thermal expansion; charge; compressibility; piezoelectricity; 19324.
- Plasma; Stark; Balmer; diagnostics; hydrogen; line-broadening; 19281.
- Plasma conductivity; electron scattering cross section; error analysis; MHD; 19090.
- Plasma desorption; time-of-flight mass spectrometer; fission fragment desorption; isotope ratio measurement; SP582, pp. 66-78 (June 1980).
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- Plasma system; trace element analysis; emission spectroscopy; inductively coupled plasma; instrumental control; multi-element analysis; 19912.
- Plastic crystal; pressure; carbon tetrachloride; melting curves; metastability; phase diagram; 19470.
- Plastic deformation; alumina; basal slip; cavitation; deformation texture; electron microscopy; grain boundary sliding; 19582.
- Plastic deformation; semicrystalline polymers; sorption; diffusivity; elastic deformation; fractional free volume; permeability; 19662.
- Plastic deformation; silicon; silicon carbide; aluminumoxide; brittle fracture; dislocations; electron microscopy; erosion; germanium; hardness measurements; 19731.
- Plastic deformation; spherulitic structure; tie molecule; crystalline polymer; cylindrical structure; fibril; fibrous structure; microfibril; necking; 19674.
- Plastic deformation; steel; surfaces; wear; wear debris; copper; electron microscopy; friction; metals; NBSIR 80-2058 (ONR).
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- Plastic dosimeters; polyvinylchloride; radiation processing; radiochromic dye films; blue cellophane; cellulose triacetate; clear Perspex; dose rate dependence; dosimetry; dyed plastic dosimeters; electron beams; gamma rays; 19338.
- Plastic flow; sapphire; thermomechanical analysis; compressive failure; laser damage; SP568, pp. 141-149 (July 1980).
- Plastics; vibrations; mechanical integrity; nondestructive evaluation; normal modes; orthopedic implants; piezoelectric polymer; 19952.
- Plastics fatigue; quantitative microscopy; statistical aspects of fatigue; composite materials; corrosion fatigue; durability; fatigue; fatigue mechanism; fatigue research; fracture mechanics; mathematical modeling; metals fatigue; 19448.
- Plastic strain; random cycling; single crystal copper; copper crystal; fatigue; persistent slip band; 19694.
- Plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 2124-T851; 7075; 7075-T6; 7075-T7351; air; alternate immersion test; aluminum alloys; ductility; elongation; heat treatment; NaCl; 19622.
- Plating coatings; zinc; aluminum; electrodeposition; epitaxy; 19657.
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- Platinum resistance thermometers; temperature scales; thermodynamic temperature; gas thermometry; International Practical Temperature Scale; 19215.
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- PMMA; poly(isobutylene); poly(methyl methacrylate); time dependent behavior; BKZ theory; non-linear viscoelasticity; normal stresses; PIB; 19672.
- PMTE; calibration labs; calibration, out-of-service; central calibration; in situ calibration; measurement; metrology; on-site calibration; *NBS-GCR-80-282*.
- PMTE; recall intervals; calibration interval; calibration interval algorithms; calibration requirements; decision table; interval adjustment; measurement; metrology; *NBS-GCR-80-283*.
- Pneumatic burst; pressure vessel; steel; ductile fracture; fracture toughness; part-through crack; 19961.
- P-n junction isolation; two-layer structures; epitaxial growth; Hall measurements; indium-doped silicon; 19417.
- PO; PO<sub>2</sub>; (PO)<sub>2</sub>; ultraviolet spectrum; vacuum ultraviolet photolysis; discharge sampling; HPO; infrared spectrum; matrix isolation; 19082.
- PO<sub>2</sub>; (PO)<sub>2</sub>; ultraviolet spectrum; vacuum ultraviolet photolysis; discharge sampling; HPO; infrared spectrum; matrix isolation; PO; 19082.
- (PO)<sub>2</sub>; ultraviolet spectrum; vacuum ultraviolet photolysis; discharge sampling; HPO; infrared spectrum; matrix isolation; PO; PO<sub>2</sub>; 19082.
- Pockels cell; ultralinear modulator; optical bistability; optical power regulator; 19578.
- Pockels effect; space charge; surface flashover; vacuum breakdown; electrical breakdown; electro-optics; interfacial breakdown; *NBS-GCR-80-203*.
- Point-contact diodes; reflectometer; return loss; Schottky-barrier diodes; semiconductor diodes; standing-wave ratio (SWR); conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; measurement uncertainties; microwave mixer diodes; modulation; *SP400-16*.
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- Point-plane electrodes; pulse height distributions; SF<sub>6</sub>; SF<sub>6</sub>-N<sub>2</sub> mixtures; corona; partial-discharge; 19785.
- Point sources; water; air; buildup factors; gamma rays; iron; photons; 19294.
- Poisoning; catalyst; Fischer-Tropsch synthesis; hydrogenation; methanation; nickel; 19201.
- Poisson's ratio; shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; physical-property variability; 19246.
- Poisson transformation; polymer configurations; random walks; spans; stable laws; 19654.
- Polarizability; autodetachment; charge transfer; electron affinity; electron scattering resonances; LiF<sup>-</sup>; molecular anions; 19197.
- Polarizability; rare-gas; Zwanzig-Mori theory; depolarized light scattering; lattice-gas; Lorentzian shape; oscillatory; parameters; 19756.
- Polarization; Be<sup>+</sup>; crossed beams; cross sections; electron impact; excitation; 19512.
- Polarization; carbon steel; chronoamperometry; corrosion rate measurement; 19840.
- Polarization; polytetrafluoroethylene; Raman spectroscopy; tetrafluoroethylene-hexafluoroethylene copolymer; orientation; perfluoro *n*-alkanes; 19633.
- Polarization; poly(vinyl chloride); poly(vinyl fluoride); poly(vinylidene fluoride); pyroelectric polymers; space charge; crystal relaxations; electrets; ferroelectricity; piezoelectric polymers; 19734.
- Polarization; poly(vinylidene fluoride); pyroelectricity; thermal expansion; charge; compressibility; piezoelectricity; plasma; 19324.
- Polarization; reflections; spectral bandpass; standard reference materials in spectrophotometry; stray radiation; transmittance stability; filters for spectrophotometry; metal-on-fused silica filters; optical transmittance accuracy; *SP260-68*.
- Polarization; refrigeration; specific heat strontium titanate; ceramics; cryogenics; dielectric constant; electrocaloric effect; entropy; ferroelectrics; glass-ceramics; heat switches; 19534.
- Polarization; source of polarized electrons; spin polarization; electron optics; electron spin polarization; GaAs; negative electron affinity; photoemission; 19310.
- Polarization effects; resonator analysis; coatings design; *SP568*, pp. 439-443 (July 1980).
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- Polarization techniques; underground corrosion; corrosion; corrosion noise; electrochemistry; *NBSIR 80-2083*.
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- Polarized emission; strontium ions; Penning collisions; 19103.
- Polarized LEED; surface magnetism; ferromagnetism; LEED; magnetism; nickel; PLEED; 19104.



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- Polarized neutrons and nuclei; pulsed neutron source; IBR-2 reactor; isomeric shift; neutron resonances; *SP594*, pp. 385-393 (Sept. 1980).
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- Polar molecules; electron collisions; model potentials; 19497.
- Policy experiments; policy problems; technology-based industries; Experimental Technology Incentives Program; framework; methodology; *NBS-GCR-ETIP 80-92*.
- Policy options; societal aspects; workshop; barrier/incentives; hydrogen energy systems; impacts of hydrogen fuel; 19699.
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- Polycyclic aromatic hydrocarbons; tissue analyses; aliphatic hydrocarbons; aromatic hydrocarbons; gas chromatography; hydrocarbons; interlaboratory comparison; liquid chromatography; mass spectrometry; mussels; 19841.
- Polycyclic aromatic hydrocarbons (PAH); retention data; reverse-phase HPLC; air particulates; high performance liquid chromatography (HPLC); normal-phase HPLC; 19547.
- Polydispersity; recycle GPC; recycle liquid size chromatography; anionic polystyrenes; column spreading; GPC; liquid size exclusion chromatography; narrow fractions; 19426.
- Polyesters; protective clothing; radiant energy; wool fabrics; aramids; burns (injuries); char strength; convective energy; cotton fabrics; fabrics; heat flux; insulative properties; modacrylics; 19120.
- Polyester urethane elastomers; hydrolytic degradation; 19585.
- Polyethylene; polyethyleneoxide; polyhexafluoropropylene; polyoxymethylene; polypropylene; polytetrafluoroethylene; accordion type oscillation; coupled rod oscillation; crystalline polymers; elastic modulus; helical chains; helical chains; inelastic neutron scattering; laser-Raman scattering; 19937.
- Polyethylene; poly(methyl methacrylate); time-dependent behavior; additivity of damage; Bailey criterion; damage accumulation; failure; fatigue; mechanical properties; PMMA; 19690.
- Polyethylene; polyvinyl butyral; radiation curing; radiation processing; radiochromic dye film; wire and cable; copper wire; cross linking; dose distribution; dosimetry; electron beams; isodose curves; 19333.
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- Polymer configurations; random walks; spans; stable laws; Poisson transformation; 19654.
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- Polymer crystallization; shish kebabs; crystallization theory flow induced crystallization; extended chain fibrils; 19167.
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- Polymer matrix; polypropylene; polysulfone; aromatic poly-



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- Polymer review; Raman and infrared spectroscopy; conformationally irregular polymers; Green's functions; molecular vibrations; normal mode calculations; numerical methods; 19713.
- Polymers; butane; diffusion; experimental methods; migration; molecular transport; nuclear magnetic resonance; 19906.
- Polymers; combustion; fire; heat release; oxygen consumption; 19322.
- Polymers; precision electric measurements; pulse-height analysis; superconducting transmission; capacitance; cryogenic; dielectric constant; dielectric properties; dissipation factor; electrical transmission; partial discharges; *NBSIR 79-1950*.
- Polymers; pyroelectric transducer; applications; piezoelectric; 19887.
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- Polymers; rubber; thermal analysis; differential scanning calorimetry; elastomers; *SP580*, pp. 55-87 (Aug. 1980).
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- Polymers, dental; refractories, dental; specifications, dental; waxes, dental; alloy, base, dental; alloy, gold, dental; amalgam, dental; cements, dental; dental materials; gypsums, dental; impression materials, dental; 19052.
- Polymer solutions; light scattering; neutron scattering; 19834.
- Polymethyl methacrylate; polyvinyl chloride; polyvinyl fluoride; polyvinyl pyrrolidone radiochromic dyes; temperature dependence; absorption spectroscopy; blue cellophane; cellulose triacetate; dosimetry; dye dosimetry; dyed plastics; film dosimeters; gamma-ray dosimetry; 19326.
- Poly(methyl methacrylate); shear stresses; BKZ theory; mechanical conditioning; nonlinear viscoelasticity; normal stresses; 19707.
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- Poly(methyl methacrylate); time dependent behavior; BKZ theory; non-linear viscoelasticity; normal stresses; PIB; PMMA; poly(isobutylene); 19672.
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- Polynuclear aromatic hydrocarbons; priority pollutants; alternate fuels; gas chromatography; high performance liquid chromatography; N-heterocyclic compounds; phenols; 19097.
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- Polyosithylene; Raman; accordion-type longitudinal oscillation; basic node; higher nodes; 19655.
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- Polyoxymethylene; polypropylene; Raman spectroscopy; Young's modulus; longitudinal acoustic mode; 19895.
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- Polypropylene; Raman spectroscopy; Young's modulus; longitudinal acoustic mode; polyoxymethylene; 19895.
- PolySAM; adsorption; chemisorption; composites; coupling agent; dental adhesion; 19658.
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- Polystyrene; pyrolysis; thermal degradation; thermogravimetry; activation energy; factor-jump thermogravimetry; oxidation; 19798.
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- Polytetrafluoroethylene; Raman spectroscopy; diamond anvil cell; high pressure physics; perfluoro n-alkanes; phase transition; 19893.
- Polytetrafluoroethylene; Raman spectroscopy; tetrafluoroethylene-hexafluoroethylene copolymer; orientation; perfluoro n-alkanes; polarization; 19633.
- Polytetrafluoroethylene; units per turn; conformation; crystal; electron; helix; irrational; Phase II; 19797.
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- Polyvalent electrolytes; solutions; thermodynamic properties; activity coefficient; correlation; critical evaluation; electrolyte theories; excess Gibbs energy; models; osmotic coefficient; 19919.
- Polyvinyl butyral; radiation curing; radiation processing; radiochromic dye film; wire and cable; copper wire; cross linking; dose distribution; dosimetry; electron beams; isodose curves; polyethylene; 19333.
- Poly(vinyl chloride); PVC; pyrolysis; carbonyl chloride; combustion; decomposition; degradation; electron capture; gas chromatography; infrared spectroscopy; mass spectroscopy; phosgene; polymer; 19503.
- Poly(vinyl chloride); poly(vinyl fluoride); poly(vinylidene fluoride); pyroelectric polymers; space charge; crystal relaxations; electrets; ferroelectricity; piezoelectric polymers; polarization; 19734.
- Polyvinyl chloride; polyvinyl fluoride; polyvinyl pyrrolidone radiochromic dyes; temperature dependence; absorption spectroscopy; blue cellophane; cellulose triacetate; dosimetry; dye dosimetry; dyed plastics; film dosimeters; gamma-ray dosimetry; humidity effects; 19326.
- Polyvinylchloride; radiation processing; radiochromic dye films; blue cellophane; cellulose triacetate; clear Perspex; dose rate dependence; dosimetry; dyed plastic dosimeters; electron beams; gamma rays; plastic dosimeters; 19338.
- Poly(vinyl fluoride); poly(vinylidene fluoride); pyroelectric polymers; space charge; crystal relaxations; electrets; ferroelectricity; piezoelectric polymers; polarization; poly(vinyl chloride); 19734.
- Polyvinyl fluoride; polyvinyl pyrrolidone radiochromic dyes; temperature dependence; absorption spectroscopy; blue cellophane; cellulose triacetate; dosimetry; dye dosimetry; dyed plastics; film dosimeters; gamma-ray dosimetry; humidity effects; megarod dosimetry; 19326.
- Poly(vinylidene fluoride); pyroelectricity; thermal expansion; charge; compressibility; piezoelectricity; plasma; polarization; 19324.
- Poly(vinylidene fluoride); pyroelectric polymers; space charge; crystal relaxations; electrets; ferroelectricity; piezoelectric



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- Porosity; porous polymers; buoyant force; dielectric insulation; dielectric oil; impregnation; 19376.
- Porosity; preparing flawed weldments; slag; three-dimensional flaws; arc strikes; blunt flaws; fracture mechanics; hydrogen-assisted cracking; low-cycle fatigue; 19762.
- Porous polymers; buoyant force; dielectric insulation; dielectric oil; impregnation; porosity; 19376.
- Porous polymers; specific volume; void filling; void volume; buoyant force; dielectric insulation; oil permeation; 19882.
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- Position-sensitive proportional counter; epithermal neutron energy; neutron radiography; nondestructive assay; nondestructive evaluation; *SP594*, pp. 436-439 (Sept. 1980).
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Safeguards; uranium; uranium hexafluoride; uranium 235; gas centrifuges; IAEA safeguards; isotope separation; material balance; material unaccounted for; nondestructive analysis; *SP582*, pp. 261-275 (June 1980).

Safeguards; uranium waste; verification; counter; estimates; gamma rays; neutrons; nondestructive assay; plutonium waste; *SP582*, pp. 622-632 (June 1980).

Safeguards/accountability; automated fuel fabrication equipment; nuclear fuel pellets; *SP582*, pp. 342-364 (June 1980).

Safeguards instrument; seal; tamper; unattended safeguards system; *SP582*, pp. 257-260 (June 1980).

Safeguards objective; safeguards performance criteria; International Atomic Energy Agency; international safeguards; *SP582*, pp. 651-669 (June 1980).

Safeguards performance criteria; International Atomic Energy Agency; international safeguards; safeguards objective; *SP582*, pp. 651-669 (June 1980).

Safeguards performance criteria; safeguards systems; safeguards technology; detection; deterrence; diversion of nuclear energy; evolution; *SP582*, pp. 670-676 (June 1980).

Safeguards systems; safeguards technology; detection; deterrence; diversion of nuclear energy; evolution; safeguards performance criteria; *SP582*, pp. 670-676 (June 1980).

Safeguards technology; detection; deterrence; diversion of nuclear energy; evolution; safeguards performance criteria; safeguards systems; *SP582*, pp. 670-676 (June 1980).

Safety; accidents; fault trees; loss prevention; risk; 19320.

Safety; shoring; soil classification; trench; workshop; acceptable work practices; excavation; geotechnical engineering; *NBSIR 79-1935*.

Safety; signs; standardization; symbols; visual alerting; fire fighting; fire safety; pictograms; 19274.

Safety; smoke; symbols; communications; evacuation; fire alarms; fire safety; human behavior; human factors; panic; *NBSIR 80-2070*.

Safety; solar collectors; solar energy; standards; thermal performance; buildings; cooling; durability/reliability; performance criteria; *SP586*, pp. 151-160 (June 1980).

Safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; *SP577*.

Safety; standard; window; anthropometry; emergency egress; escape behavior; HUD; mobile home; *NBSIR 80-2049*.

Safety; standards; concrete; construction; cooling tower; formwork; hoisting system; regulations; *NBSIR 80-1964*.

Safety; temperature; tracealloy; vapor detectors; wood heating; fire; fluidic sensors; ionizing radiation; neutron; passive solar; radiography; *DIM/NBS 64*, No. 10, 1-32 (1980).

Safety; x rays; calibration; diagnostic x-rays; electrical measurements; health; radiation; radiation safety; *NBSIR 80-2072*.

Safety belts; scaffolding; accident data; fall arresting systems; industrial and construction industries; occupational safety; 19233.

Safety equivalency; safety evaluation; smoke detection; automatic sprinklers; building codes; building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; *NBSIR 78-1555-1*.

Safety evaluation; smoke detection; automatic sprinklers; building codes; building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; *NBSIR 78-1555-1*.

Safety regulation; standards organizations; voluntary standards; administrative law; law; legal aspects of standards; regulation; *NBS-GCR-79-171*.

Safety regulations; shoring; trenching; construction safety; construction standards; excavation; *NBSIR 80-1988*.

Salt; synthesis; acid; aromatic; bond-delocalized; croconic; dianion; malononitrile; nonbenzenoid; pseudooxocarbons; 19560.

Salt; synthesis; acid; aromatic; bond-delocalized; croconic; dianion; malononitrile; nonbenzenoid; oxocarbon; *J. Res.* **85**, No. 2, 73-86 (Mar.-Apr. 1980).

Sample; standards; heterogeneous; in-house; laboratory; preparation; riffle; *SP591*, pp. 45-49 (Aug. 1980).

Sample carrier; coefficient of luminous intensity; coefficient of retroreflection; projector; receiver; retroreflectometer; retroreflector; 19394.

Sample characterization; sample processing effects; 25 gram capacity bomb calorimeter; bomb calorimetry; gross calorific values; refuse-derived-fuels; *NBSIR 80-1968*.

Sample perturbation; actinide recycle; cross section evaluation; fast critical facility; fast reactor; integral experiment; least square fitting; neutron spectrum; *SP594*, pp. 552-556 (Sept. 1980).

Sample preparation; scintillation counting; solgel; inorganic radiochemical; liquid scintillator; radioactivity; 19817.

Sample processing effects; 25 gram capacity bomb calorimeter; bomb calorimetry; gross calorific values; refuse-derived-fuels; sample characterization; *NBSIR 80-1968*.

Sampler; transition duration; amplitude comparator; Josephson junction; risetime; 19056.



- Samples; spectrometric analysis; transmission; measurements; number of nuclei; *SP594*, pp. 903-906 (Sept. 1980).
- Sampling (temporal); statistics; time-varying signals; community noise; measurement errors; noise; noise exposure; *19116*.
- Sand; surface reactions; tropospheric sink; catalysis; nitrous oxide; photochemistry; *19953*.
- S- and p-wave strength functions; total cross sections; W isotopes; elastic and inelastic scattering cross sections; energy range 10 keV-15 MeV; optical and statistical model calculations; potential scattering radii; *SP594*, pp. 336-339 (Sept. 1980).
- Sanduleak 3; Wolf-Rayet stars; OVI stars; *19741*.
- Santa Cruz; entrepreneurship; innovation; innovation centers; invention; invention evaluation; *19261*.
- Sapphire; thermomechanical analysis; compressive failure; laser damage; plastic flow; *SP568*, pp. 141-149 (July 1980).
- Sapphire-Al<sub>2</sub>O<sub>3</sub>; standard reference material; tele-microscope; thermal expansion; high temperature; interferometer; *19915*.
- Satellite; d-hole pairs; photoemission; *19271*.
- Satellite; spectrum; spectrum conservation; standard; time broadcast stations; voice announcements; clocks; HF; interference; *19525*.
- Satellite; time; time scales; Hermes/CTS; international time comparison; precise time transfer; *19530*.
- Satellite; time dissemination; *19528*.
- Satellite time code; standard frequencies; television color subcarrier; time calibrations; time signals; broadcast of standard frequencies; frequency calibrations; GOES satellite; high frequency; low frequency; *SP432*, *1979 Edition*.
- S atom reaction; CF<sub>2</sub> reaction; CF<sub>2</sub>I; CF<sub>2</sub>S; H atom reaction; HCF<sub>2</sub>; I atom reaction; infrared spectrum; matrix isolation; *19410*.
- Saturated absorption; saturation spectroscopy; Doppler-free spectroscopy; high-resolution spectroscopy; laser spectroscopy; non-linear spectroscopy; *19288*.
- Saturation; titration curve; dissolution; Karl Fischer water determination; mass fraction of water; rate constant; *19591*.
- Saturation effect; chemical kinetics; exposure; exposure reciprocity; kinetic equations; photochemistry; photon intensity; photoresist exposure; rate constants; *19418*.
- Saturation point; throughput rate; load control; multiprogramming; operational analysis; optimization; queueing theory; response time; *SP500-65*, pp. 207-213 (Oct. 1980).
- Saturation spectroscopy; Doppler-free spectroscopy; high-resolution spectroscopy; laser spectroscopy; non-linear spectroscopy; saturated absorption; *19288*.
- Saturation spectroscopy; four-wave mixing; heterodyne spectroscopy; iodine spectroscopy; non-linear spectroscopy; phase conjugate spectroscopy; *19287*.
- Saturation states; thermodynamic properties of water; vapor pressure; virial coefficients; water; enthalpy of water; heavy water; *PvT*; *JPCRD 9*, No. 3, 735-750 (1980).
- Saturn's satellites; constraints on composition; orbital evolution; *19774*.
- Savings-to-investment ratio; benefit-cost; building design; construction economics; discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; *SP544*.
- Scaffold failures; scaffolds; accidents; accident statistics; construction regulations; construction safety; employee casualties; environmental hazards; human factors; occupational safety; *NBSIR 79-1955*.
- Scaffolding; accident data; fall arresting systems; industrial and construction industries; occupational safety; safety belts; *19233*.
- Scaffolds; accidents; accident statistics; construction regulations; construction safety; employee casualties; environmental hazards; human factors; occupational safety; scaffold failures; *NBSIR 79-1955*.
- Scaffolds; stiffness; strength; structural safety; work surfaces; codes and standards; construction safety; design; loads; maintenance; occupational hazards; *NBSIR 79-1937*.
- Scales; specifications; taximeters; tolerances; volume-measuring devices; weighing devices; weights; length-measuring devices; liquid-measuring devices; measures; *H44*, *1980 Edition*.
- Scaling laws; Burnett method; coexistence curve; critical exponents; critical isochore; critical parameters; equation of state; ethylene; impurities; isochores; *19894*.
- Scaling parameter; transport mean free path; albedo; backscatter; electrons; range; reflection; *19391*.
- Scaling theory; solids; Van Vleck susceptibility; anomalous behavior; frequency shifts; hydrostatic pressure; Knight shift; *19925*.
- Scandium energy levels; atomic energy levels; atomic spectra; *JPCRD 9*, No. 2, 473-512 (1980).
- Scanning acoustic microscope; scanning electron microscope; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; *SP400-45*.
- Scanning electron microscope; semiconductor technology; filar eyepiece; image-shearing eyepiece; integrated circuits; linewidth measurements; microelectronics; micrometrology; optical microscope; photoelectric microscope; photomask; *SP400-43*.
- Scanning electron microscope; electroforming; electroplating; micrometer scale; *19833*.
- Scanning electron microscope; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; *SP400-45*.
- Scanning electron microscope; silicon (Li) detector; spectral artifacts; x-ray spectrometry; analytical electron microscope; energy dispersive x-ray spectrometry; *19631*.
- Scanning electron microscope; spectral artifacts; transmission electron microscopy; electron probe microanalysis; energy dispersive x-ray spectrometry; microanalysis; qualitative analysis; quantitative analysis; *19088*.
- Scanning electron microscopy; transmission electron microscopy; wear; abrasive wear; copper; erosive wear; *19958*.
- Scanning electron microscopy; x-ray microanalysis; aluminum wiring; duplex connectors; high resistance junctions; junction resistance; *J. Res. 85*, No. 6, 429-440 (Nov.-Dec. 1980).
- Scattered gamma radiation; XRF analysis. <sup>252</sup>Cf; metal exploration; natural gamma radiation; neutron activation analysis; neutron inelastic scattering; nuclear cross sections; nuclear reactors; radiative neutron capture; *SP594*, pp. 615-626 (Sept. 1980).
- Scattering; angular distribution; computer programs; corrections; energy distribution; finite geometry; Monte Carlo method; multiple scattering; neutron; *SP594*, pp. 504-508 (Sept. 1980).
- Scattering; thallium iodide; antireflective coating; deposition technique; environmental stability; masking layer; potassium chloride window; *SP568*, pp. 355-357 (July 1980).
- Scattering in a laser field; stimulated bremsstrahlung; multiphoton transitions; *19227*.
- Scatter tables; hashing; resource allocation; *19242*.
- Scheduling policies; simulation model; system performance; workloads; cumulative distribution function; events; hardware configuration; model validation; queue; *SP500-65*, pp. 111-128 (Oct. 1980).
- Scheelite; brannerite; cerium niobate; cerium tantalate; cerium titanate; crystal chemistry; crystallography; fergusonite; *19676*.
- Scheelite; thermogravimetric analysis; cerium niobate; cerium tantalate; fergusonite; oxidation-reduction; *19638*.
- Scheffe, design; spline; volume; calibration curve; experiments; finite elements; *J. Res. 85*, No. 4, 295-304 (July-Aug. 1980).
- Schema; simulation modeling; CODASYL; data base; data base management systems; data description language; data manipulation language; performance evaluation; *SP500-65*, pp. 3-10



(Oct. 1980).

Schladitz whiskers; carbon; cementite; hyperfine fields; iron fibers; magnetism; Mossbauer effect; 19253.

Schools; smoke; evacuation; fire departments; fire investigations; flashover; *NBS-GCR-80-237*.

Schottky-barrier diodes; semiconductor diodes; standing-wave ratio (SWR); conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; measurement uncertainties; microwave mixer diodes; modulation; point-contact diodes; reflectometer; return loss; *SP400-16*.

Schottky-barrier diodes; voltage comparator; wideband comparator; linear voltage response; rf voltage comparator; 19544.

Schottky diode bridge; time controlled sampling; diode bridge sampling gates; diode bridge switches; diode clipping circuits; diode shunt limiters; *TN1121*.

Scientific computation; computer; instrumentation; laboratory automation; 19133.

Scientific computing engineering; software; standards; data processing; Federal Information Processing Standard; FORTRAN; numeric methods; programming language; *FIPS PUB 69*.

Scientific uncertainty; societal decisions; socioscientific problems; theory; time constants; basic research; challenge to the analytical chemist; chemical measurement process; energy; environment; health; modelling; 19666.

Scintillation counting; solgel; inorganic radiochemical; liquid scintillator; radioactivity; sample preparation; 19817.

Screen evaluations; sensitivity of screens; spectroradiometry of screens; x-radiation of intensifier screens; fluorescent screens; intensifier screen standards; radiographic intensifier screen efficiency; 19234.

SEC regulations; venture capital; capital asset; capital market; market model; pricing model; *Monogr. 166*.

SEM; stylus; surface; surface roughness; surface texture; metrology; profilometer; razor blade; 19064.

SEM; thickness measurement; video waveform; gold coating cross section; magnification calibration; 19859.

Seal; tamper; unattended safeguards system; safeguards instrument; *SP582*, pp. 257-260 (June 1980).

Seasonal cost of operation; add-on heat pumps; furnaces; heat pumps; hybrid heat pumps; hybrid systems; rating procedure; *NBSIR 80-2090*.

Seasonal performance; test method; central air conditioners; central heating equipment; heating seasonal performance; heat pumps; rating procedure; residential heating; *NBSIR 80-2002*.

Secondary charged particles; tissue-equivalent gas; dosimetry; energy per ion pair; kerma; neutrons; 19331.

Secondary ion mass spectrometry; sensitivity factors; sputtering; surface analysis; local thermal equilibrium model; microanalysis; 19642.

Secondary ion mass spectrometry; sputtering; surface analysis; ion microprobe mass analysis; microanalysis; quantitative analysis; 19532.

Secondary ion mass spectrometry; surface analysis; glasses; ion microprobe mass analysis; microanalysis; quantitative analysis; 19869.

Secondary ion mass spectrometry; surface analysis; ion microanalysis; ion microprobe; microanalysis; quantitative analysis; 19643.

Secondary ion mass spectrometry; surface analysis; ion probe microanalysis; local thermal equilibrium model; microanalysis; relative elemental sensitivity factors; 19151.

Secondary-ion mass spectroscopy; surface analysis; x-ray photoelectron spectroscopy; Auger-electron spectroscopy; ion-scattering spectroscopy; quantitative analysis; 19293.

Secondary radiation; multiplicity spectrum; neutron cross section; *SP594*, pp. 521-523 (Sept. 1980).

Secondary standards; signs; symbols; antifouling coating; communication; gamma-ray measurement; human serum; industrial development; industrial furnace; measurement; polarized electrons; *DIM/NBS 64*, No. 2, 1-36 (1980).

Secondary temperature fixed point; thermometry; defining temperature fixed point; gallium; gallium melting-point temperature; gallium triple-point temperature; 19058.

Second breakdown; semiconductors; test structures; thermal resistance; very large scale integration; VLSI; wire bonds; Department of Commerce; integrated circuits; metrology for semiconductors; National Bureau of Standards; photomasking; resistivity; *NBSIR 80-2057*.

Second breakdown, reverse-bias; transistor, power; turn-off, transistor; focusing, current; measurement, nondestructive; 19161.

Second Law of Thermodynamics; system efficiency; availability analysis; energy; energy conservation; process efficiency; *TN1115*.

Second sound; shock wave profile; thermal relaxation; argon; computer simulation; Lennard-Jones potential; liquid; molecular dynamics non-equilibrium processes; 19487.

Second virial; state-of-the-art; temperature; Burnett PVT measurements; coefficient; ethylene; 19115.

Security; audit-in-depth; auditing; auditing aids; internal controls; *SP500-65*, pp. 23-32 (Oct. 1980).

Security; design methodology; formal specification; formal verification; hierarchical design; programming methodology; *SP500-67*.

Security controls; system life cycle; system security; ADP availability; ADP security; application system security; computer applications; computer reliability; computer security; data confidentiality; data integrity; data security; *FIPS PUB 73*.

Security systems; sensory processes; cognitive processes; nuclear weapon theft; perceptual processes; psychological deterrence; *NBSIR 80-2038*.

Security violations; SMF retrieval; audit trails; computer fraud; computer security; job tracking; *SP500-65*, pp. 33-46 (Oct. 1980).

Segmented polyurethane; time dependent failure; urethane-silicone copolymer; biomaterials; blood pump materials; butyl rubber; elastomers; polyolefin rubber; *NBSIR 80-2008*.

Segregation; standard; calibration; environments; homogeneity; natural materials; nondestructive assay; particles; quality assurance; radiation; radioactivity; radiochemical assay; radionuclide; 19298.

Seismicity; structural engineering; bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; *SP592*.

Seismology; standards; storm surge; structural engineering; structural response; tsunamis; wind loads; winds; accelerograph; codes; design criteria; disaster; earthquakes; ground motion; *SP560*.

Selected transition probabilities; atomic oscillator strengths; compact tabulation; critical evaluation; hydrogen through iron; 19824.

Selection; service; analysis; computer; evaluation; Federal Information Processing Standards Publication; measurement; performance; remote batch; *FIPS PUB 72*.

Selection methodology; binary selection; computer comparison; computer measurement; computer service; data analysis; performance evaluation; ranking and selection; *SP500-58*.

Selection of thermoluminescence dosimetry system; survey; thermoluminescence; United States; calibration; dosimetry; high-energy bremsstrahlung; operational characteristics; radiation therapy; recommendations; *TN1119*.

Selective coupling; 6-amino-6-deoxy-D-galactose-6-<sup>15</sup>N derivatives; carbon-13 n.m.r.; nitrogen-15 coupling constants; nucleophilic substitution; paramagnetic broadening; proton n.m.r.; 19670.

Self broadening; theoretical and experimental comparisons; low pressures; noble gas broadening; O<sub>2</sub> microwave spectrum; pressure broadening; 19721.

Self broadening; Van der Waals type wing; Lorentzian type wing; quasistatic wing; 19776.



Self-broadening of alkali lines; asymmetries; quasistatic wings; resonance lines; 19228.

Self-discharge; battery; microcalorimeter; pacemaker; power cell; *J. Res.* 85, No. 3, 193-203 (May-June 1980).

Self-entanglement effects; computer simulation; end-to-end length; entanglement effects; excluded volume effects; lattice-model polymer chains; polymer chain dynamics; random-coil polymer chains; relaxation times; 19864.

Self-focusing; Abbe value; coolant; index-matching liquids; nonlinear refractive index; *SP568*, pp. 91-98 (July 1980).

Self-focusing; spot size dependence; alkali halides; intrinsic damage; IR windows; laser damage; *SP568*, pp. 497-517 (July 1980).

Self-focusing; stimulated Brillouin scattering (SBS); damage morphology; damage thresholds; laser bulk damage; laser surface damage; optical materials; *SP568*, pp. 519-527 (July 1980).

Self-indication; self-shielding and fission factors; time-of-flight; He proportional counter; fission chamber; *SP594*, pp. 692-697 (Sept. 1980).

Self-shielding and fission factors; time-of-flight; He proportional counter; fission chamber; self-indication; *SP594*, pp. 692-697 (Sept. 1980).

Self-shielding factors; spherical model; transport theory  $k_{eff}$ ; diffusion theory; *SP594*, pp. 187-189 (Sept. 1980).

Semantics; TDMS; tree; tree structures; ambiguity; Boolean; database; hierarchical; information; query; query language; 19433.

Semiautomated pipetting; serum lithium analysis; statistical analysis; accuracy; clinical analysis; clinical chemistry; definitive method; electrolytes; flame atomic absorption spectroscopy; interlaboratory testing; precision; reference method; *SP260-69*.

Semiconductor; silicon; spreading resistance; two probe measurements; dopant profiles; resistivity; resistivity profiles; 19105.

Semiconductor; tape bonded devices; acoustic emission; beam lead devices; electronic devices; hermeticity; hybrids; nondestructive tests; 19108.

Semiconductor detector efficiency; standards; detector efficiency; gamma-ray efficiency; Marinelli beaker; Reentrant beaker; 19408.

Semiconductor device packages; back pressurization hermetic test; helium mass spectrometer leak test; hermeticity; hybrid microcircuits; leak testing; 19821.

Semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; deep level transient spectroscopy; *SP400-45*.

Semiconductor devices; semiconductor materials; semiconductor process control; silicon; electronics; integrated circuits; measurement technology; microelectronics; *NBSIR 80-2006*.

Semiconductor devices; semiconductor materials; semiconductor processing; semiconductor technology; silicon; 19213.

Semiconductor devices; very large scale integration; x-ray lithography; electron-beam lithography; metal-oxide-semiconductor device; process-induced radiation damage; radiation damage; 19162.

Semiconductor diodes; standing-wave ratio (SWR); conversion loss; diode measurement; intermediate-frequency (i-f) output conductance; measurement uncertainties; microwave mixer diodes; modulation; point-contact diodes; reflectometer; return loss; Schottky-barrier diodes; *SP400-16*.

Semiconductor industry; technological change; competition; Experimental Technology Incentives Program; government policy; innovation; *NBS-GCR-ETIP 80-91*.

Semiconductor mass analysis; field evaporation; molecular ions; 19917.

Semiconductor materials; semiconductor process control; silicon; electronics; integrated circuits; measurement technology; microelectronics; semiconductor devices; *NBSIR 80-2006*.

Semiconductor materials; semiconductor process control; silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; deep level transient spectroscopy; electrical properties; electronics; *SP400-45*.

Semiconductor materials; semiconductor processing; semiconductor technology; silicon; semiconductor devices; 19213.

Semiconductor materials; sensitivity; trace element analysis; accuracy; analytical methods; microanalysis; 19314.

Semiconductor measurements; sheet resistance; solar cell; solar cell measurements; solar cell stability; device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; *NBSIR 80-2027*.

Semiconductor measurements; sheet resistance; solar cells; cell cracks; device measurements; laser scanning; light biasing; metallization; ohmic contacts; reliability; 19435.

Semiconductor process control; silicon; electronics; integrated circuits; measurement technology; microelectronics; semiconductor devices; semiconductor materials; *NBSIR 80-2006*.

Semiconductor process control; silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; deep level transient spectroscopy; electrical properties; electronics; *SP400-45*.

Semiconductor processing; semiconductor technology; silicon; semiconductor devices; semiconductor materials; 19213.

Semiconductors; dimensional metrology; electronics; integrated circuits; materials characterization; microelectronics; 19109.

Semiconductors; dimensional metrology; electronics; integrated circuits; materials characterization; measurement methods; microelectronics; microstructures; *SP400-61*.

Semiconductors; silicon; dopant density; electrical measurements; mobility; resistivity; 19806.

Semiconductors; silicon; dopant density; electrical measurements; mobility; resistivity; 19783.

Semiconductors; silicon; electrical measurements; Hall measurements; 19415.

Semiconductors; silicon; vacancies; Brownian motion; diffusion; Fick's Law; Fokker-Planck equation; process modeling; 19726.

Semiconductors; stress; zinc-blende structure; covalent bonding; diamond structure; elastic constants; gallium arsenide; indium antimonide; ionicity; optical phonons; Raman scattering; 19580.

Semiconductors; surge arresters; varistors; voltage-variable resistors; zinc oxide; electrically conducting ceramics; electrical transmission; lightning arresters; nonlinear resistors; *NBSIR 79-1939*.

Semiconductors; test structures; thermal resistance; very large scale integration; VLSI; wire bonds; Department of Commerce; integrated circuits; metrology for semiconductors; National Bureau of Standards; photomasking; resistivity; second breakdown; *NBSIR 80-2057*.

Semiconductor technology; filar eyepiece; image-shearing eyepiece; integrated circuits; linewidth measurements; microelectronics; micrometrology; optical microscope; photoelectric microscope; photomask; scanning electron microscope; *SP400-43*.

Semiconductor technology; silicon; semiconductor devices; semiconductor materials; semiconductor processing; 19213.

Semicrystalline polymers; sorption; diffusivity; elastic deformation; fractional free volume; permeability; plastic deformation; 19662.

Semi-dynamic material control; diversion sensitivity; reprocessing facilities; *SP582*, pp. 730-739 (June 1980).

Semiempirical model; excitation functions  $E = 5-80$  MeV; nuclear reactions; *SP594*, pp. 778-782 (Sept. 1980).

Seminars; State/local; training; inspectors; laboratory; metrology; 19438.

Senior citizens; smoke; breathing apparatus; evacuation; fire departments; fire fatalities; flashover; hotels; room fires; *NBS-GCR-80-253*.



Sense information; status byte; command codes; disk drives; Federal Information Processing Standard; format track; operational specification; rotating mass storage subsystems; *FIPS PUB 63*.

Sensitivity; standards; ultrasonics; calibration; image quality indicator; nondestructive testing; radiography; 19877.

Sensitivity; trace element analysis; accuracy; analytical methods; microanalysis; semiconductor materials; 19314.

Sensitivity; ultrasonic inspection; coupling; magnetic inspection; nondestructive testing; pulsed mode; rail test car; railroad rail; 19885.

Sensitivity analysis; assessment; documentation; energy; forecasting; mathematical models; *NBSIR 80-2128*.

Sensitivity analysis; capture cross section of pseudo fission product; fission products kinetics; ratio  $^{134}\text{Cs}/^{137}\text{Cs}$ ; residual decay heat; *SP594*, pp. 886-889 (Sept. 1980).

Sensitivity analysis; material balance declaration; measurement error sources; *SP582*, pp. 690-701 (June 1980).

Sensitivity analysis; separation standard; vertical error; vertical overlap; air safety; collision probability; probability distribution; *NBSIR 80-1990*.

Sensitivity analysis; shielding application; structural material; total cross section; unresolved resonance; elastic scattering cross section; partial inelastic scattering cross section; resonance self-shielding effect; *SP594*, pp. 586-590 (Sept. 1980).

Sensitivity analysis; simultaneous equations; Box-Jenkins; forecasting; multiple regression; *SP500-65*, pp. 215-229 (Oct. 1980).

Sensitivity analysis; uncertainty analysis; breeding ratio; calculational bias uncertainties; fast reactors; group cross sections; integral experiments; least-squares adjustment; *LMFBR; SP594*, pp. 177-181 (Sept. 1980).

Sensitivity analysis; validation; assessment; documentation; econometric models; energy modeling forum; energy models; evaluation; mathematical models; model access; model management; *SP569*.

Sensitivity change; stability; strain gages; structure; transducers; zero shift; adhesive; backing; connection; environment; gage element; leads; load; protective coating; resistance; 19049.

Sensitivity coefficient; time-of-flight; transport calculation; group constants; neutron spectrum; *SP594*, pp. 265-274 (Sept. 1980).

Sensitivity factors; sputtering; surface analysis; local thermal equilibrium model; microanalysis; secondary ion mass spectrometry; 19642.

Sensitivity of screens; spectroradiometry of screens; x-radiation of intensifier screens; fluorescent screens; intensifier screen standards; radiographic intensifier screen efficiency; screen evaluations; 19234.

Sensitometry; Van Kreveld's law; exposure; exposure modeling; photolysis kinetics; photoresist; 19801.

Sensory environment; social sciences; thermal environment; architecture; audition; built environment; color; environmental psychology; illumination; perception; questionnaires; research methodology; *SP474*.

Sensory feedback; vision system; line following; part acquisition; plane of light; real time; robot; 19096.

Sensory processes; cognitive processes; nuclear weapon theft; perceptual processes; psychological deterrence; security systems; *NBSIR 80-2038*.

Separation; solvent extraction; activation analysis; cadmium; mercury; radiochemical; 19283.

Separation standard; vertical error; vertical overlap; air safety; collision probability; probability distribution; sensitivity analysis; *NBSIR 80-1990*.

Sequence of events; Three Mile Island; China syndrome myth; hydrogen bubble myth; reactor cooling; reactor safety system; *SP594*, pp. 916-919 (Sept. 1980).

Sequential simplex procedure; x-ray spectra; computer program; fitting Gaussian profiles; incomplete charge collection; lithium-drifted silicon detector; 19130.

Serials; standards; transactions; annual reports; diffusion in metals; fire; journals; library holdings; NBS library; NBS periodicals; periodicals; proceedings; *NBSIR 79-1932*.

Serum; cholesterol; gas chromatography/mass spectrometry; isotope dilution; 19899.

Serum density; specific gravity of blood and serum; blood density; 19558.

Serum lithium analysis; statistical analysis; accuracy; clinical analysis; clinical chemistry; definitive method; electrolytes; flame atomic absorption spectroscopy; interlaboratory testing; precision; reference method; semiautomated pipetting; *SP260-69*.

Service; analysis; computer; evaluation; Federal Information Processing Standards Publication; measurement; performance; remote batch; selection; *FIPS PUB 72*.

Service specification transport protocol; verification; alternating bit protocol; communication protocol; file transfer protocol; protocol specification; readability analysis; *NBS-GCR-80-281*.

Session protocol; transport protocols; communication protocols; computer network protocols; feature analysis; network architecture; networking; *NBS-GCR-80-245*.

Session protocols; transport protocols; communication protocols; computer network protocols; network architecture; networking; protocol design specification; *NBS-GCR-80-289*.

Session protocols; transport protocols; communication protocols; computer network protocols; design specification; formal specification; network architecture; networking; *NBS-GCR-80-246*.

Settling velocity; Stokes law velocity; vibrating orifice aerosol generator; aerosol size calibrations; optical particle counter; particle Doppler shift spectrometer; particle size distribution; 19171.

SF<sub>6</sub>; SF<sub>6</sub>-N<sub>2</sub> mixtures; corona; partial-discharge; point-plane electrodes; pulse height distributions; 19785.

SF<sub>6</sub>; 20 microK thermostat; comparison with He<sup>3</sup>, Ne; critical anomaly; dielectric constant; differential capacitance cell; 19484.

SF<sub>6</sub>-N<sub>2</sub> mixtures; corona; partial-discharge; point-plane electrodes; pulse height distributions; SF<sub>6</sub>; 19785.

Shale oil; SRM; weights and measures; x-ray exams; compact range; data; daylighting; energy; environmental; *DIM/NBS 64*, No. 6, 1-24 (1980).

Shale oil; trace organic analysis; gas chromatography; liquid chromatography; mass spectrometry; quantitation; 19598.

Shape evaluation; alpha counting; normalization uncertainties; *SP594*, pp. 483-487 (Sept. 1980).

Shape resonance; synchrotron radiation; angle resolved photoemission; angular distributions; carbon monoxide; CO; photoelectron spectra; photoionization; 19559.

Shape resonance; synchrotron radiation; vibrational intensity distribution; branching ratios; Franck-Condon factors; ion; nitrogen; N<sub>2</sub>; photoelectron spectra; photoionization; 19607.

Shape resonance; synchrotron radiation; vibrational intensity distribution; carbon monoxide; CO; Franck-Condon factors; ion; photoelectron spectra; photoionization; 19184.

Shared resources; input/output system; *SP500-65*, pp. 157-163 (Oct. 1980).

Shear; bulk modulus; compressibility; finite elasticity; modulus; rubber; 19886.

Shear-bond strength; simulated geothermal fluids; geothermal-well cements; high pressure vessel; high temperature furnace; permeability; *NBSIR 80-2099-3*.

Shear-bond strength to steel; splitting tensile strength; compressive strength; exposure to geothermal fluids; geothermal-well cements; permeability to water; *NBSIR 80-2099-2*.

Shear modulus; sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; physical-property variability; Poisson's ratio; 19246.

Shear (S) mode; ultrasonic diffraction; welds; compressional (P) modes; cracks; defect characterization; dimensioning; one-transducer technique; *NBSIR 80-1983*.



- Shear stresses; BKZ theory; mechanical conditioning; nonlinear viscoelasticity; normal stresses; poly(methyl methacrylate); 19707.
- Sheet and chain silicates; mineralogy; Raman microprobe; Raman spectroscopy; 19590.
- Sheet resistance; solar cell; solar cell measurements; solar cell stability; device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; *NBSIR 80-2027*.
- Sheet resistance; solar cells; cell cracks; device measurements; laser scanning; light biasing; metallization; ohmic contacts; reliability; semiconductor measurements; 19435.
- Sheet resistance; spreading resistance; correction factor; depth profiling; Laplace's equation; local slope analysis; multilayer analysis; resistivity; 19703.
- Sheet resistor; test methods; test pattern; test structure; circuit characterization; cross-bridge sheet resistor; electrical alignment test structure; gated diode; integrated test structure; microelectronic test structure; process validation wafer; random fault test structure; 19165.
- Sheets; spheres; type II diffusion; diffusivity; glass-gel boundary; 19668.
- Sheet type structure; symmetric hydrogen bonds; calcium ammonium phosphate; calcium phosphate; crystal structure; 19386.
- Shell; collapse; concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; *NBSIR 78-1578*.
- Shielding; bias factors; neutron transport; *SP594*, pp. 275-284 (Sept. 1980).
- Shielding; fusion; neutral beam injection; neutrons; nuclear heating; photon dose rate; photons; *SP594*, pp. 239-245 (Sept. 1980).
- Shielding; spacecraft; bremsstrahlung; dose; electrons; proton; 19226.
- Shielding application; structural material; total cross section; unresolved resonance; elastic scattering cross section; partial inelastic scattering cross section; resonance self-shielding effect; sensitivity analysis; *SP594*, pp. 586-590 (Sept. 1980).
- Shipboard fires; cost benefit analysis; cost effectiveness; fire departments; fire losses; fire models; fire protection; marine transportation; merchant vessels; *NBS-GCR-79-173*.
- Shish kebabs; crystallization theory flow induced crystallization; extended chain fibrils; polymer crystallization; 19167.
- Shock deformation; Tishomingo meteorite; x-ray diffraction; electron microscopy; Fe-Ni alloys; martensite; 19947.
- Shock tube; 1-hexene; allylic resonance energy; allyl radicals; biradical; cyclohexane; decomposition; decyclization; isomerization; olefins; 19784.
- Shock wave profile; thermal relaxation; argon; computer simulation; Lennard-Jones potential; liquid; molecular dynamics non-equilibrium processes; second sound; 19487.
- Shoring; slope stability; construction; excavation; geotechnical engineering; retaining structures; *NBS-GCR-80-202*.
- Shoring; slope stability; soil classification; soil pressure; soil testing; trenching; braced excavations; construction; excavation; geotechnical engineering; retaining structures; *BSS121*.
- Shoring; slope stability; soil classification; soil pressure; standards; trenching; braced excavation; construction; retaining structures; *BSS127*.
- Shoring; softwood; timber engineering; trench bracing; trenching; construction lumber; construction safety; excavation; hardwood; lumber grading; *BSS122*.
- Shoring; soil classification; trench; workshop; acceptable work practices; excavation; geotechnical engineering; safety; *NBSIR 79-1935*.
- Shoring; trenching; construction practices; construction safety; excavation; *NBSIR 79-1936*.
- Shoring; trenching; construction safety; construction standards; excavation; safety regulations; *NBSIR 80-1988*.
- Shredded and slit films; solids; sparks; test methods; Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; *NBSIR 78-1580*.
- Shunt reactors; bridges; calibration; current comparator; dissipation factor; electrical measurements; energy loss; 19767.
- SI; base units; convention of the meter; economic benefits; epistemology; measurement system; metric system; 19639.
- SI; standards; units; measurements; metric; metrology; 19628.
- SI; standards; units; measurements; metric; metrology; 19868.
- SI units; standard reference materials; traceability; definitive methods; measurement compatibility; protocol; reference methods; *SP582*, pp. 15-24 (June 1980).
- SI units for building; convenient values; metric conversion; preferred dimensions; preferred values; 19519.
- SiC substrates; surface defects; thermal diffusivity; vapor-deposited mirrors; crystalline disorder; Cu mirrors; diamond turning; laser-induced slip; polishing; ripples; *SP568*, pp. 175-186 (July 1980).
- Side grooves; three-dimensional crack; torsional beam; compliance analysis; curved crack profile; double-torsion testing; fracture (materials); fracture toughness; 19693.
- Side grooves; three-dimensional crack; torsional beam; compliance analysis; curved crack profile; double-torsion testing; fracture (materials); fracture toughness; 19684.
- Signal processing; tomography; ultrasonics; automated testing; continuous monitoring; nondestructive testing; radiography; 19475.
- Signal processing; waves; microwave systems; transmission-line theory; 19367.
- Signs; standardization; symbols; visual alerting; fire fighting; fire safety; pictograms; safety; 19274.
- Signs; symbols; antifouling coating; communication; gamma-ray measurement; human serum; industrial development; industrial furnace; measurement; polarized electrons; secondary standards; *DIM/NBS 64*, No. 2, 1-36 (1980).
- Silicates; coal slag; conductivity; electrical; electrical conductivity; ferric; ferric/ferrous ratio; ferrous; ionic; ionic conductivity; magnetohydrodynamics iron; MHD; 19576.
- Silicon; capacitance-voltage profiling; damage effects; electrical activation of implanted impurities; ion implantation; laser annealing; 19724.
- Silicon; carrier density; computer program; electrical properties of silicon; Hall effect; mobility; resistivity; *SP400-63*.
- Silicon; dopant density; electrical measurements; mobility; resistivity; semiconductors; 19806.
- Silicon; dopant density; electrical measurements; mobility; resistivity; semiconductors; 19783.
- Silicon; electrical measurements; Hall measurements; semiconductors; 19415.
- Silicon; electronics; integrated circuits; measurement technology; microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; *NBSIR 80-2006*.
- Silicon; field ion microscopy; photoillumination effect; 19210.
- Silicon; Hall effect; junction C-V measurements; neutron activation analysis; phosphorus density; photometric technique; 19431.
- Silicon; semiconductor devices; semiconductor materials; semiconductor processing; semiconductor technology; 19213.
- Silicon; silicon carbide; aluminumoxide; brittle fracture; dislocations; electron microscopy; erosion; germanium; hardness measurements; plastic deformation; 19731.
- Silicon; silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; deep level transient spectroscopy; electrical properties; electronics; electron irradiation. hole mobility; *SP400-45*.
- Silicon; silicon photodetector; spectral response; visible; quantum efficiency; quantum yield; 19646.
- Silicon; spreading resistance; thyristor; aluminum-doped silicon; boron-doped silicon; gallium-doped silicon; p-type silicon; resistivity; 19422.
- Silicon; spreading resistance; two probe measurements; dopant profiles; resistivity; resistivity profiles; semiconductor; 19105.



- Silicon; spreading resistance measurements; thermally stimulated measurements; thyristor materials measurements; thyristor measurements; zinc oxide varistors; dc transmission; deep-level measurements; energy conservation; measurement methods; *NBSIR 80-2061*.
- Silicon; stability; crystal; Czochralski; edge-defined film-fed growth (EFG); floating zone; meniscus; *19945*.
- Silicon; sulfur; thermally stimulated measurements; dynathermal capacitance responses; dynathermal current response; isotopes; *19163*.
- Silicon; temperature coefficient of refractive index; germanium; optical constants; refractive index; *JPCRD 9*, No. 3, 561-658 (1980).
- Silicon; thermally stimulated measurements; interface states; measurement interferences; mobile ions; MOS capacitor; *19166*.
- Silicon; thyristors; defects; neutron transmutation doping; power device materials; radiation damage; *SP400-60*.
- Silicon; vacancies; Brownian motion; diffusion; Fick's Law; Fokker-Planck equation; process modeling; semiconductors; *19726*.
- Silicon analysis; size exclusion chromatography; tin analysis; fractionation; graphite furnace atomic absorption; high pressure liquid chromatography; organometallic polymers; organotin silicate; refractive index; reverse bonded phase chromatography; *19398*.
- Silicon carbide; aluminumoxide; brittle fracture; dislocations; electron microscopy; erosion; germanium; hardness measurements; plastic deformation; silicon; *19731*.
- Silicon cell; solar cell; spectral response; radiometry; *19669*.
- Silicon dioxide; spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; deep level transient spectroscopy; electrical properties; electronics; electron irradiation. hole mobility; integrated circuits; *SP400-45*.
- Silicon (Li) detector; spectral artifacts; x-ray spectrometry; analytical electron microscope; energy dispersive x-ray spectrometry; scanning electron microscope; *19631*.
- Silicon monoxide; thorium fluoride; zinc selenide; zinc sulfide; absorption; coatings; internal reflectance spectroscopy; *SP568*, pp. 247-256 (July 1980).
- Silicon nitride; strength; ceramic turbines; failure prediction; fracture; oxidation; *19792*.
- Silicon nitride; yttria-doped silicon nitride; ceramic; high voltage electron microscopy; *in situ*; oxidation; *19605*.
- Silicon nitride; yttria-doped silicon nitride; ceramic; high voltage electron microscopy; *in situ*; oxidation; *NBSIR 80-2075*.
- Silicon on sapphire; surface roughness; ultraviolet reflectance; work damage; infrared reflectance; optical reflectance; polishing; *SP400-62*.
- Silicon photodetector; spectral response; visible; quantum efficiency; quantum yield; silicon; *19646*.
- Silicon photodetector; storage ring; synchrotron radiation; radiometry; *19935*.
- Silicon photodiode; spectroradiometry; absolute spectral response; laser power measurement; photodetector; radiant power measurement; radiometry; *19354*.
- Silicon photodiode; surface recombination; collection efficiency; quantum efficiency; *19738*.
- Silicon photodiodes; cleaning; dirt films; reflectance; *19675*.
- Silicon photovoltaic; specific adsorption; radiometric measurements; *19955*.
- Silver; coulometer; coulometry; electrochemistry; Faraday constant; *19472*.
- Silver; coulometry; electrochemical equivalent; electrochemistry; Faraday; fundamental constants; *J. Res. 85*, No. 3, 175-191 (May-June 1980).
- Silver alloys; copper alloys; corrosion behavior; creep properties; dental amalgam; manganese alloys; marginal stability; *19247*.
- Silver nitrate; aromatic hydrocarbons; gas-solid chromatography; *19913*.
- Similarity principle; crystal; double-diffusive convection; floating zone; materials processing; microgravity; morphological stability; *19178*.
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- Simulated geothermal fluids; geothermal-well cements; high pressure vessel; high temperature furnace; permeability; shear-bond strength; *NBSIR 80-2099-3*.
- Simulated paint films; chromates; coated metals; corrosion inhibitor; corrosion mechanisms; ellipsometry; *19659*.
- Simulation; apparatus spectrum; data library; fission products; full energy peak; gamma-ray spectrum; multiplets; optimization; peak/Compton ratio; *SP594*, pp. 878-880 (Sept. 1980).
- Simulation; building codes; building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; *SP586*, pp. 205-224 (June 1980).
- Simulation; bus networks; bus performance; computer programs; contention; CSMA; GPSS; local area networks; packet switching; *SP500-65*, pp. 79-85 (Oct. 1980).
- Simulation; statistics; sunspots; ARMA models; forecasts; Maunder minimum, models; *TN1022*.
- Simulation; workload definition; benchmarking; capacity planning; computer performance evaluation; computer performance measurement; computer performance prediction; computer system acquisition; CPE in auditing; installation management; on-line system evaluation; *SP500-65*.
- Simulation model; system performance; workloads; cumulative distribution function; events; hardware configuration; model validation; queue; scheduling policies; *SP500-65*, pp. 111-128 (Oct. 1980).
- Simulation modeling; CODASYL; data base; data base management systems; data description language; data manipulation language; performance evaluation; schema; *SP500-65*, pp. 3-10 (Oct. 1980).
- Simulation of human behavior; architectural research; building fires; computer-aided design; environmental psychology; fire research; fire safety; human behavior in fires; modeling technique; programming; *NBSIR 80-1982*.
- Simulation sampling errors; wind loads; climatological sampling errors; hurricanes; *19549*.
- Simultaneous equations; Box-Jenkins; forecasting; multiple regression; sensitivity analysis; *SP500-65*, pp. 215-229 (Oct. 1980).
- Simultaneous evaluation; absolute measurement; consistency; fission cross section; JENDL-2; nuclear data; optical potential parameter; relative measurement; *SP594*, pp. 715-719 (Sept. 1980).
- Single chain scattering form factor; small angle neutron scattering; concentrated solution; interchain interference; polyisoprene; radius of gyration; *19355*.
- Single crystal; carbide; carbon; catalysis; kinetics; methanation; nickel; *19480*.
- Single crystal; carbon; catalysis; hydrogenation; kinetics; methanation; ruthenium; *19492*.
- Single crystal; interstitials; sodium beta alumina; internal friction; ionic transport mechanism; sodium ion; *19442*.
- Single-crystal; structure refinement; x-ray diffraction; bond delocalized dianion; oxocarbon; *J. Res. 85*, No. 2, 87-97 (Mar.-Apr. 1980).
- Single crystal; surface science; carbon monoxide; catalysis; kinetics methanation; nickel; ruthenium; *19482*.
- Single crystal; ternary metal sulfide; x-ray diffraction; [Et<sub>3</sub>P]<sub>2</sub>PtWS<sub>4</sub>; molecular structure; Pt-W complex; *19172*.
- Single crystal; total cross section; Si(n,n); *SP594*, pp. 86-88 (Sept. 1980).
- Single-crystal; Weissenberg methods; x rays; absorption correction; diffractometers; flat-cone; macromolecules; neutrons; *19509*.
- Single crystal copper; copper crystal; fatigue; persistent slip



band; plastic strain; random cycling; 19694.

Single-crystal methods; twinning; critical evaluation; derivative lattices; indexing; lattice relationships; lattices; 19804.

Single crystal x-ray diffraction; standard test; urea complex; urea in sera; crystal structure; molecular structure; *J. Res.* **85**, No. 3, 205-210 (May-June 1980).

Single crystal x-ray diffraction; synthesis; *cis*-4-phenylcyclophosphamide; cyclophosphamide analogs; *in vivo* anticancer activity; molecular structure determination; 19829.

Single-level analysis; Zr(n,total) cross section; *SP594*, pp. 319-322 (Sept. 1980).

Single longitudinal mode pulse; TEA laser; beam diameter; insertion loss; optical detectors; photon drag detector; pyroelectric detector; responsivity; *TN1023*.

Single vibronic level spectroscopy; CF<sub>2</sub>; difluorocarbene; fluorescence excitation spectroscopy; Franck-Condon factors; laser excited fluorescence; radiative lifetime; 19371.

Singular perturbation problems; cell Reynolds number; diffusion convection equations; error estimates; higher order finite difference methods; numerical experiments; parabolic equations; 19490.

Si(n,n); single crystal; total cross section; *SP594*, pp. 86-88 (Sept. 1980).

Site selection; condensed phase; emission; laser absorption; molecules; 19111.

Site visit; accreditation; accreditation committee; American Industrial Hygiene Association; coordinator; industrial hygiene laboratories; laboratory; PAT; performance; personnel; proficient; quality control; reaccreditation; *SP591*, pp. 67-70 (Aug. 1980).

Six-port; automatic network analyzer; calibration; microwave; microwave measurements; 19303.

Six-port; automatic network analyzer; microwave measurements; 19564.

Size effect; solid mechanics; statistical methods; steel; fatigue; fracture; mathematical modeling; micromechanics; microstructure; nuclear fuel element; paper; quantitative microscopy; 19086.

Size exclusion chromatography; tin analysis; fractionation; graphite furnace atomic absorption; high pressure liquid chromatography; organometallic polymers; organotin silicate; refractive index; reverse bonded phase chromatography; silicon analysis; 19398.

Slag; three-dimensional flaws; arc strikes; blunt flaws; fracture mechanics; hydrogen-assisted cracking; low-cycle fatigue; porosity; preparing flawed weldments; 19762.

Sleep; smoke detectors; wakefulness; adults; alarm responses; auditory perception; decibel levels; fire departments; frequency distribution; noise (sound); *NBS-GCR-80-284*.

Sliding glass door; test methods; burglary resistance; forced entry; patio door; performance criteria; performance standard; 19702.

Sliding wear; wear; wear models; copper alloys; friction; metallic materials; microstructure; 19826.

Slip bands; statistical aspects of fatigue; striations; composite materials; corrosion fatigue; dislocations; fatigue mechanism; fracture mechanics; mathematical modeling; micromechanics; polymers; quantitative microscopy; 19087.

Slope stability; construction; excavation; geotechnical engineering; retaining structures; shoring; *NBS-GCR-80-202*.

Slope stability; soil classification; soil pressure; soil testing; trenching; braced excavations; construction; excavation; geotechnical engineering; retaining structures; shoring; *BSS121*.

Slope stability; soil classification; soil pressure; standards; trenching; braced excavation; construction; retaining structures; shoring; *BSS127*.

Slow crack growth; surface chemistry; atmosphere-assisted slow crack growth; chemically assisted fracture; fracture; fracture models; reaction rate theory; 19588.

Slow crack growth; surface energy; environmental fracture; fracture; materials failure; reaction rate theory; 19843.

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Slurry analysis; SNM assay; solution analysis; total sampling; x-ray fluorescence analysis; dissolver solution; *SP582*, pp. 547-554 (June 1980).

SMF retrieval; audit trails; computer fraud; computer security; job tracking; security violations; *SP500-65*, pp. 33-46 (Oct. 1980).

Sm; dosimetry; EBR-II; Eu isotopes; integral cross sections; Nd; *SP594*, pp. 557-562 (Sept. 1980).

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Small angle scattering; superconductivity; crystal field; magnetic superconductors; neutron scattering; rare earth; 19255.

Small business; conglomerates; innovation; invention; large corporations; productivity; 19230.

Small-format; x-ray imaging system; <sup>125</sup>I x-ray source; microchannel plate; portable; rare-earth scintillator; 19402.

Small gas proportional and liquid scintillation counters; atmospheric pollutants; figure of merit; low-level counting; natural radiocarbon; 19677.

Small particles; solid solutions; solubility; surfaces; thermodynamics; vapor pressure; interstitials; melting; 19830.

Small polymer crystal; surface free energy; constrained polymer; polymer; polymer in a cone; polymer interference; *J. Res.* **85**, No. 4, 273-282 (July-Aug. 1980).

Smear layer; acid etch; adhesion; coupling agents; dentin; mordants; 19329.

Smoke; apartments; building fires; doors; egress; evacuation; fire departments; fire fighters; fire investigations; mattresses; *NBS-GCR-79-187*.

Smoke; breathing apparatus; evacuation; fire departments; fire fatalities; flashover; hotels; room fires; senior citizens; *NBS-GCR-80-253*.

Smoke; doors; evacuation; fire extinguishers; fire investigations; hospitals; nursing staff; patients; *NBS-GCR-80-231*.

Smoke; doors; fire departments; fire investigations; *NBS-GCR-80-221*.

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Smoke; egress; evacuation; fire alarm systems; fire departments; fire fighters; hospitals; nursing staff; patients; *NBS-GCR-80-192*.

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Smoke; evacuation; fire departments; fire investigations; mattresses; patients; *NBS-GCR-80-266*.

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Smoke; evacuation; fire departments; fire investigations; nursing homes; nursing staff; patients; *NBS-GCR-80-242*.

Smoke; evacuation; fire extinguishers; fire investigations; *NBS-GCR-80-276*.

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Smoke; evacuations; fire alarm systems; fire departments; fire investigations; mattresses; nursing staff; *NBS-GCR-80-268*.

Smoke; fabric flammability; fire departments; fire investigations; *NBS-GCR-80-270*.

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Smoke; smoke detectors; fire departments; fire investigations; hospitals; *NBS-GCR-80-261*.

Smoke; smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; *NBSIR 80-2004*.

Smoke; smoke movement; stairwells; tracers; air movement; elevators; fire tests; hospitals; *NBS-GCR-79-183*.

Smoke; smoldering; bedding; fire departments; fire investigations; hospitals; nursing staff; patients; *NBS-GCR-80-239*.

Smoke; sprinkler systems; evacuation; fire departments; fire extinguishers; fire investigations; hospitals; patients; *NBS-GCR-80-233*.

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Smoke; sprinkler systems; fire alarm systems; fire departments; fire investigations; *NBS-GCR-80-263*.

Smoke; students; doors; dormitories; evacuation; fire departments; fire fatalities; fire fighters; flashover; ladders; room fires; *NBS-GCR-80-193*.

Smoke; symbols; communications; evacuation; fire alarms; fire safety; human behavior; human factors; panic; safety; *NBSIR 80-2070*.

Smoke; upholstered furniture; doors; evacuations; fire departments; fire extinguishers; nursing staff; patients; room fires; *NBS-GCR-80-220*.

Smoke; upholstered furniture; evacuation; fire departments; fire fatalities; fire investigations; flashover; group homes; halfway houses; mental disorders; *NBS-GCR-80-200*.

Smoke detection; automatic sprinklers; building codes; building construction; Delphi Method; fire safety; health care facilities; hospitals; interior finishes; Life Safety Code; nursing homes; risk analysis; safety equivalency; safety evaluation; *NBSIR 78-1555-1*.

Smoke detectors; aerosol generators; aerosols; detector sensitivity; fire detectors; ionization detectors; light scattering detectors; monodisperse aerosols; particle size; photo-electric detectors; *J. Res.* 85, No. 3, 223-238 (May-June 1980).

Smoke detectors; death; doors; egress; evacuation; fire alarm systems; fire departments; fire fighters; flashover; nursing homes; nursing staff; patients; room fires; *NBS-GCR-80-191*.

Smoke detectors; evacuation; fire departments; fire investigations; nursing staff; patients; smoke; *NBS-GCR-80-238*.

Smoke detectors; fire departments; fire extinguishers; fire investigations; hospitals; nursing staff; smoke; *NBS-GCR-80-232*.

Smoke detectors; fire departments; fire investigations; hospitals; smoke; *NBS-GCR-80-261*.

Smoke detectors; surveys; detector location; false alarms; health care facilities; hospitals; ionization detectors; maintenance; NFPA 101; nursing homes; photoelectric detectors; *NBSIR 80-2130*.

Smoke detectors; toxicity; bibliographies; building fires; cable fires; compartment fires; decision analysis; fabric flammability; fire suppression; fire tests; flame research; *NBSIR 80-2114*.

Smoke detectors; wakefulness; adults; alarm responses; auditory perception; decibal levels; fire departments; frequency distribution; noise (sound); sleep; *NBS-GCR-80-284*.

Smoke movement; sprinkler systems; clothing wardrobes; health care facilities; hospitals; mattresses; *NBSIR 80-2097*.

Smoke movement; stack effects; test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; *NBSIR 80-2004*.

Smoke movement; stairwells; tracers; air movement; elevators; fire tests; hospitals; smoke; *NBS-GCR-79-183*.

Smoldering; bedding; fire departments; fire investigations; hospitals; nursing staff; patients; smoke; *NBS-GCR-80-239*.

Smoldering ignition; thermal analysis; thermal insulation; activation energy; borax; boric acid; cellulose; critical radiant flux; fire; fire retardants; fire tests; loose fill insulation; *NBSIR 80-2085*.

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SNM assay; solution analysis; total sampling; x-ray fluorescence analysis; dissolver solution; slurry analysis; *SP582*, pp. 547-554 (June 1980).

SNM monitors; ZPPR; IAEA safeguards; neutron detectors; portal monitors; radiation detectors; *SP582*, pp. 365-371 (June 1980).

Snow; solar collector; structural engineering; building; ice; load; roof; roof load; *NBS-GCR-79-180*.

Snow; wind; building collapse; ice; *SP586*, pp. 259-270 (June 1980).

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Social environments; social learning theory; antisocial behavior; arson; cognition; firesetters; human behavior; *NBS-GCR-80-194*.

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Sodium; tooth enamel; apatite; carbonate apatite; hydrolysis; impurities; octacalcium phosphate; *19647*.

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Sodium beta alumina; internal friction; ionic transport mechanism; sodium ion; single crystal; interstitials; *19442*.

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Sodium disilicate; glass; oxygen dependence; *19188*.

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Sodium ion; single crystal; interstitials; sodium beta alumina; internal friction; ionic transport mechanism; *19442*.

Sodium nitrate; activity coefficients; critically evaluated data; excess Gibbs energy for electrolytes; osmotic coefficients; *JPCRD 9*, No. 2, 513-518 (1980).

Sodium propagation experiments; Na cross-section adjustment; *SP594*, pp. 194-198 (Sept. 1980).

Sodium stearate; transition temperatures; gas chromatography; *19914*.

Sodium void coefficient; structural materials; benchmark tests; control rod worth; Doppler coefficient; JENDL-1; reaction rate distribution; reaction rate ratio; reactivity worth; *SP594*, pp. 581-585 (Sept. 1980).

Soft gamma-ray; spectrometer; energy resolution; hard x-ray; imaging; Lixscope; *19403*.

Soft gamma-ray; spectrometer; energy resolution; hard x-ray; imaging; Lixscope; *19404*.

Softness expansion; dilute gas transport properties; inverse power potential; logarithmic terms; perturbation theory; *19389*.

Softness expansion; thermal conductivity; viscosity; classical scattering angle; dilute gases; inverse power potential; logarithmic terms; *19194*.

Soft spheres; computer simulation; conformal solution theory; mixture; molecular dynamics; radial distribution function; *19538*.

Soft spheres; transport coefficients; Boltzmann equation; collision integral; dilute gas; kinetic perturbation theory; kinetic theory; nonequilibrium perturbation theory; perturbation theory; *19866*.

Software; computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; Federal Information Processing Standards Publication; *FIPS PUB 76*.

Software; computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; *NBSIR 80-2115*.

Software; software selection; computer applications; computer programs; data administration; database management; database standards; data processing; data resource management; Federal Information Processing Standards Publication; file processing; *FIPS PUB 77*.

Software; specifications; standards; systems analysis/engineering; codes; computer program; decision table; network; performance requirements; *NBS-GCR-80-258*.

Software; specifications; standards; systems analysis/engineering; codes; computer program; decision table; network; performance requirements; *NBS-GCR-80-257*.

Software; standards; data processing; Federal Information Processing Standard; FORTRAN; numeric methods; programming language; scientific computing engineering; *FIPS PUB 69*.

Software; standards; time-sharing; BASIC; data processing; Federal Information Processing Standard; interactive programming; programming language; *FIPS PUB 68*.

Software development; software management; software tools; static analysis; dynamic analysis; programming aids; *NBSIR 80-2159*.

Software development; testing; program verification; *SP500-56*.

Software engineering; abstract data types; artificial intelligence; data abstraction; database management systems; data structures; programming languages; *SP500-59*.

Software engineering; software techniques; software tools; taxonomy; automated aids; programming aids; *NBS-GCR-80-199*.

Software management; software tools; static analysis; dynamic analysis; programming aids; software development; *NBSIR 80-2159*.

Software selection; computer applications; computer programs; data administration; database management; database standards; data processing; data resource management; Federal Information Processing Standards Publication; file processing; software; *FIPS PUB 77*.

Software specifications; APT; automation; computer aided manufacturing; NC machining; NC programming; numerical control; part programming; *NBSIR 80-2073.3*.

Software standards; software testing; BASIC; language processor testing; minimal basic; programming language standards; *SP500-70/2*.

Software standards; software testing; BASIC; language processor testing; minimal basic; programming language standards; *SP500-70/1*.

Software techniques; software tools; taxonomy; automated aids; programming aids; software engineering; *NBS-GCR-80-199*.

Software testing; BASIC; language processor testing; minimal basic; programming language standards; software standards; *SP500-70/1*.

Software testing; BASIC; language processor testing; minimal basic; programming language standards; software standards; *SP500-70/2*.

Software tools; static analysis; dynamic analysis; programming aids; software development; software management; *NBSIR 80-2159*.

Software tools; taxonomy; automated aids; programming aids; software engineering; software techniques; *NBS-GCR-80-199*.

Softwood; timber engineering; trench bracing; trenching; construction lumber; construction safety; excavation; hardwood; lumber grading; shoring; *BSS122*.

Soft x-ray diagnostics; CsI; CuI; photoabsorption cross sections; photocathodes; plasma diagnostic detectors; radiometry; *19602*.

Soil classification; soil pressure; soil testing; trenching; braced excavations; construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; *BSS121*.

Soil classification; soil pressure; standards; trenching; braced excavation; construction; retaining structures; shoring; slope stability; *BSS127*.

Soil classification; trench; workshop; acceptable work practices; excavation; geotechnical engineering; safety; shoring; *NBSIR 79-1935*.

Soil pressure; soil testing; trenching; braced excavations; construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; soil classification; *BSS121*.

Soil pressure; standards; trenching; braced excavation; construction; retaining structures; shoring; slope stability; soil classification; *BSS127*.

Soil testing; trenching; braced excavations; construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; soil classification; soil pressure; *BSS121*.



Solar; testing; computer; energy; heat transfer; hot water; measurement; modeling; 19375.

Solar; testing; computer; energy; heat transfer; hot water; measurement; modeling; 19459.

Solar; testing; computer; energy; heat transfer; hot water; measurement; modeling; 19498.

Solar absorber coatings; SRM's; structural safety; automation; computers; electrical wiring; radiation exposure; *DIM/NBS 64*, No. 8, 1-28 (1980).

Solar air heating systems; solar collector; air leakage; computer simulation; performance criteria; 19619.

Solar builder/developer; solar energy; building code; code official; demonstration program; institutional constraints; 19729.

Solar builder/developer; solar energy; building code; code official; demonstration program; institutional constraints; *SP586*, pp. 181-185 (June 1980).

Solar builder/developer; solar energy; building code; code official; demonstration program; institutional constraints; *NBSIR 79-1957*.

Solar calorimeter tests; solar-optical properties tests; solar simulation; thermal performance test procedures; thermal transmission tests; thin-film resistance heaters; passive product types; 19820.

Solar cell; solar cell measurements; solar cell stability; device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; *NBSIR 80-2027*.

Solar cell; spectral response; radiometry; silicon cell; 19669.

Solar cell measurements; solar cell stability; device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cell; *NBSIR 80-2027*.

Solar cells; cell cracks; device measurements; laser scanning; light biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; 19435.

Solar cells; test method preparation; consensus standards; measurement technology; photovoltaic energy conversion; photovoltaics; *NBSIR 80-2060*.

Solar cell stability; device measurements; laser scanning; light-biasing; metallization; ohmic contacts; reliability; semiconductor measurements; sheet resistance; solar cell; solar cell measurements; *NBSIR 80-2027*.

Solar collector; air leakage; computer simulation; performance criteria; solar air heating systems; 19619.

Solar collector; durability/reliability; environmental degradation; materials degradation; 19451.

Solar collector; solar heating and cooling; standards; testing; 19813.

Solar collector; standard insulation test methods; accelerated aging; collector insulation; insulation; *NBSIR 79-1908*.

Solar collector; structural engineering; building; ice; load; roof; roof load; snow; *NBS-GCR-79-180*.

Solar collector; surface morphology; ultra-black surface coating; etchant bath; light absorption; microscopic pores; nickel-phosphorus alloy; *U.S. Patent 4,233,107*.

Solar collector; thermal performance; efficiency; flow rate; heat transfer fluid; *NBS-GCR-79-184*.

Solar collectors; absorber materials; absorptive coatings; accelerated aging; cover plates; durability; environmental exposure; materials; polymeric materials; 19364.

Solar collectors; collector installation; field survey; guidelines; low-sloped roofs; roofing performance; *TN1134*.

Solar collectors; solar energy; energy conversion; laboratory accreditation; photovoltaics; product certification; *NBSIR 80-2028*.

Solar collectors; solar energy; fire prevention; fire tests; flammability; flash point; heat transfer fluids; insulation; leakage; *NBSIR 79-1931*.

Solar collectors; solar energy; standards; thermal performance; buildings; cooling; durability/reliability; performance criteria; safety; *SP586*, pp. 151-160 (June 1980).

Solar collectors; solar simulators; thermal testing; ASHRAE Standard 93; collector rating; environmental influence; outdoor testing; 19366.

Solar collectors; thermal losses; thermal performance testing; instantaneous efficiency; optical efficiency; *NBSIR 80-2087*.

Solar collectors; wind speed and sky temperature effects on solar collector performance; collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; 19239.

Solar collectors; wind speed and sky temperature effects on solar collector performance; collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; 19325.

Solar constant; absolute radiometry; cavity absorptance; cavity reflectance; electrically calibrated radiometer; pyroheliometry; 19909.

Solar constant; solar variability; climatology; pyrheliometry; 19473.

Solar data base; solar energy system; solar heating and cooling; automatic data processing; computer retrieval; data base retrieval; residential buildings; *NBSIR 80-2144*.

Solar economics; windows; benefit cost; building economics; discounting; economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; *H132*.

Solar energy; building code; code official; demonstration program; institutional constraints; solar builder/developer; 19729.

Solar energy; building code; code official; demonstration program; institutional constraints; solar builder/developer; *SP586*, pp. 181-185 (June 1980).

Solar energy; building code; code official; demonstration program; institutional constraints; solar builder/developer; *NBSIR 79-1957*.

Solar energy; energy conservation; federal buildings; life-cycle costing; 19067.

Solar energy; energy conversion; laboratory accreditation; photovoltaics; product certification; solar collectors; *NBSIR 80-2028*.

Solar energy; fire prevention; fire tests; flammability; flash point; heat transfer fluids; insulation; leakage; solar collectors; *NBSIR 79-1931*.

Solar energy; solar photovoltaic; cost effectiveness; economic evaluations; energy conservation; Federal energy management program; life-cycle costing; public buildings; renewable energy; *H135*.

Solar energy; special collectors; energy estimates; geographical distribution; low temperature collectors; manufacturing activity; medium temperature collector; 19527.

Solar energy; standards; thermal performance; buildings; cooling; durability/reliability; performance criteria; safety; solar collectors; *SP586*, pp. 151-160 (June 1980).

Solar energy storage; thermal storage device; ASHRAE standard 94-77; Glauber's salt; latent heat storage; pebble-bed; phase-change unit; 19175.

Solar energy system; solar heating and cooling; automatic data processing; computer retrieval; data base retrieval; residential buildings; solar data base; *NBSIR 80-2144*.

Solar energy system; TRNSYS computer program; air leakage; f-chart method; flat-plate solar collectors; 19870.

Solar energy system; thermal performance evaluation; heating and cooling performance; *NBS-GCR-79-189*.

Solar energy system; thermal performance evaluation; heating and cooling performance; *NBSIR 80-1980*.

Solar energy systems; active solar energy; break-even analysis; building economics; commercial buildings; economic feasibility; economic optimization; 19350.

Solar energy systems; benefit-cost analysis; building economics; commercial buildings; investment analysis; life-cycle cost analysis; passive solar energy; retrofit; revitalization; *BSS125*.



- Solar heating and cooling; automatic data processing; computer retrieval; data base retrieval; residential buildings; solar data base; solar energy system; *NBSIR 80-2144*.
- Solar heating and cooling; standards; testing; solar collector; 19813.
- Solar heating system; standards; codes; performance criteria; 19377.
- Solar heating systems; air corrections; air leakage; computer simulation; damper leakage; performance criteria; 19615.
- Solar-heat transfer liquid containment; stagnation; corrosion; elevated temperature; heat transfer; liquid flow rate; *NBSIR 79-1919*.
- Solar installations; standardization; dimensions; flat plate collectors; preferred sizes; *NBSIR 80-2116*.
- Solar Kr abundance; s-process systematics; neutron capture cross sections; *SP594*, pp. 857-862 (Sept. 1980).
- Solar-optical properties tests; solar simulation; thermal performance test procedures; thermal transmission tests; thin-film resistance heaters; passive product types; solar calorimeter tests; 19820.
- Solar performance criteria; solar standards; updating criteria; 19237.
- Solar photovoltaic; cost effectiveness; economic evaluations; energy conservation; Federal energy management program; life-cycle costing; public buildings; renewable energy; solar energy; *H135*.
- Solar simulation; thermal performance test procedures; thermal transmission tests; thin-film resistance heaters; passive product types; solar calorimeter tests; solar-optical properties tests; 19820.
- Solar simulators; thermal testing; ASHRAE Standard 93; collector rating; environmental influence; outdoor testing; solar collectors; 19366.
- Solar standards; updating criteria; solar performance criteria; 19237.
- Solar storage walls; testing procedures; thermal performance; finite-difference computer model; passive solar energy; responsive coefficients; 19815.
- Solar variability; climatology; pyrheliometry; solar constant; 19473.
- Solgel; inorganic radiochemical; liquid scintillator; radioactivity; sample preparation; scintillation counting; 19817.
- Solid contact; wear; copper; copper alloys; friction; microstructure; 19708.
- Solid electrolyte; tungsten carbide; catalyst; cerium dioxide; electrocatalysis; fuel cells; impedance; *NBSIR 80-1991*.
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- Solid-liquid interface; stability; alloy; constitutional supercooling; local equilibrium; perturbation; solidification; 19748.
- Solid mechanics; statistical methods; steel; fatigue; fracture; mathematical modeling; micromechanics; microstructure; nuclear fuel element; paper; quantitative microscopy; size effect; 19086.
- Solids; sparks; test methods; Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; shredded and slit films; *NBSIR 78-1580*.
- Solids; Van Vleck susceptibility; anomalous behavior; frequency shifts; hydrostatic pressure; Knight shift; scaling theory; 19925.
- Solid solutions; alloy theory; crystal chemistry; intermediate phases; phase diagrams; phase equilibria; *SP564*.
- Solid solutions; solubility; surfaces; thermodynamics; vapor pressure; interstitials; melting; small particles; 19830.
- Solid state physics; synchrotron radiation; ultraviolet optical system design; ultraviolet spectroscopy; extreme ultraviolet mirrors; extreme ultraviolet telescopes; optical constants; reflectivity; reflectometer; 19640.
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- Solubility; aqueous potassium chloride; gaseous cyclopropane; Henry's constant; 19795.
- Solubility; equilibrium partitioning; Fickian diffusion; food package; interaction parameter; migration; partition coefficient; radiolabeled additive; 19651.
- Solubility; solubility product; sparingly soluble lead salts; aqueous solubility of lead salts; lead carbonate; lead halides; lead nitrate; lead phosphates; lead sulfate; lead sulfide; *JPCRD 9*, No. 3, 751-784 (1980).
- Solubility; solubility product; standard electrode potentials; standard thermodynamic functions; compilation of solubility data; disproportionation of mercury (I); electromotive force measurements; mercury (I) chloride; *JPCRD 9*, No. 4, 1307-1330 (1980).
- Solubility; surfaces; thermodynamics; vapor pressure; interstitials; melting; small particles; solid solutions; 19830.
- Solubility product; sparingly soluble lead salts; aqueous solubility of lead salts; lead carbonate; lead halides; lead nitrate; lead phosphates; lead sulfate; lead sulfide; solubility; *JPCRD 9*, No. 3, 751-784 (1980).
- Solubility product; standard electrode potentials; standard thermodynamic functions; compilation of solubility data; disproportionation of mercury (I); electromotive force measurements; mercury (I) chloride; solubility; *JPCRD 9*, No. 4, 1307-1330 (1980).
- Solute; alloy; convection; interface; solidification; 19264.
- Solute trapping; thermodynamics; interface stability; kinetics; microsegregation; rapid solidification; 19946.
- Solution analysis; total sampling; x-ray fluorescence analysis; dissolver solution; slurry analysis; SNM assay; *SP582*, pp. 547-554 (June 1980).
- Solution calorimetry; standard reference materials; thermochemistry; tris(hydroxymethyl)aminomethane; calorimetry; enthalpy of solution; KCl; *J. Res.* 85, No. 6, 467-481 (Nov.-Dec. 1980).
- Solution density; accountability tanks; differential pressure; in-tank density determination; nuclear process solutions; 19170.
- Solution density; accountability tanks; differential pressure; in-tank density determination; nuclear process solutions; *J. Res.* 85, No. 3, 219-221 (May-June 1980).
- Solution density; accountability tanks; differential pressure; in-tank density determination; nuclear process solutions; *SP582*, pp. 534-537 (June 1980).
- Solutions; data compilations; photochemistry; photophysics; review; *SP578*.
- Solutions; thermodynamic properties; activity coefficient; correlation; critical evaluation; electrolyte theories; excess Gibbs energy; models; osmotic coefficient; polyvalent electrolytes; 19919.
- Solutions; thermodynamic properties; aqueous electrolytes; electrolyte data center; evaluations; reviews; 19920.
- Solvent extraction; activation analysis; cadmium; mercury; radiochemical; separation; 19283.
- Solvent extraction; spectrometer; alpha counting; alpha particle; liquid scintillation; *SP582*, pp. 111-120 (June 1980).
- Solvent-extraction contactors; chemical modeling; dynamic materials accounting; in-process inventory; *SP582*, pp. 712-717 (June 1980).
- Sorption; annealing; diffusion; drawing; low density polyethylene; 19850.
- Sorption; diffusivity; elastic deformation; fractional free volume; permeability; plastic deformation; semicrystalline polymers;



- Sound; acoustics; building acoustics; environmental pollution; noise control; noise isolation; *TN1113-2*.
- Sound; traffic noise; transportation noise; acoustics; environmental pollution; highway noise; motor vehicle noise; noise; noise control; *TN1113-1*.
- Sound field; ultrasonics; analog recording; C-scan; instrumentation; *19061*.
- Sound velocities; stainless steels; elastic constants; iron alloys; low temperatures; magnetic transitions; *19563*.
- Sound velocities; tensor-property averaging; copper; Debye temperature; elastic constants; polycrystals; *19696*.
- Sound velocity; boron-aluminum; composite; elastic constants; *19212*.
- Sound velocity; stainless steel; Young's modulus; bulk modulus; elastic constants; physical-property variability; Poisson's ratio; shear modulus; *19246*.
- Source dyadic; dyadic Green's functions; electric field; integral equation; *19249*.
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- Source of polarized electrons; spin polarization; electron optics; electron spin polarization; GaAs; negative electron affinity; photoemission; polarization; *19310*.
- Sources; standardization; calibration; detection; dosimetry; facilities; fluence; flux; monitor; neutron; *SP594*, pp. 747-751 (Sept. 1980).
- Sources; stars, coroneae-stars; individual, x ray; *19222*.
- Sources; ultraviolet; arc; calibrations; irradiance; radiance; *19876*.
- Source-to-detector distance; accelerator; borehole sonde; capture  $\gamma$ -ray analysis; *SP594*, pp. 604-614 (Sept. 1980).
- South Pole atmosphere; airborne particles; atmospheric aerosol; atmospheric sulfate environmental pollution; microsampling; molecular microanalysis; particle microanalysis; Raman microprobe; Raman spectra; Raman spectroscopy; *19883*.
- SPRTs; temperature fixed point; the kelvin; thermometric fixed point; triple point of gallium; triple point of water; International Practical Temperature Scale; *19099*.
- Space astrophysics; stellar atmospheres; stellar chromospheres; stellar coroneae; stellar winds; ultraviolet spectroscopy; *19456*.
- Space charge; beam transport; high current ion beams; inertially-confined fusion; numerical simulation; *19626*.
- Space charge; crystal relaxations; electrets; ferroelectricity; piezoelectric polymers; polarization; poly(vinyl chloride); poly(vinyl fluoride); poly(vinylidene fluoride); pyroelectric polymers; *19734*.
- Space charge; sulfur hexafluoride ( $\text{SF}_6$ ); uv radiation; 60 Hz ac and dc; compressed gas; corona; electron avalanche; inception voltage; ionization; ion mobilities; partial discharge; photodetachment; *19786*.
- Space charge; surface flashover; vacuum breakdown; electrical breakdown; electro-optics; interfacial breakdown; Pockels effect; *NBS-GCR-80-203*.
- Space cooling; space heating; building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; *19235*.
- Spacecraft; bremsstrahlung; dose; electrons; proton; shielding; *19226*.
- Spaceflight; calculations; gamma-ray spectrometers; germanium; induced radioactivity; sodium-iodide; *19749*.
- Space group frequency; symmetry; Bravais lattice; classification; crystal data; reduced forms; *19832*.
- Space heating; building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; *19235*.
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- Space standards; equivalency; housing standards; minimum standards; *SP586*, pp. 103-115 (June 1980).
- Spallation; evaporation; fission; high energy proton; neutron yield analysis; *SP594*, pp. 417-421 (Sept. 1980).
- Spans; stable laws; Poisson transformation; polymer configurations; random walks; *19654*.
- Sparingly soluble lead salts; aqueous solubility of lead salts; lead carbonate; lead halides; lead nitrate; lead phosphates; lead sulfate; lead sulfide; solubility; solubility product; *JPCRD 9*, No. 3, 751-784 (1980).
- Sparks; test methods; Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; shredded and slit films; solids; *NBSIR 78-1580*.
- Sparse matrices; conjugate gradient algorithm; elliptic partial differential equations; iterative methods for linear algebraic equations; Neumann boundary conditions; *J. Res. 85*, No. 5, 367-390 (Sept.-Oct. 1980).
- Spatial filtering microscope; sputter-Auger method; test structures; transistors; wire bonds; capacitance-voltage methods; deep level transient spectroscopy; electrical properties; electronics; electron irradiation. hole mobility; integrated circuits; ion knock-on effect; *SP400-45*.
- Spatial resolution; analytical electron microscopy; electron scattering; energy dispersive x-ray spectrometry; microanalysis; Monte Carlo electron trajectory simulation; *19660*.
- Special collectors; energy estimates; geographical distribution; low temperature collectors; manufacturing activity; medium temperature collector; solar energy; *19527*.
- Special libraries; telecommunications; bibliographic utilities; information revolution; information technology; library automation; library networks; reprography; *19392*.
- Special libraries; White House conference on library and information services; Federal data bases; Federal information services; Federal libraries; networks; *19250*.
- Special nuclear material; analyses; destructive; nondestructive assay; NRC Safeguards; *SP582*, pp. 189-191 (June 1980).
- Special nuclear material; inventory control; neutron interrogation; *SP582*, pp. 372-390 (June 1980).
- Special nuclear materials; x-ray fluorescence; accountability; accuracy; gamma spectrometry; mass spectrometry; nondestructive assay; nuclear safeguards; precision; reference materials; *SP582*.
- Speciation; electrochemical detector; high performance liquid chromatography; methylmercury; organometals; *19555*.
- Specific adsorption; radiometric measurements; silicon photovoltaic; *19955*.
- Specifications; dental agencies; devices; history; materials; programs; *SP571*.
- Specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; *SP577*.
- Specifications; standards; systems analysis/engineering; codes; computer program; decision table; network; performance requirements; software; *NBS-GCR-80-257*.
- Specifications; standards; systems analysis/engineering; codes; computer program; decision table; network; performance requirements; software; *NBS-GCR-80-258*.
- Specifications; taximeters; tolerances; volume-measuring devices; weighing devices; weights; length-measuring devices; liquid-measuring devices; measures; scales; *H44, 1980 Edition*.
- Specifications; test methods; accuracy; chromaticity; coefficient of luminous intensity; intercomparisons; retroreflectance; retroreflector; *TN1125*.
- Specifications and tolerances; weights and measures; consumer affairs; education; electronic devices; International Organization of Legal Metrology; legal metrology; measurement assurance; metrication; model laws and regulations; moisture loss; packaging and labeling; *SP566*.
- Specifications, dental; waxes, dental; alloy, base, dental; alloy, gold, dental; amalgam, dental; cements, dental; dental materi-



- als; gypsums, dental; impression materials, dental; polymers, dental; refractories, dental; 19052.
- Specifications standards; systems analysis/engineering; codes; decision theory; editing; networks; *NBS-GCR-80-259*.
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- Specific heat; atom migration; high temperature; lattice structure; Monte Carlo calculations; rubidium; 19337.
- Specific heat; thermal expansion; hardness; homogeneity; infrared laser absorption properties; mechanical properties; *SP568*, pp. 65-72 (July 1980).
- Specific heats; thermodynamic properties; vapor pressures; co-existence boundary; critical point; densities; equation of state; fluids; orthobaric densities; propane; 19204.
- Specific heat strontium titanate; ceramics; cryogenics; dielectric constant; electrocaloric effect; entropy; ferroelectrics; glass-ceramics; heat switches; polarization; refrigeration; 19534.
- Specific volume; void filling; void volume; buoyant force; dielectric insulation; oil permeation; porous polymers; 19882.
- Speckle; specular reflectance; surface roughness; diffuseness; in-process; manufacturing engineering; on-line; optical Fourier transform; optical techniques; power spectral density; production engineering; *Ra*; 19477.
- Spectra; atomic spectroscopy; Cd; configuration interaction theory; perturbations; quantum defect theory; Rydberg states; 19369.
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- Spectra, atomic; wavelengths, atoms and ions; atomic energy levels; atomic spectra; bibliography; energy levels, atomic; *SP363. Supplement 2*.
- Spectral artifacts; transmission electron microscopy; electron probe microanalysis; energy dispersive x-ray spectrometry; microanalysis; qualitative analysis; quantitative analysis; scanning electron microscopy; 19088.
- Spectral artifacts; x-ray spectrometry; analytical electron microscope; energy dispersive x-ray spectrometry; scanning electron microscope; silicon (Li) detector; 19631.
- Spectral bandpass; standard reference materials in spectrophotometry; stray radiation; transmittance stability; filters for spectrophotometry; metal-on-fused silica filters; optical transmittance accuracy; polarization; reflections; *SP260-68*.
- Spectral index; uranium; autoradiography; fast critical assemblies; nondestructive assay; plutonium; reactivity; *SP582*, pp. 391-424 (June 1980).
- Spectral irradiance; spectral radiance; vacuum ultraviolet radiation; vacuum ultraviolet sources; radiation standards; 19478.
- Spectral irradiance; spectral radiant power; spectroradiometry; ultraviolet radiation measurements; visible radiation measurements; electrical substitution radiometer; infrared radiation measurements; radiometry; 19300.
- Spectral irradiance; standards; vacuum ultraviolet; deuterium lamps; radiometry; 19852.
- Spectral line intensity measurements; gas mixture composition; gravimetrically prepared gas mixtures; molar intensity ratios; natural gas components; Raman spectrometric method; 19540.
- Spectral line shapes; resonance fluorescence; resonance Raman scattering; 19471.
- Spectral moments; three-body contributions; virial coefficients; anisotropic polarizability; CO<sub>2</sub>; induced absorption spectra; molecular calculations; N<sub>2</sub>; O<sub>2</sub>; 19296.
- Spectral radiance; vacuum ultraviolet radiation; vacuum ultraviolet sources; radiation standards; spectral irradiance; 19478.
- Spectral radiant power; spectroradiometry; ultraviolet radiation measurements; visible radiation measurements; electrical substitution radiometer; infrared radiation measurements; radiometry; spectral irradiance; 19300.
- Spectral response; radiometry; silicon cell; solar cell; 19669.
- Spectral response; visible; quantum efficiency; quantum yield; silicon; silicon photodetector; 19646.
- Spectral shape; coefficient induced dipoles; collision-induced spectra; dielectric virial; intermolecular transactions; molecular constance; 19413.
- Spectrometer; alpha counting; alpha particle; liquid scintillation; solvent extraction; *SP582*, pp. 111-120 (June 1980).
- Spectrometer; energy resolution; hard x-ray; imaging; Lixiscope; soft gamma-ray; 19403.
- Spectrometer; energy resolution; hard x-ray; imaging; Lixiscope; soft gamma-ray; 19404.
- Spectrometer efficiency; wavelength dispersive spectrometry (WDS); crystal spectrometer calibration; electron microprobe analysis; energy dispersive spectrometry (EDS); L-series x-ray lines; relative x-ray line intensities; 19678.
- Spectrometric analysis; transmission; measurements; number of nuclei; samples; *SP594*, pp. 903-906 (Sept. 1980).
- Spectrophotometers; high-temperature; infrared; optical instrumentation; reflectometers; *SP568*, pp. 281-286 (July 1980).
- Spectrophotometric; irradiated fuels; plutonium; *SP582*, pp. 497-508 (June 1980).
- Spectrophotometric; uranium; determination; dual wavelength; nitric acid; *SP582*, pp. 121-128 (June 1980).
- Spectrophotometry; specular; standards; mirrors; reflectance; 19335.
- Spectrophotometry; systematic errors; transmittance accuracy; absorbance accuracy; instrumental standards; method accuracy; multielement analyses; NBS standard reference materials; 19818.
- Spectroradiometry; absolute spectral response; laser power measurement; photodetector; radiant power measurement; radiometry; silicon photodiode; 19354.
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- Stars, late-type; stars, RS CVn-type; ultraviolet; emission; stars; stars, chromospheres; stars, corona; *19189*.
- Stars, long period variables; stars, supergiants; interstellar, molecules, masers, polarization; *19536*.
- Stars, RS CVn-type; ultraviolet; emission; stars; stars, chromospheres; stars, corona; stars, late-type; *19189*.
- Stars, supergiants; interstellar, molecules, masers, polarization; stars, long period variables; *19536*.
- State diagram; action table; computer program; finite automata; formal description technique; graphs; natural language; Petri net; *NBS-GCR-80-247*.
- State energy conservation office contact personnel; State energy conservation plans and programs; energy conservation measures for consumer products; Energy Extension Service (EES) program; regulations; standards; *NBSIR 80-2017*.
- State energy conservation plans and programs; energy conservation measures for consumer products; Energy Extension Service (EES) program; regulations; standards; State energy conservation office contact personnel; *NBSIR 80-2017*.
- State/local; training; inspectors; laboratory; metrology; seminars; *19438*.
- State-of-the-art; temperature; Burnett PVT measurements; coefficient; ethylene; second virial; *19115*.
- State-of-the-art in 1979; laboratory accreditation; *SP591*, pp. 6-10 (Aug. 1980).
- State Plane Coordinate System; surveying; Universal Transverse Mercator (UTM); coordinate system; elevation; Federal Information Processing Standard; geographic point location; latitude; Latitude and Longitude; longitude; mapping; *FIPS PUB 70*.
- State specific rate constants; two-photon; collisional ionization; opto-galvanic spectroscopy; sodium; *19956*.
- Static analysis; dynamic analysis; programming aids; software development; software management; software tools; *NBSIR 80-2159*.
- Static dielectric constant; steam; water; critically evaluated data; critical review; data compilation; International Formulation; *JPCRD 9*, No. 4, 1291-1306 (1980).
- Static pressure; building fires; fire tests; flow measurement; furniture; interior finishes; residential buildings; room fires; *NBSIR 80-1984*.
- Static test set; analog-to-digital converter testing; automatic; digital-to-analog converter testing; gain; high resolution; linearity; noise; offset; *19075*.
- Stationary U target; linear accelerator; post-acceleration beam compression; rotating U target; *SP594*, pp. 534-536 (Sept. 1980).
- Station positions; artificial satellites; distance measurements; geodesy; geodynamics; lasers; *19742*.
- Statistical analysis; accuracy; clinical analysis; clinical chemistry; definitive method; electrolytes; flame atomic absorption spectroscopy; interlaboratory testing; precision; reference method; semiautomated pipetting; serum lithium analysis; *SP260-69*.
- Statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; *SP577*.
- Statistical analysis; structural engineering; tropical cyclones; wind (meteorology); buildings (codes); climatology; hurricanes; *19835*.
- Statistical analysis; structural engineering; tropical cyclones; wind (meteorology); building (codes); climatology; hurricanes; *BSS124*.
- Statistical analysis; total serum cholesterol; cholesterol; definitive method; gas chromatography/mass spectrometry; isotope dilution/mass spectrometry; reference method; *19554*.
- Statistical and coupled-channel analysis; optical model; *SP594*, pp. 893-897 (Sept. 1980).
- Statistical aspects of fatigue; composite materials; corrosion fatigue; durability; fatigue; fatigue mechanism; fatigue research; fracture mechanics; mathematical modeling; metals fatigue; plastics fatigue; quantitative microscopy; *19448*.
- Statistical aspects of fatigue; striations; composite materials; corrosion fatigue; dislocations; fatigue mechanism; fracture mechanics; mathematical modeling; micromechanics; polymers; quantitative microscopy; slip bands; *19087*.
- Statistical data; ADP standards; computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; national government; representations and codes; standards; *FIPS PUB 6-3*.
- Statistical evaluation; thermal analysis; depletable energy; HUD Demonstration Program; passive solar buildings; performance criteria; *19823*.
- Statistical evaluation; uranium; alpha spectrometry; intercomparison programs; mass spectrometry; plutonium; safeguards; *SP582*, pp. 42-54 (June 1980).
- Statistical methods; steel; fatigue; fracture; mathematical modeling; micromechanics; microstructure; nuclear fuel element; paper; quantitative microscopy; size effect; solid mechanics; *19086*.
- Statistical model; actinide fission; high energy cross sections; intranuclear cascade; *SP594*, pp. 422-426 (Sept. 1980).
- Statistical model; evaluation; neutron cross-sections; optical model; resonances; *SP594*, pp. 872-876 (Sept. 1980).
- Statistical model; experimental trends; *SP594*, pp. 848-852 (Sept. 1980).



Statistical model; triple humped shapes; fission barriers derived; fission channel analysis; *SP594*, pp. 469-474 (Sept. 1980).

Statistical model analysis; cross sections on Se, Cd, Os; *SP594*, pp. 307-310 (Sept. 1980).

Statistical model calculations; Y, Nb, Gd, W and Au(n, $\gamma$ ); *SP594*, pp. 323-327 (Sept. 1980).

Statistical modeling; welding; ASME Boiler Code; data; fabrication; failure analysis; fatigue; fracture; materials science; non-destructive evaluation; piping; pressure vessels; product liability; pumps and valves; standards; *SP588*.

Statistical models; width fluctuation correction factor; compound-nucleus reactions; cross sections; elastic enhancement factors; factorization; Hauser-Feshbach theory; *SP594*, pp. 762-764 (Sept. 1980).

Statistical pattern recognition; test environments; test workload generation; benchmark; evaluation environments; *19059*.

Statistical quality control; accuracy; control chart; control limits; corrective action; data validation; precision; proficiency analytical testing; quality control; *SP591*, pp. 104-108 (Aug. 1980).

Statistical weights; symmetric top molecules; group theory; nuclear spin; ro-vibronic species; *19789*.

Statistics; chemical petrology; closure correlation; principal components analysis; *19778*.

Statistics; covariance matrix; curve fitting; iterative refinement; least squares solution; linear constraints; overdetermined system of equations; regression; *19154*.

Statistics; sunspots; ARMA models; forecasts; Maunder minimum, models; simulation; *TN1022*.

Statistics; test problems; algorithms; computer programs; least squares; regression; *19158*.

Statistics; test problems; test results; algorithms; curve fitting; least squares; modified Gram-Schmidt; pseudoinverse; regression; *TN1126*.

Statistics; time-varying signals; community noise; measurement errors; noise; noise exposure; sampling (temporal); *19116*.

Statistics; unit costs; weatherization; building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; *NBSIR 80-2167*.

Status byte; command codes; disk drives; Federal Information Processing Standard; format track; operational specification; rotating mass storage subsystems; sense information; *FIPS PUB 63*.

Steady state; thermal conductivity; energy current; isotopic disorder; nonequilibrium; one-dimensional harmonic crystal; random matrix products; *19873*.

Steam; viscosity; coal gasification; coal slag; high temperature; *NBSIR 80-2124*.

Steam; viscosity; water; water vapor; correlation length; critical region equation of state; critical viscosity enhancement; *JPCRD 9*, No. 4, 1255-1290 (1980).

Steam; water; critically evaluated data; critical review; data compilation; International Formulation; static dielectric constant; *JPCRD 9*, No. 4, 1291-1306 (1980).

Steam; water; critically evaluated data; reference data; *19569*.

Steel; alloys; differential thermal analysis; gas analysis; *SP580*, pp. 33-53 (Aug. 1980).

Steel; ductile fracture; fracture toughness; part-through crack; pneumatic burst; pressure vessel; *19961*.

Steel; fatigue; fracture; mathematical modeling; micromechanics; microstructure; nuclear fuel element; paper; quantitative microscopy; size effect; solid mechanics; statistical methods; *19086*.

Steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; *SP577*.

Steel; surfaces; wear; wear debris; copper; electron microscopy; friction; metals; plastic deformation; *NBSIR 80-2058 (ONR)*.

Steel; wear; wear debris; abrasive particles; electron microscopy; erosive wear; impact; *19874*.

Steel; wood; fire endurance; fire tests; flame through; floors; furniture; interior finishes; joists; room fires; *NBSIR 80-2134*.

Steels; fatigue (materials); fracture (materials); low temperature tests; mechanical properties; nickel alloys; *19550*.

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Stellar atmospheres; stellar chromospheres; ultraviolet spectra; late-type stars; *19357*.

Stellar birthrates; supernovae; nucleosynthesis; *19278*.

Stellar chromospheres; stellar coronae; stellar winds; late-type stars; *19268*.

Stellar chromospheres; stellar coronae; stellar winds; ultraviolet spectroscopy; space astrophysics; stellar atmospheres; *19456*.

Stellar chromospheres; stellar coronae; ultraviolet spectra; binary stars; late-type stars; RS Canum Venaticorum; *19781*.

Stellar chromospheres; stellar coronae; ultraviolet spectra; late-type stars; *19315*.

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Stellar chromospheres; stellar winds; ultraviolet spectra; x-ray sources; chromosphere sun; emission-line stars; late-type stars; *19523*.

Stellar chromospheres; ultraviolet spectra; late-type stars; *19765*.

Stellar chromospheres; ultraviolet spectra; late-type stars; stellar atmospheres; *19357*.

Stellar coronae; stellar winds; late-type stars; stellar chromospheres; *19268*.

Stellar coronae; stellar winds; ultraviolet spectroscopy; space astrophysics; stellar atmospheres; stellar chromospheres; *19456*.

Stellar coronae; ultraviolet spectra; binary stars; late-type stars; RS Canum Venaticorum; stellar chromospheres; *19781*.

Stellar coronae; ultraviolet spectra; late-type stars; stellar chromospheres; *19315*.

Stellar coronae; ultraviolet spectra; x-ray sources; flare stars; stellar chromospheres; *19269*.

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Stellar evolution; stellar pulsation; helium stars; R CrB Stars; *19711*.

Stellar evolution; supernovae; blue stragglers; stars; *19450*.

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Stellar processes; neutron cross sections; nuclear clocks; *SP594*, pp. 627-633 (Sept. 1980).

Stellar pulsation; helium stars; R CrB Stars; stellar evolution; *19711*.

Stellar statistics; clusters; evolution-stars; open-stars; *19138*.

Stellar winds; late-type stars; stellar chromospheres; stellar coronae; *19268*.

Stellar winds; ultraviolet spectra; cool stars; radiation pressure; *19095*.

Stellar winds; ultraviolet spectra; x-ray sources; chromosphere sun; emission-line stars; late-type stars; stellar chromospheres; *19523*.

Stellar winds; ultraviolet spectroscopy; space astrophysics; stellar atmospheres; stellar chromospheres; stellar coronae; *19456*.

Stepped surfaces; surface bonding; tungsten; adsorption; chemisorption; electron stimulated desorption; ion angular distribution; oxygen; *19860*.

Stiffness; strength; structural safety; work surfaces; codes and standards; construction safety; design; loads; maintenance; occupational hazards; scaffolds; *NBSIR 79-1937*.

Stimulated Brillouin scattering (SBS); damage morphology; damage thresholds; laser bulk damage; laser surface damage; optical materials; self-focusing; *SP568*, pp. 519-527 (July 1980).

Stimulated bremsstrahlung; multiphoton transitions; scattering in



a laser field; 19227.

Stimulated Raman scattering; double resonance; 19465.

Stirling cycle; cryocoolers; helium liquefaction; refrigerator; regenerator materials; 19359.

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Stoke's velocity; aerosol; light scattering; Lorenz-Mie light scattering calculation; particle sizing; 19695.

Stone; stone consolidation; conservation; consolidating materials; deterioration of stone; preservation; *TN1118*.

Stone consolidation; conservation; consolidating materials; deterioration of stone; preservation; stone; *TN1118*.

Stone decay; stone preservatives; accelerated decay; performance criteria; preservative testing; 19348.

Stone preservatives; accelerated decay; performance criteria; preservative testing; stone decay; 19348.

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Stopping power; W-values; electrons; energy degradation spectra; fano factor; ionization yields; 19400.

Stopping power ratios; tissue equivalence; ionization chambers; kerma; neutron dosimetry; *SP594*, pp. 447-455 (Sept. 1980).

Storage partitioning; systems performance modeling; systems storage restructuring; file binding; I/O resource allocation; logical storage to physical device mapping; O.S. performance prediction; O.S. tuning; *SP500-65*, pp. 175-188 (Oct. 1980).

Storage ring; synchrotron; vacuum ultraviolet; VUV standards; radiometry; 19641.

Storage ring; synchrotron radiation; radiometry; silicon photodetector; 19935.

Stored ions; atomic spectroscopy; double resonance; high-resolution spectroscopy; laser cooling; laser spectroscopy; microwave spectroscopy; optical pumping; 19440.

Stored ions; cesium atomic resonator; frequency retrace accuracy; frequency stability; passive/active hydrogen atomic resonator; rubidium atomic resonator; 19432.

Storm surge; structural engineering; structural response; tsunami; wind loads; winds; accelerograph; codes; design criteria; disaster; earthquakes; ground motion; seismology; standards; *SP560*.

Storm water runoff; toxicity; water pollution; air pollution; chromate ore; environmental effects; lead chromate pigments; *NBSIR 80-1974*.

Stoves; wood; chimneys; fire models; fire safety; fire tests; flues; heating equipment; heat transfer; literature reviews; radiant energy; *NBSIR 80-2140, Vol. 1*.

Strain; alloy; defect; diffuse scattering; neutron; niobium; 19307.

Strain; stress; transverse optic-phonon; anisotropy;  $\text{BaF}_2$ ;  $\text{CaF}_2$ ; effective charge; oscillator strength; photoelastic; piezo-birefringence; piezo-optic;  $\text{SrF}_2$ ; 19579.

Strain; superconducting coil composite; superconducting wire; critical current; fiberglass/epoxy composite; mechanical properties; niobium-tin; niobium-titanium; *NBSIR 80-1633*.

Strain; transformation; criteria; finite; jellium; martensite; model; stability; 19243.

Strain dipole; translation-rotation; dipole glass;  $(\text{KCN})(\text{KBr})$ ; order parameter; orientational; 19596.

Strained melt; crystallization temperature; melting temperature; row nucleation; stirred solution; 19904.

Strain energy; Valanis-Landel form; elasticity; elastomers; finite deformation; rubber; 19597.

Strain-energy function; Valanis-Landel form; biaxial; elasticity; elastomers; extension; rubber; 19502.

Strain gages; structure; transducers; zero shift; adhesive; backing; connection; environment; gage element; leads; load; protective coating; resistance; sensitivity change; stability; 19049.

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Strategic model; theories of behavior; management theory; managers; organizational development; organization culture; 19844.

Stratosphere; absorption cross-section; chlorine chemistry; formaldehyde; ozone; 19535.

Stratosphere; Cl atoms; formaldehyde; kinetics; ozone; resonance fluorescence; 19704.

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Stray radiation; transmittance stability; filters for spectrophotometry; metal-on-fused silica filters; optical transmittance accuracy; polarization; reflections; spectral bandpass; standard reference materials in spectrophotometry; *SP260-68*.

Strength; ceramics; crack growth; delayed failure; fracture; mechanical reliability; mechanics; 19636.

Strength; ceramics; erosion; glass; impact; indentation fracture; 19594.

Strength; ceramic turbines; failure prediction; fracture; oxidation; silicon nitride; 19792.

Strength; elastic modulus; extruded semicrystalline polymers; fibrous materials; polymers; 19938.

Strength; stress-corrosion cracking; sub-critical crack growth; ceramics; fracture; glass; 19791.

Strength; striae; electron microprobe; glass; interferometry; ion-exchange; refractive index; 19744.

Strength; structural safety; work surfaces; codes and standards; construction safety; design; loads; maintenance; occupational hazards; scaffolds; stiffness; *NBSIR 79-1937*.

Strength; tie molecules; crystalline polymer; elastic modulus; fibrils; fibrous structure; fracture; load-elongation curve; microfibrils; point defects of microfibrillar structure; ruptured chains; 19901.

Strength; toughness; welds; cryogenic; delta ferrite; ferrite content; fracture; mechanical properties; stainless steel; 19673.

Strength degradation; ceramics; fracture; impact energy; 19589.

Strength function; fission; level spacing; multilevel analysis; neutron total cross section; *SP594*, pp. 707-710 (Sept. 1980).

Stress; transverse optic-phonon; anisotropy;  $\text{BaF}_2$ ;  $\text{CaF}_2$ ; effective charge; oscillator strength; photoelastic; piezo-birefringence; piezo-optic;  $\text{SrF}_2$ ; strain; 19579.

Stress; zinc-blende structure; covalent bonding; diamond structure; elastic constants; gallium arsenide; indium antimonide; ionicity; optical phonons; Raman scattering; semiconductors; 19580.

Stress birefringence; calcium fluoride; hot isostatic forging; hot isostatic pressing; laser windows; optical absorption; optical homogeneity; optical scattering; *SP568*, pp. 47-63 (July 1980).

Stress corrosion; subcritical crack growth; dynamic fatigue; fracture mechanics; lifetime prediction; proof testing; *NBSIR 80-2047*.

Stress corrosion cracking; austenitic stainless steels; coal gasification; elevated temperatures; ferritic stainless steels; gaseous environments; nickel alloy 671; nickel alloy 800; oxidizing/sulfidizing gas; premature failure; 19623.

Stress-corrosion cracking; sub-critical crack growth; ceramics; fracture; glass; strength; 19791.

Stress corrosion cracking; 2124-T851; 7075; 7075-T6; 7075-T7351; air; alternate immersion test; aluminum alloys; ductility; elongation; heat treatment;  $\text{NaCl}$ ; plate gage; reduction in area; slow strain rate technique; strain rate; 19622.

Stressed solid; thermodynamics; vacancies; coherent interfaces; equilibrium; incoherent interfaces; solid-fluid interface; 19949.

Stress relaxation; uniaxial creep; continuum model; critical



strain; instability point; molecular weight distribution; necking; polyethylene; 19681.

Stress to break; coalescence of microcracks; end of microfibril; microcrack formation; microfibrillar structure; rupture of taut tie molecules; strain to break; 19948.

Striae; electron microprobe; glass; interferometry; ion-exchange; refractive index; strength; 19744.

Striations; composite materials; corrosion fatigue; dislocations; fatigue mechanism; fracture mechanics; mathematical modeling; micromechanics; polymers; quantitative microscopy; slip bands; statistical aspects of fatigue; 19087.

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Strong laser field; time-dependent spectrum; transient spectrum; fluorescence spectrum; laser excitation; multi-photon processes; non-stationary processes; resonance fluorescence; 19220.

Strong scattering; transport anomalies; conductivity; disordered alloy; localization; phonon; 19755.

Strontium ions; Penning collisions; polarized emission; 19103.

Structural considerations; twinning; computer assessment; crystal structures; epitaxy; inter-layerings; nonstoichiometry; *J. Res. 85, No. 5, 347-362 (Sept.-Oct. 1980)*.

Structural defects; transverse acoustic modes; bond polarizabilities; calculated frequencies; Fermi resonance; longitudinal acoustic modes; *n*-alkanes; Raman intensities; 19692.

Structural design standards; building regulations; building standards development; consensus standards; development of standards; 19091.

Structural engineering; bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; seismicity; *SP592*.

Structural engineering; building; building codes; building design; earthquakes; engineering; standards; *NBSIR 80-2111-2*.

Structural engineering; building; ice; load; roof; roof load; snow; solar collector; *NBS-GCR-79-180*.

Structural engineering; concrete (reinforced); creep tests; evaluation; organic coating; pullout tests; reinforcing steels; 19077.

Structural engineering; structural response; tsunami; wind loads; winds; accelerograph; codes; design criteria; disaster; earthquakes; ground motion; seismology; standards; storm surge; *SP560*.

Structural engineering; tall buildings; wind forces; wind pressures; acceleration; buffeting; buildings; buildings (codes); deflection; dynamic response and gust loads; 19121.

Structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; *SP577*.

Structural engineering; tornadoes; wind; engineering; missiles; *NBSIR 80-2117*.

Structural engineering; tornadoes; winds; buildings; climatology; hurricanes; 19360.

Structural engineering; towers; turbulence; wind (meteorology); aerodynamics; buildings (codes); dynamics; 19143.

Structural engineering; tropical cyclones; wind (meteorology); building (codes); climatology; hurricanes; statistical analysis; *BSS124*.

Structural engineering; tropical cyclones; wind (meteorology); buildings (codes); climatology; hurricanes; statistical analysis; 19835.

Structural material; total cross section; unresolved resonance; elastic scattering cross section; partial inelastic scattering cross section; resonance self-shielding effect; sensitivity analysis; shielding application; *SP594*, pp. 586-590 (Sept. 1980).

Structural materials; benchmark tests; control rod worth; Doppler coefficient; JENDL-1; reaction rate distribution; reaction rate ratio; reactivity worth; sodium void coefficient; *SP594*, pp. 581-585 (Sept. 1980).

Structural properties; amorphous alloys; magnetism; metallic glasses; neutron scattering; rare earths; 19113.

Structural response; tsunami; wind loads; winds; accelerograph; codes; design criteria; disaster; earthquakes; ground motion; seismology; standards; storm surge; structural engineering; *SP560*.

Structural safety; automation; computers; electrical wiring; radiation exposure; solar absorber coatings; SRM's; *DIM/NBS 64, No. 8, 1-28 (1980)*.

Structural safety; work surfaces; codes and standards; construction safety; design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; *NBSIR 79-1937*.

Structural stability; alloy phase formation; alloy stability; atomic size; electronegativity; heats of formation; 19566.

Structure; amino acid; centrifugal distortion; glycine; microwave spectrum; rotational constants; 19365.

Structure; transducers; zero shift; adhesive; backing; connection; environment; gage element; leads; load; protective coating; resistance; sensitivity change; stability; strain gages; 19049.

Structure; vibration spectrum; hydride; interstitial holes; metallic glass; neutron scattering; 19606.

Structure refinement; atomic models; flat-cone geometry; neutron diffraction; protein structure; ribonuclease-A; 19808.

Structure refinement; x-ray diffraction; bond delocalized dianion; oxocarbon; single-crystal; *J. Res. 85, No. 2, 87-97 (Mar.-Apr. 1980)*.

Stuck-fault testing; test cases; validation vs. maintenance; communications security; computer security; cryptography; Data Encryption Standard; in-service testing; maintenance tests; Monte-Carlo testing; *SP500-61*.

Students; doors; dormitories; evacuation; fire departments; fire fatalities; fire fighters; flashover; ladders; room fires; smoke; *NBS-GCR-80-193*.

Stylus; surface; surface roughness; surface texture; metrology; profilometer; razor blade; SEM; 19064.

SU4; charge exchange reactions; exotic nuclei; heavy ion collision; mass formula; quartets; 19265.

Sub-critical crack growth; ceramics; fracture; glass; strength; stress-corrosion cracking; 19791.

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Sublattice magnetization; hydrides; Laves-phase; neutron scattering; rare earth-iron intermetallics; 19617.

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Sulfates; sulfides; surface tension; tungstates; viscosity; carbonates; density; electrical conductance; hexafluoroaluminates; metaphosphates; molten salts; molybdates; *JPCRD 9, No. 4, 831-1022 (1980)*.

Sulfides; surface tension; tungstates; viscosity; carbonates; density; electrical conductance; hexafluoroaluminates; metaphosphates; molten salts; molybdates; sulfates; *JPCRD 9, No. 4, 831-1022 (1980)*.

Sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen; oxygen; rate of reaction; *NSRDS-67*.

Sulfur; Arrhenius parameters; chemical kinetics; combustion; decomposition; free radicals; gas phase; hydrocarbons; hydrogen; nitrogen oxygen; rate of reaction; *NBSIR 80-2118*.

Sulfur; absorption cross section; manganese bath; pile oscillator; small-angle scattering; *SP594*, pp. 738-742 (Sept. 1980).

Sulfur; leakage;  $\text{MnSO}_4$ -bath; *SP594*, pp. 988-989 (Sept. 1980).

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- Sulfur hexafluoride; tracer gas; air leakage measurements; environmental chamber; fan depressurization; mobile home; *NBSIR 80-2105*.
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- Sulfuric acid; thermochemistry; calorimetry; electrolytes; enthalpy of dilution; heat; hydrochloric acid; lithium chloride; relative apparent molal enthalpy; relative partial molal enthalpy; *J. Res.* **85**, No. 1, 11-17 (Jan.-Feb. 1980).
- Sulfuric acid; tools; awards; computers; didymium glass filters; energy efficiency; inventors; innovation; labels; standards; *DIM/NBS 64*, No. 7, 1-28 (1980).
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- Superconducting; accelerators; coincidence measurements; electrons; linac; nuclear reactions; 19248.
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- Superconducting coils; absolute ampere; current balance; magnetic force; radial magnetic field; *J. Res.* **85**, No. 4, 257-272 (July-Aug. 1980).
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- Superconducting tunnel junction; superconducting weak link; controllable weak link; cryoelectronic; Josephson effect; nonequilibrium superconductivity; quasiparticle injection; 19416.
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- Superconducting wire; critical current; fiberglass/epoxy composite; mechanical properties; niobium-tin; niobium-titanium; strain; superconducting coil composite; *NBSIR 80-1633*.
- Superconductivity; aerospace; amplifier; Josephson junction; magnetic gradiometer; magnetometer; quantum interference; 19203.
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Testing; accreditation; Canada; laboratories; standards; Standards Council of Canada; *SP591*, pp. 88-91 (Aug. 1980).

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Testing; benefits; consumer; information; label; product; *NBSIR 80-2016*.

Testing; computer; energy; heat transfer; hot water; measurement; modeling; solar; 19375.

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Testing; computer; energy; heat transfer; hot water; measurement; modeling; solar; 19498.

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Testing; training code officials; building codes; building inspectors; code enforcement; course development; educational requirements; inspection; licensing; *SP586*, pp. 71-83 (June 1980).

Testing; useful life; consumer products; life-cycle performance; methodology; reliability; terminology; *NBSIR 76-1157*.

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Testing laboratories; accreditation; audit certification; laboratory accreditation; laboratory performance evaluation; quality control; *SP591*.

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Test method; central air conditioners; central heating equipment; heating seasonal performance; heat pumps; rating procedure; residential heating; seasonal performance; *NBSIR 80-2002*.

Test method; critical radiant flux; fire safety; flame spread; flammability; floor coverings; flooring radiant panel test; *NBSIR 79-1954*.

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Test method; window foil; alarm; burglar alarm; detector; intrusion alarm; standard; 19697.

Test method preparation; consensus standards; measurement technology; photovoltaic energy conversion; photovoltaics; solar cells; *NBSIR 80-2060*.

Test methods; accuracy; chromaticity; coefficient of luminous intensity; intercomparisons; retroreflectance; retroreflector; specifications; *TN1125*.

Test methods; building fires; compartment fires; doors; egress; fire tests; high-rise buildings; leakage; life safety; smoke; smoke movement; stack effects; *NBSIR 80-2004*.

Test methods; burglary resistance; forced entry; patio door; performance criteria; performance standard; sliding glass door; 19702.

Test methods; carbon; characterization; graphite; nomenclature; standards; terminology; 19486.

Test methods; drop test parameter; head injury; helmet; injury criteria; mathematical model; *NBSIR 80-1987*.

Test methods; Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; shredded and slit films; solids; sparks; *NBSIR 78-1580*.

Test methods; test pattern; test structure; circuit characterization; cross-bridge sheet resistor; electrical alignment test structure; gated diode; integrated test structure; microelectronic test structure; process validation wafer; random fault test structure; sheet resistor; 19165.

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- Workload definition; benchmarking; capacity planning; computer performance evaluation; computer performance measurement; computer performance prediction; computer system acquisition; CPE in auditing; installation management; on-line system evaluation; queuing models; *SP500-65*.
- Workload forecasting; workload update; benchmark; capacity management; capacity planning; *SP500-65*, pp. 255-261 (Oct. 1980).
- Workloads; cumulative distribution function; events; hardware configuration; model validation; queue; scheduling policies; simulation model; system performance; *SP500-65*, pp. 111-128 (Oct. 1980).
- Workload update; benchmark; capacity management; capacity planning; workload forecasting; *SP500-65*, pp. 255-261 (Oct. 1980).
- Workshop; acceptable work practices; excavation; geotechnical engineering; safety; shoring; soil classification; trench; *NBSIR 79-1935*.
- Workshop; barrier/incentives; hydrogen energy systems; impacts of hydrogen fuel; policy options; societal aspects; *19699*.
- Work surfaces; codes and standards; construction safety; design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; *NBSIR 79-1937*.
- Worst case retrievals; buckets; hashing; open addressing; *19060*.
- W-values; electrons; energy degradation spectra; fano factor; ionization yields; stopping power; *19400*.
- "white" neutron sources; WNR; comparison neutron yields; GELINA; HELIOS; KFK; ORELA; PSR; *SP594*, pp. 920-928 (Sept. 1980).

## X

- X $\alpha$ ; B<sub>2</sub>; CO; C<sub>2</sub>; F<sub>2</sub>; H<sub>2</sub>; local density models; N<sub>2</sub>; O<sub>2</sub>; *19289*.
- Xanthen-0-yl derivatives of urea; carbon-13 NMR; chemical shifts; coupling constants; mass spectrometry; nitrogen-15 NMR; proton NMR; *19312*.
- Xenon; Ag I; energy levels; isoelectric sequence; VUV spectra; wavelengths; *19069*.
- Xenon; energy levels; theta-pinch; wavelengths; *19117*.
- Xenotime; yttrium orthophosphate; yttrium phosphate; absorption spectra; calcite; flux growth; laser damage; neodymium:glass; polarizer; pyrophosphate; *SP568*, pp. 137-140 (July 1980).
- XPS; AES; chemisorption; EELS; electron spectroscopy; photoemission; UPS; *19176*.
- XRF analysis. <sup>252</sup>Cf; metal exploration; natural gamma radiation; neutron activation analysis; neutron inelastic scattering; nuclear cross sections; nuclear reactors; radiative neutron capture; reaction interferences; *SP594*, pp. 615-626 (Sept. 1980).
- X-radiation of intensifier screens; fluorescent screens; intensifier screen standards; radiographic intensifier screen efficiency; screen evaluations; sensitivity of screens; spectroradiometry of screens; *19234*.
- X-ray absorption-edge densitometry; densitometer evaluation; uranium and plutonium solutions assay; *SP582*, pp. 633-650 (June 1980).
- X-ray continuum; backscattered electrons; continuum x-ray loss; electron probe; Monte Carlo method for electron trajectories; particle analysis; quantitative analysis; *19867*.
- X-ray diffraction; ammonium nitrate; crystal structure; hydrogen bonding; neutron diffraction; phase transitions; *19897*.
- X-ray diffraction; bond delocalized dianion; oxocarbon; single-crystal; structure refinement; *J. Res.* 85, No. 2, 87-97 (Mar.-Apr. 1980).
- X-ray diffraction; crystal structure; heteropoly complexes; hydrogen bonds; molybdoarsinate; neutron diffraction; *19846*.
- X-ray diffraction; crystal structures; lattice constants; powder patterns; reference intensities; standard; *Monogr. 25, Section 17*.
- X-ray diffraction; cuprous chloride; diamond cell; optical microscopy; phase transition; resistivity; *19687*.
- X-ray diffraction; [Et<sub>3</sub>P]<sub>2</sub>PtWS<sub>4</sub>; molecular structure; Pt-W



- complex; single crystal; ternary metal sulfide; 19172.
- X-ray diffraction; electron microscopy; Fe-Ni alloys; martensite; shock deformation; Tishomingo meteorite; 19947.
- X-ray diffraction; electro-optical detectors; flash x-ray generators; synchrotron x-radiation; 19714.
- X-ray edge; electron-hole pairs; molecular processes; surface reactions; 19837.
- X-ray exams; compact range; data; daylighting; energy; environmental; shale oil; SRM; weights and measures; *DIM/NBS* 64, No. 6, 1-24 (1980).
- X-ray fluorescence; accountability; accuracy; gamma spectrometry; mass spectrometry; nondestructive assay; nuclear safeguards; precision; reference materials; special nuclear materials; SP582.
- X-ray fluorescence; automation; data processing; HTGR spent fuel reprocessing; in-line measurements; off-line measurements; process control; remote pipettors; remote sample preparation; SNM accountability; SP582, pp. 55-65 (June 1980).
- X-ray fluorescence; chemical profiling; energy dispersive; macrosegregation; monochromatic incident x-ray beam; multiphase structure; 19959.
- X-ray fluorescence; x-ray microanalysis; x-ray spectrometry; electron probe microanalysis; energy dispersive x-ray spectrometry; solid state x-ray detectors; 19434.
- X-ray fluorescence analysis; accountability; computer-based system; dynamic concentration measurements; inventory control; nondestructive measurements; on-line real-time measurements; plutonium concentration and isotopics determinations; SP582, pp. 584-601 (June 1980).
- X-ray fluorescence analysis; dissolver solution; slurry analysis; SNM assay; solution analysis; total sampling; SP582, pp. 547-554 (June 1980).
- X-ray fluorescence spectrometry; calibration standards; focused-ion beam sputtering; thin films; 19871.
- X-ray image magnifier; background scattering; collimation; high resolution; image intensifier; image signals; microradiography; monochromatic radiography; real-time radiography; 19863.
- X-ray image storage; digital image requirement; image information; information content; medical x-ray image; 19134.
- X-ray imaging system;  $^{125}\text{I}$  x-ray source; microchannel plate; portable; rare-earth scintillator; small-format; 19402.
- X-ray interferometry; atomic weights; Avogadro's constant; gamma-ray spectroscopy; stabilized lasers; wavelength standards; 19488.
- X-ray laser; computerized axial tomography; Fresnel zone; holographic reconstruction; imaging; laminagraphy; nondestructive testing; radiography; three-dimensional radiography; tomography; 19855.
- X-ray lithography; electron-beam lithography; metal-oxide-semiconductor device; process-induced radiation damage; radiation damage; semiconductor devices; very large scale integration; 19162.
- X-ray microanalysis; aluminum wiring; duplex connectors; high resistance junctions; junction resistance; scanning electron microscopy; *J. Res.* 85, No. 6, 429-440 (Nov.-Dec. 1980).
- X-ray microanalysis; electron probe microanalysis; glass particles; mineral particles; Monte Carlo methods; particle; peak-to-background ratios; quantitative analysis; 19921.
- X-ray microanalysis; x-ray spectrometry; electron probe microanalysis; energy dispersive x-ray spectrometry; solid state x-ray detectors; x-ray fluorescence; 19434.
- X-ray neutron; applications; lattice parameters; peak shape; powder diffraction; profile fitting; SP567.
- X-ray opacification; dental composite resin restorations; finishability; gelled inorganic "polymers"; microporous filler; system nontoxicity; *U.S. Patent* 4,217,264.
- X-ray photoelectron spectroscopy; Auger-electron spectroscopy; ion-scattering spectroscopy; quantitative analysis; secondary-ion mass spectroscopy; surface analysis; 19293.
- X-ray photoelectron spectroscopy; binding energies; copper; ESCA; gold; relative intensities; round robin; 19202.
- X-ray proportional-counter; Apollo-15 and -16; gamma-ray spectrometers; lunar chemical analysis; 19129.
- X rays; absorption correction; diffractometers; flat-cone; macromolecules; neutrons; single-crystal; Weissenberg methods; 19509.
- X rays; attenuation coefficient; coherent scattering; Compton scattering; gamma rays; pair production; photoelectric absorption; photons; triplet production; *JPCRD* 9, No. 4, 1023-1148 (1980).
- X rays; calibration; diagnostic x-rays; electrical measurements; health; radiation; radiation safety; safety; *NBSIR* 80-2072.
- X rays; crystal diffraction; gamma-ray energy standards; 19302.
- X rays; dust grains; molecular clouds; star formation; supernovae; supernova remnants; 19384.
- X-ray scattering; methyl group; molecular reorientation; neutron scattering; nitromethane; quantum tunnelling; 19809.
- X-ray scattering; methyl group; molecular reorientation; neutron scattering; nitromethane; quantum tunnelling; 19810.
- X-ray sources; chromosphere sun; emission-line stars; late-type stars; stellar chromospheres; stellar winds; ultraviolet spectra; 19523.
- X-ray sources; flare stars; stellar chromospheres; stellar coronae; ultraviolet spectra; 19269.
- X-ray sources; late-type stars; stellar coronae; 19501.
- X-ray spectra; computer program; fitting Gaussian profiles; incomplete charge collection; lithium-drifted silicon detector; sequential simplex procedure; 19130.
- X-ray spectrometry; analytical electron microscope; energy dispersive x-ray spectrometry; scanning electron microscope; silicon (Li) detector; spectral artifacts; 19631.
- X-ray spectrometry; electron probe microanalysis; energy dispersive x-ray spectrometry; solid state x-ray detectors; x-ray fluorescence; x-ray microanalysis; 19434.
- X-ray spectroscopy; activation analysis; computers; data processing; gamma-ray spectroscopy; 19128.
- X-ray spectroscopy; adsorption; Franck-Condon; lineshapes; photoelectron spectroscopy; 19209.
- X rays, sources; x rays, spectra; stars, coronae; stars, flare; 19476.
- X rays, spectra; stars, coronae; stars, flare; x rays, sources; 19476.
- X-ray structure determination; zwitterion; inner salt; iodonium compound; reaction mechanism; synthetic intermediate; 19939.
- X-ray telescope; CsI scintillator; energy resolution; low-energy gamma rays; microchannel plates; position-sensitive detector; 19401.
- X-ray topography; Bragg diffraction; double crystal diffraction; nickel single crystal; process of crystal growth; subgrain misorientation; surface reflection; 19727.
- XX Virginis; cepheids; population II cepheids; 19148.

## Y

- Y-doped  $\text{CeO}_2$ ;  $\text{CeO}_2$ ; conducting ceramic; conductivity; diffusion; oxygen conductor; slow transient effect; transport; 19444.
- Yeast; biological matrix; bovine liver; certified reference materials; chromium; foods; interlaboratory study; standard reference materials; 19420.
- Yield; integrated circuit; process control; reliability; test pattern; test structure; transistors; 19244.
- Yield stress; brittle failure; failure criteria; flaws; fracture;  $K_{Ic}$ ; laser windows; Weibull; SP568, pp. 151-159 (July 1980).
- Y, Nb, Gd, W and  $\text{Au}(n, \gamma)$ ; statistical model calculations; SP594, pp. 323-327 (Sept. 1980).
- Youden graphical analysis; collaborative reference programs; history; interlaboratory testing program; laboratory evaluation; National Bureau of Standards; paper; paperboard; TAPPI; test methods; 19321.
- Youden two-sample analysis; collaborative reference program; test method; interlaboratory testing; laboratory evaluation;



linear model; measuring process; proficiency testing; *SP591*, pp. 25-30 (Aug. 1980).

Young's modulus; bulk modulus; elastic constants; physical-property variability; Poisson's ratio; shear modulus; sound velocity; stainless steel; *19246*.

Young's modulus; longitudinal acoustic mode; polyoxymethylene; polypropylene; Raman spectroscopy; *19895*.

Yrast level; gamma-ray production cross section; gamma-ray strength function; spin-dependent evaporation model; *SP594*, pp. 775-777 (Sept. 1980).

Yrast states; atomic transition probabilities; beam-foil method; cascading; core-excited states; *19347*.

Ytterbium; Auger; core-holes; mixed-valence; photoionization; resonance; *19853*.

Yttria-doped silicon nitride; ceramic; high voltage electron microscopy; *in situ*; oxidation; silicon nitride; *19605*.

Yttria-doped silicon nitride; ceramic; high voltage electron microscopy; *in situ*; oxidation; silicon nitride; *NBSIR 80-2075*.

Yttrium lithium fluoride; advanced laser materials; crystal growth; crystalline fluorides; Faraday rotator; high power laser materials; optical damage threshold; top-seeded solution technique; two photon absorption; uniaxial crystal; *SP568*, pp. 127-135 (July 1980).

Yttrium orthophosphate; yttrium phosphate; absorption spectra; calcite; flux growth; laser damage; neodymium:glass; polarizer; pyrophosphate; xenotime; *SP568*, pp. 137-140 (July 1980).

Yttrium phosphate; absorption spectra; calcite; flux growth; laser damage; neodymium:glass; polarizer; pyrophosphate; xenotime; yttrium orthophosphate; *SP568*, pp. 137-140 (July 1980).

## Z

Zeeman laser; stabilized laser; wavelength standards; *19740*.

Zero shift; adhesive; backing; connection; environment; gage element; leads; load; protective coating; resistance; sensitivity change; stability; strain gages; structure; transducers; *19049*.

Zinc; aluminum; coatings; electrodeposition; epitaxy; tin aluminum; *19730*.

Zinc; aluminum; electrodeposition; epitaxy; plating coatings; *19657*.

Zinc-blende structure; covalent bonding; diamond structure; elastic constants; gallium arsenide; indium antimonide; ionicity; optical phonons; Raman scattering; semiconductors; stress; *19580*.

Zinc in dental amalgam; comprehensive strength of amalgam; density of dental amalgam; dental amalgam; dimensional change in dental amalgam; mercury/alloy ration in dental amalgam; mercury content in dental amalgam; *19632*.

Zinc oxide; electrically conducting ceramics; electrical transmission; lightning arresters; nonlinear resistors; semiconductors; surge arresters; varistors; voltage-variable resistors; *NBSIR 79-1939*.

Zinc oxide varistors; dc transmission; deep-level measurements; energy conservation; measurement methods; neutron transmutation doped silicon; power-device grade silicon; resistivity variations; silicon; spreading resistance measurements; *NBSIR 80-2061*.

Zinc point; fixed point; freezing point; *19081*.

Zinc selenide; zinc sulfide; absorption; coatings; internal reflectance spectroscopy; silicon monoxide; thorium fluoride; *SP568*, pp. 247-256 (July 1980).

Zinc sequence; beryllium sequence; collision strength; effective Gaunt-factor; electron impact excitation; magnesium sequence; *19353*.

Zinc sulfide; absorption; coatings; internal reflectance spectroscopy; silicon monoxide; thorium fluoride; zinc selenide; *SP568*, pp. 247-256 (July 1980).

Zirconia; ceramic oxides; electrodes;  $\text{LaCrO}_3$ ; magnetohydrodynamics; spinels; *19644*.

Zirconium; energy levels; ion; ionization energy; spectrum; wa-

lengths; *19118*.

Zirconium; spectra; ultraviolet; *19543*.

ZnSe; absorption; calculated performance;  $\text{CO}_2$  laser; holographic interferometry; measured performance; optical path difference; temperature profile; thermal distortion; thermal lensing; *SP568*, pp. 73-89 (July 1980).

ZnSe; bulk optical absorption coefficient; optoacoustic spectroscopy; photoacoustic spectroscopy; surface optical absorption coefficient; *SP568*, pp. 293-300 (July 1980).

ZnSe; bulk optical absorption coefficient; optoacoustic spectroscopy; photoacoustic spectroscopy; surface optical absorption coefficient;  $\text{ThF}_4$ ; *SP568*, pp. 301-311 (July 1980).

ZPPR; IAEA safeguards; neutron detectors; portal monitors; radiation detectors; SNM monitors; *SP582*, pp. 365-371 (June 1980).

ZPR critical assembly; delayed neutron data; eigenvalue; ENDF/B-IV; integral experiments; reaction rate ratios; reactivity worths; *SP594*, pp. 297-306 (Sept. 1980).

Zr, Mo, and Sm isotopes; *SP594*, pp. 135-138 (Sept. 1980).

Zr(n,total) cross section; single-level analysis; *SP594*, pp. 319-322 (Sept. 1980).

Zr-95/Cs-137; burn-up; cooling time; Cs-134/Cs-137 ratios; Pu/U; spent fuel; *SP582*, pp. 509-516 (June 1980).

Zwanzig-Mori theory; depolarized light scattering; lattice-gas; Lorentzian shape; oscillatory; parameters; polarizability; rare-gas; *19756*.

Zwitterion; inner salt; iodonium compound; reaction mechanism; synthetic intermediate; x-ray structure determination; *19939*.

0.02-350 eV; fast chopper; Nd-145; resonance parameters; total cross section; *SP594*, p. 877 (Sept. 1980).

0.5-60 MeV; carbon; hydrogen; iron; neutrons; oxygen; total cross sections; *SP594*, pp. 34-38 (Sept. 1980).

1-hexene; allylic resonance energy; allyl radicals; biradical; cyclohexane; decomposition; decyclization; isomerization; olefins; shock tube; *19784*.

1 ns; 1.06  $\mu\text{m}$  damage; absorption; electric-field strength; film materials; impurities; overcoat; polished surfaces; pulsedwidth dependence; thin-film coatings; *SP568*, pp. 391-403 (July 1980).

1.06  $\mu\text{m}$  damage; absorption; electric-field strength; film materials; impurities; overcoat; polished surfaces; pulsedwidth dependence; thin-film coatings; 1 ns; *SP568*, pp. 391-403 (July 1980).

1,1-difluoroethylene; diode laser spectroscopy; heterodyne measurement; high-precision; line assignments; line frequencies; rapid measurement technique; *19186*.

1.15  $\mu\text{m}$ ; frequency; He-Ne laser; nonlinear optics; visible frequencies; *19709*.

$^{12}\text{C}$ ; absolute measurement; activation; electric dipole; electroexcitation; giant resonance; *19763*.

$^{12}\text{C}$ ; dispersion relation; giant quadrupole resonance; photon scattering; *19735*.

12-membered cage, x-ray diffraction;  $((\text{C}_7\text{H}_7)_3\text{P})_4\text{Cu}_4\text{W}_2\text{O}_{25}\text{S}_6$ ; coordination complex; metalloenzymes, single crystal; *19173*.

$^{125}\text{I}$  x-ray source; microchannel plate; portable; rare-earth scintillator; small-format; x-ray imaging system; *19402*.

$^{13}\text{C}$ ; annealing; drawn; NMR; noncrystalline; orientation; polyethylene; *19686*.

14.73 MeV;  $^{56}\text{Fe}(n,p)$  cross section; evaluation; *SP594*, pp. 980-984 (Sept. 1980).

$^{165}\text{Ho}$  single crystal;  $^{166m}\text{Ho}$ ; gamma rays; low temperatures; multiaxes nuclear spin system;  $\gamma$ -ray multipolarity; *19620*.

$^{166m}\text{Ho}$ ; gamma rays; low temperatures; multiaxes nuclear spin system;  $\gamma$ -ray multipolarity;  $^{165}\text{Ho}$  single crystal; *19620*.

2DB; calculated neutron spectrum; fast breeder blanket facility; fast reactor; neutron spectrum; proton-recoil; *SP594*, pp. 568-571 (Sept. 1980).

20 microK thermostat; comparison with  $\text{He}^3$ , Ne; critical anomaly; dielectric constant; differential capacitance cell;  $\text{SF}_6$ ; *19484*.

2124-T851; 7075; 7075-T6; 7075-T7351; air; alternate immersion



test; aluminum alloys; ductility; elongation; heat treatment; NaCl; plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 19622.

$^{22}\text{Ne}(e,e')$ ; deduced  $J$ ,  $\pi$ ,  $B(CL)$ ; enriched  $^{22}\text{Ne}$  target;  $E = 60$  to 110 MeV; 19691.

$^{238}\text{U}$ ; Doppler effect; fission; gas target; molecular vibrations; neutron reactions; 19146.

25 gram capacity bomb calorimeter; bomb calorimetry; gross calorific values; refuse-derived-fuels; sample characterization; sample processing effects; *NBSIR 80-1968*.

30 MHz to 180 MHz; dipole radiator for EMI measurements; electromagnetic field measurement; spherical dipole; standard field radiator; 19737.

4-aminopyridine; coulometry; Faraday constant; 19814.

5-10 MeV; angular distributions; Cr, Fe, Ni(n, $\alpha$ ) cross sections; *SP594*, pp. 844-847 (Sept. 1980).

$^{56}\text{Fe}(n,p)$  cross section; evaluation; 14.73 MeV; *SP594*, pp. 980-984 (Sept. 1980).

6-amino-6-deoxy-D-galactose-6- $^{15}\text{N}$  derivatives; carbon-13 n.m.r.; nitrogen-15 coupling constants; nucleophilic substitution; paramagnetic broadening; proton n.m.r.; selective coupling; 19670.

$^{60}\text{CoCo}$   $\gamma$ -ray anisotropy thermometry; cryogenic temperature scale; Josephson junction; noise thermometry; nuclear orientation; thermometry; 19685.

60 Hz ac and dc; compressed gas; corona; electron avalanche; inception voltage; ionization; ion mobilities; partial discharge; photodetachment; space charge; sulfur hexafluoride ( $\text{SF}_6$ ); uv radiation; 19786.

7075; 7075-T6; 7075-T7351; air; alternate immersion test; aluminum alloys; ductility; elongation; heat treatment; NaCl; plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 2124-T851; 19622.

7075-T6; 7075-T7351; air; alternate immersion test; aluminum alloys; ductility; elongation; heat treatment; NaCl; plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 2124-T851; 7075; 19622.

7075-T7351; air; alternate immersion test; aluminum alloys; ductility; elongation; heat treatment; NaCl; plate gage; reduction in area; slow strain rate technique; strain rate; stress corrosion cracking; 2124-T851; 7075; 7075-T6; 19622.



## 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).  
    Samford University, Harwell G. Davis Library (1884).  
Enterprise: Enterprise State Junior College, Learning Resource Center (1967).  
Florence: University of North Alabama, Collier Library (1932).  
Gadsden: Gadsden Public Library (1963).  
Huntsville: University of Alabama, Huntsville Campus Library (1964).  
Jacksonville: Jacksonville State University, Ramona Wood Library (1929).  
Maxwell A.F. Base: Air University Library (1963).  
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.  
Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).  
St. Bernard: St. Bernard College, Herman J. Heidrich Library (1962).  
Troy: Troy State University, Lurleen B. Wallace Educational Resources Center (1963).  
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).  
University:  
    University of Alabama, School of Law Library (1967).  
    University of Alabama Library (1860)-REGIONAL

### ALASKA

Anchorage:  
    Supreme Court of Alaska Library (1973).  
    University of Alaska, Anchorage Library (1961).  
College: University of Alaska, Elmer E. Rasmuson Library (1922).  
Juneau: Alaska State Library (1964).  
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 and Archives (unknown)-REGIONAL.  
    Grand Canyon College, Fleming Library.  
    Phoenix Public Library (1917).  
Prescott: Yavapai College Library (1976).  
Tempe:  
    Arizona State University, Matthews Library (1944).  
    Arizona State University, College of Law Library (1977).  
Thatcher: Eastern Arizona Junior 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 Library (1925).  
Conway: Hendrix College, O. C. Bailey Library (1903).  
Fayetteville: University of Arkansas Library (1907).  
Little Rock:  
    Arkansas Supreme Court Library (1962).  
    Little Rock Public Library (1953).  
    University of Arkansas at Little Rock Library (1973).  
Magnolia: Southern Arkansas University, Mogale 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 College, Beaumont Memorial Library (1963).  
State College: 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 College Library (1963).  
Bakersfield:  
    California State College, Bakersfield Library (1974).  
    Kern County Library System (1943).  
Berkeley:  
    University of California, General Library (1907).  
    University of California, Law Library, Earl Warren Legal Center (1963).  
Carson:  
    California State University, Dominguez Hills, Educational Resources Center (1973).  
    Carson Regional Library (1973).  
Chico: Chico State University Library (1962).  
Claremont: Pomona College Documents Collection, Honnold Library (1913).  
Coalinga: West Hills Community College (1978).



Compton: Compton Library (1972).  
 Culver City: Culver City Library (1966).  
 Davis:  
   University of California at Davis Library (1953).  
   University of California at Davis, School of Law Library (1972).  
 Downey: Downey City Library (1963).  
 Fresno:  
   California State University Library (1962).  
   Fresno County Free Library (1920).  
 Fullerton: California State University, Fullerton Library (1963).  
 Garden Grove: Garden Grove Regional Library (1963).  
 Gardena: Gardena Public Library (1966).  
 Hayward: California State College at Hayward Library (1963).  
 Huntington Park: Huntington Park Library, San Antonio Region (1970).  
 Inglewood: Inglewood Public Library (1963).  
 Irvine: University of California at Irvine Library (1963).  
 La Jolla: University of California, San Diego, University Library (1963).  
 Lakewood: Angelo Iacoboni Public Library (1970).  
 Lancaster: Lancaster Regional Library (1967).  
 Long Beach:  
   California State University at Long Beach Library (1962).  
   Long Beach Public Library (1933).  
 Los Angeles:  
   California State College at Los Angeles, John F. Kennedy Memorial Library (1956).  
   Los Angeles County Law Library (1963).  
   Los Angeles Public Library (1891).  
   Loyola University of Los Angeles Library (1933).  
   Occidental College, Mary Norton Clapp Library (1941).  
   Pepperdine University Library (1963).  
   Southwestern University, School of Law Library (1975).  
   University of California at Los Angeles Library (1932).  
   University of California at Los Angeles, Law Library (1958).  
   University of Southern California Library (1933).  
 Menlo Park: Department of the Interior, Geological Survey Library (1962).  
 Montebello: Montebello Library (1966).  
 Monterey: Naval Postgraduate School Library (1963).  
 Monterey Park: Bruggemeyer Memorial Library (1964).  
 Northridge: California State University at Northridge, Delmar T. Oviatt Library (1958).  
 Norwalk: Los Cerritos Regional Library (1973).  
 Oakland:  
   Mills College Library (1966).  
   Oakland Public Library (1923).  
 Ontario: Ontario City Library (1974).  
 Pasadena:  
   California Institute of Technology, Robert A. 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.  
   Sacramento City-County Library (1880).  
   Sacramento County Law Library (1963).  
   Sacramento State University Library (1963).  
 San Bernardino: San Bernardino County Free Library (1964).

San Diego:  
   San Diego State University, Love Library (1962).  
   San Diego County Law Library (1973).  
   San Diego County Library (1966).  
   San Diego Public Library (1895).  
   University of San Diego Law Library (1967).  
 San Francisco:  
   Mechanics' Institute Library (1889).  
   San Francisco Public Library (1889).  
   San Francisco State College, Social Science and Business Library (1955).  
   Supreme Court of California Library (1972).  
   U.S. Court of Appeals for Ninth Circuit Library (1971).  
   University of San Francisco, Richard A. Gleeson Library (1963).  
 San Jose: San Jose State College Library (1962).  
 San Leandro: San Leandro Community Library Center (1961).  
 San Luis Obispo: California State Polytechnic 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 Library (1963).  
 Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).  
 Stanford: Stanford University Libraries (1895).  
 Stockton: Public Library of Stockton and San Joaquin County (1884).  
 Thousand Oaks: California Lutheran College Library (1964).  
 Torrance: Torrance Civic Center Library (1969).  
 Turlock: Stanislaus State College Library (1964).  
 Valencia: Valencia Library (1972).  
 Ventura: Ventura County Library Services Agency (1975).  
 Visalia: Tulare County Free Library (1967).  
 Walnut: Mount San Antonio College Library (1966).  
 West Covina: West Covina Library (1966).  
 Whittier: Whittier College, Wardman Library (1963).

## CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

## COLORADO

Alamosa: Adams State College, Learning Resources Center (1963).  
 Boulder: University of Colorado Libraries (1879)-REGIONAL.  
 Colorado Springs:  
   Colorado College, Charles Leaming Tutt Library (1880).  
   University of Colorado, Colorado Springs Library (1974).  
 Denver:  
   Auraria Libraries (1978).  
   Colorado State Library (unknown).  
   Denver Public Library (1884)-REGIONAL.  
   Department of Interior, Bureau of Reclamation Library (1962).  
   Regis College, Dayton Memorial Library (1915).  
   Supreme Court Library (1978).  
   University of Denver, Penrose Library (1909).  
   U.S. Court of Appeals for Tenth Circuit Library (1973).  
 Fort Collins: Colorado State University Library (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 Regional Library (1968).  
 Pueblo:  
   Pueblo Regional Library (1893).  
   University Southern Colorado Library, Learning Resources Center (1965).  
 U.S. Air Force Academy: Academy Library (1956).

## CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).  
 Danbury: Western Connecticut State College, Ruth A. Haas Library (1967).  
 Danielson: Quinebaug Valley Community College (1975).  
 Enfield: Enfield Public Library (1967).  
 Hartford:  
   Connecticut State Library (unknown)-REGIONAL.  
   Hartford Public Library (1945).  
   Trinity College Library (1895).  
 Middletown: Wesleyan University Library (1906).  
 Mystic: Marine Historical Association, Inc., G. W. Blunt White Library (1964).  
 New Britain: Central Connecticut State College, Elihu Burritt Library (1973).  
 New Haven:  
   Southern Connecticut State College Library (1968).  
   Yale University Library (1859).  
 New London:  
   Connecticut College Library (1926).  
   U.S. Coast Guard Academy Library (1939).  
 Stamford: Stamford Public Library (1973).  
 Storrs: University of Connecticut, Wilbur Cross Library (1907).  
 Waterbury:  
   Post College, Traurig Library (1977).  
   Silas Bronson Library (1869).  
 West Haven: University of New Haven Library (1971).

## DELAWARE

Dover:  
   Delaware State College, William C. Jason Library (1962).  
   State Department of Community Affairs and Economic Development, Division of Libraries (1972).  
   State Law Library in Kent County (unknown).  
 Georgetown:  
   Delaware Technical and Community College, Southern Branch Library (1968).  
   Sussex County Law Library (1976).  
 Newark: University of Delaware, Morris Library (1907).  
 Wilmington:  
   Delaware Law School Library (1976).  
   New Castle County Law Library (1974).  
   Wilmington Institute and New Castle County Library (1861).

## DISTRICT OF COLUMBIA

Washington:  
   Administrative Conference of U.S. Library (1977).  
   Advisory Commission on Intergovernmental Relations Library (1972).  
   Civil Aeronautics Board Library (1975).  
   Civil Service Commission Library (1963).  
   Department of Commerce Library (1955).

Department of Health, Education, and Welfare Library (1954).  
 Department of Housing and Urban Development Library (1969).  
 Department of the Interior Central Library (1895).  
 Department of Justice Main Library (1895).  
 Department of Labor Library (1976).  
 Department of State Library (1895).  
 Department of State, Office of Legal Advisor, Law Library (1966).  
 Department of Transportation, National Highway Traffic Safety Administration Library (1968).  
 District of Columbia Public Library (1943).  
 Federal City College Library (1970).  
 Federal Deposit Insurance Corporation Library (1972).  
 Federal Election Commission Library (1975).  
 Federal Reserve System Law Library (1976).  
 General Accounting Office Library (1975).  
 General Services Administration Library (1975).  
 Georgetown University Library (1969).  
 Indian Claims Commission Library (1968).  
 Library of Congress, Gift and Exchange Division (1977).  
 National Defense University Library (1895).  
 Navy Department Library (1895).  
 Navy Department, Office of Judge Advocate General Library (1963).  
 Office of Management and Budget Library (1965).  
 Office of The Adjutant General, Department of Army Library (1969).  
 Postal Service Library (1895).  
 Research Library, Board of Governors of the Federal Reserve System (1978).  
 Treasury Department Library (1895).  
 U.S. Court of Appeals, Judge's Library (1975).  
 U.S. Supreme Court Library (1978).  
 Veterans' Administration, Central Office Library (1976).

## FLORIDA

Boca Raton: Florida Atlantic University Library (1963).  
 Clearwater: Clearwater Public Library (1972).  
 Coral Gables: University of Miami Library (1939).  
 Crestview: Robert F. L. Sikes Public Library (1978).  
 Daytona Beach: Volusia County Public Libraries (1963).  
 DeLand: Stetson University, duPont-Ball Library (1887).  
 Fort Lauderdale:  
   Broward County Library System (1967).  
   Nova University Law Library (1967).  
 Fort Pierce: Indian River Community College Library (1975).  
 Gainesville: University of Florida Libraries (1907)-REGIONAL.  
 Jacksonville:  
   Haydon Burns Library (1914).  
   Jacksonville University, Swisher Library (1962).  
   University of North Florida 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: Florida Technological University Library (1966).  
 Palatka: St. Johns River Junior 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 Law Library (1975).  
 Sarasota: Selby Public Library (1970).  
 Tallahassee:  
 Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).  
 Florida State University, R. M. Stozier Library (1941). (1941).  
 Florida Supreme Court Library (1974).  
 State Library of Florida (1929).  
 Tampa:  
 Tampa Public Library (1965).  
 University of South Florida Library (1962).  
 University of Tampa, Merle Kelce Library (1953).  
 Winter Park: Rollins College, Mills Memorial Library (1909).

## GEORGIA

Albany: Albany Public Library (1964).  
 Americus: Georgia Southwestern College, James Earl Carter Library (1966).  
 Athens: University of Georgia Libraries (1907)-REGIONAL.  
 Atlanta:  
 Atlanta Public Library (1880).  
 Atlanta University, Trevor Arnett Library (1962).  
 Emory University, Robert W. 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 Library (1970).  
 Augusta: Augusta College Library (1962).  
 Brunswick: Brunswick-Glyn County Regional Library (1965).  
 Carrollton: West Georgia College, Sanford Library (1962).  
 Columbus: Columbus College, Simon Schwob Memorial Library (1975).  
 Dahlonega: North Georgia College Library (1939).  
 Dalton: Dalton Junior College Library (1978).  
 Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).  
 Macon: Mercer University Library (1964).  
 Marietta: Kennesaw Junior College Library (1968).  
 Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).  
 Mount Berry: Berry College, Memorial Library (1970).  
 Savannah: Savannah Public and Chatham-Effingham Liberty Regional Library (1857).  
 Statesboro: Georgia Southern College Library (1939).  
 Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

## GUAM

Agana: Nieves M. Flores Memorial Library (1962).

## HAWAII

Hilo: University of Hawaii, Hilo Campus Library (1962).  
 Honolulu:  
 Hawaii Medical Library, Inc. (1968).  
 Hawaii State Library (1929).  
 Municipal Reference Library of the City and County of Honolulu (1965).  
 Supreme Court Law Library (1973).  
 University of Hawaii Library (1907)-REGIONAL.  
 Laie: Church College of Hawaii, Woolley Library (1964).  
 Lihue: Kauai Public Library (1967).

Pearl City: Leeward Community College Library (1967).  
 Wailuku: Maui Public Library (1962).

## IDAHO

Boise:  
 Boise State University Library (1966).  
 Boise Public Library and Information Center (1929).  
 Idaho State Law Library (unknown).  
 Idaho State Library (1971).  
 Caldwell: College of Idaho, Terteling Library (1930).  
 Moscow: 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 Library (1932).  
 Carlinville: Blackburn College Library (1954).  
 Carterville: Shawnee Library System (1971).  
 Champaign: University of Illinois Law Library, College of Law (1965).  
 Charleston: Eastern Illinois University, Booth Library (1962).  
 Chicago:  
 Chicago Public Library (1876).  
 Chicago State University Library (1954).  
 DePaul University, Lincoln Park Campus Library (1975).  
 Field Museum of Natural History Library (1963).  
 John Crerar Library (1909).  
 Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).  
 Northeastern Illinois University Library (1961).  
 University of Chicago Law Library (1964).  
 University of Chicago Library (1897).  
 University of Illinois, Chicago Circle Campus Library (1957).  
 Decatur: Decatur Public Library (1954).  
 De Kalb: Northern Illinois University, Swen Franklin Parson Library (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).  
 Jacksonville: MacMurray College, Henry Pfeiffer Library (1929).  
 Kankakee: Olivet Nazarene College, Benner Library and 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).  
 Lockport: Lewis University Library (1952).  
 Macomb: Western Illinois University Memorial Library (1962).  
 Moline: Black Hawk College, Learning Resources Center (1970).  
 Monmouth: Monmouth College Library (1860).  
 Morton Grove: Oakton Community College Library (1976).  
 Mt. Carmel: Wabash Valley College Library (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 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 Library (1966).
- Rockford: Rockford Public Library (unknown).
- Springfield: Illinois State Library (unknown)-REGIONAL.
- 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).
- 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, Walter E. Helmke Library (1965).
  - Public Library of Fort Wayne and Allen County (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 Library (1892).
- Huntington: Huntington College Library (1964).
- Indianapolis:
  - Butler University, Irwin Library (1965).
  - Indiana State Library (unknown)-REGIONAL.
  - Indiana Supreme Court Law Library (1975).
  - Indiana University, Law Library (1967).
  - Indianapolis-Marion County Public Library (1906).
- Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
- Lafayette: Purdue University Library (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).

## IOWA

- Ames: Iowa State University of Science and Technology Library (1907).
- Cedar Falls: University of Northern Iowa Library (1946).
- Council Bluffs:
  - Free Public Library (1885).
  - Iowa Western Community College, Hoover Media Library (1972).
- Davenport: Davenport Public Library (1973).
- Des Moines:
  - Drake University, Cowles Library (1966).
  - Drake University Law Library (1972).

- State Library Commission of Iowa (unknown).
- Public Library of Des Moines (1888).

## Dubuque:

- Carnegie-Stout Public Library (unknown).
- Loras College, Wahlert Memorial Library (1967).
- Fayette: Upper Iowa College, Henderson-Wilder Library (1974).
- Grinnell: Grinnell College, Burling Library (1874).
- Iowa City:
  - University of Iowa, Law Library (1968).
  - University of Iowa Library (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 University, Ramaker Library (1970).
- Sioux City: Sioux City Public Library (1894).

## KANSAS

- Atchison: Benedictine College Library (1965).
- Baldwin City: Baker University Library (1908).
- Colby: Colby Community Junior College Library (1968).
- Emporia: Emporia State University, William Allen White Library (1909).
- Hays: Fort Hays Kansas State College, Forsyth Library (1926).
- Hutchinson: Hutchinson Public Library (1963).
- Lawrence:
  - University of Kansas, Watson Library (1869)-REGIONAL.
  - University of Kansas Law Library (1971).
- Manhattan: Kansas State University, Farrell Library (1907).
- Pittsburg: Pittsburg State University, Porter Library (1952).
- Salina: Kansas Wesleyan University, Memorial Library (1930).
- 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 Library (1901).

## KENTUCKY

- Ashland: Ashland Public Library (1946).
- Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
- Bowling Green: Western Kentucky University, Cravens Graduate Center and Library (1934).
- Covington: Thomas More College Library (1970).
- Danville: Centre College, Grace Doherty Library (1884).
- Frankfort:
  - Kentucky Department of Libraries (1967).
  - Kentucky State University, Blazer Library (1972).
  - State Law Library (unknown).
- Highland Heights: Northern Kentucky University, W. Frank Stealy Library (1973).
- Hopkinsville: Hopkinsville Community College Library (1976).
- Lexington:
  - University of Kentucky, Law Library (1968).
  - University of Kentucky, Margaret I. King Library (1907)-REGIONAL.
- Louisville:
  - Louisville Free Public Library (1904).
  - University of Louisville, Belknap Campus Library (1925).
  - University of Louisville Law Library (1975).
- Morehead: Morehead State University, Johnson Camden Library (1955).
- Murray: Murray State University Library (1924).



Owensboro: Kentucky Wesleyan College Library (1966).  
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

## LOUISIANA

### Baton Rouge:

Louisiana State Library (1976).  
Louisiana State University Law Library (1929).  
Louisiana State University Library (1907)-REGIONAL.  
Southern University Library (1952).

Eunice: Louisiana State University at Eunice, Le Doux Library (1969).

Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).

Lafayette: University of Southwestern Louisiana Library (1938).

Lake Charles: McNeese State University, Frazar Memorial Library (1941).

Monroe: Northeast Louisiana University, Sandel Library (1963).

Natchitoches: Northwestern State University, Watson Memorial Library (1887).

### New Orleans:

Isaac Delgado College, Moss Technical Library (1968).  
Law Library of Louisiana (unknown).  
Loyola University Library (1942).  
New Orleans Public Library (1883).  
Southern University in New Orleans Library (1962).  
Tulane University, Howard-Tilton Memorial Library (1942).  
Tulane University Law Library (1976).  
U.S. Court of Appeals, Fifth Circuit Library (1973).  
University of New Orleans Library (1963).

Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).

Ruston: Louisiana Technical University Library (1896)-REGIONAL.

### Shreveport:

Louisiana State University at Shreveport Library (1967).  
Shreve Memorial Library (1923).

Thibodaux: Francis T. Nicholls State University, Leonidas Polk Library (1962).

## MAINE

### Augusta:

Maine Law and Legislative Reference Library (1973).  
Maine State Library (unknown).

Bangor: Bangor Public Library (1884).

Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).

Castine: Maine Maritime Academy, Nutting Memorial Library (1969).

Lewiston: Bates College Library (1882).

Orono: University of Maine, Raymond H. Fogler Library (1907)-REGIONAL.

### Portland:

Portland Public Library (1884).  
University of Maine Law Library (1964).

Springvale: Nason College Library (1961).

Waterville: Colby College Library (1884).

## MARYLAND

### Annapolis:

Maryland State 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, Langsdale Library (1973).

University of Maryland, Baltimore County Library (1971).

University of Maryland, School of Law Library (1969).

Bel Air: Harford Community College Library (1967).

Beltsville: Department of Agriculture, National Agricultural Library (1895).

Bethesda: National Library of Medicine Library (1978).

Chestertown: Washington College, Chester 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).

Germantown: Energy Research & Development Adm. Library (1963).

Patuxent River: 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).

Westminster: Western Maryland College Library (1896).

## MASSACHUSETTS

### Amherst:

Amherst College Library (1884).  
University of Massachusetts, Godell Library (1907).

Belmont: Belmont Memorial Library (1968).

### Boston:

Boston Athenaeum Library (unknown).  
Boston College, Bapst Library (1963).  
Boston Public Library (1859)-REGIONAL.  
Northeastern University, Dodge Library (1962).  
State Library of Massachusetts (unknown).

Brookline: Public Library of Brookline (1925).

### Cambridge:

Harvard College Library (1860).  
Massachusetts Institute of Technology Libraries (1946).  
Middlesex County Law Library (1978).

Chicopee: Our Lady of the Elms College Library (1969).

Lowell: University of Lowell/North Campus, Alumni/Lydon Library (1952).

Lynn: Lynn Public Library (1953).

Marlborough: Marlborough Public Library (1971).

Medford: Tufts University Library (1899).

Milton: Curry College Library (1972).

New Bedford: New Bedford Free Public Library (1858).

North Dartmouth: Southeastern Massachusetts University Library (1965).

North Easton: Stonehill College, Cushing-Martin Library (1962).

Springfield: Springfield City Library (1966).

Waltham: Brandeis University, Goldfarb 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 Library (1972).  
Worcester Public Library (1859).

## MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).

Allendale: Grand Valley State College Library (1963).

Alma: Alma College, Monteith Library (1963).

### Ann Arbor:

Great Lakes Basin Commission Library (1971).  
University of Michigan, Harlan Hatcher Library (1884).

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 Public Library (1868)–REGIONAL.  
   Marygrove College Library (1965).  
   Mercy College of Detroit Library (1965).  
   University of Detroit Library (1884).  
   Wayne State University Law Library (1971).  
   Wayne State University, G. Flint Purdy Library (1973).  
 Dowagiac: Southwestern Michigan College Library (1971).  
 East Lansing:  
   Michigan State University, Law Library (1971).  
   Michigan State University Library (1907).  
 Escanaba: Michigan State Library, Upper Peninsula Branch (1964).  
 Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).  
 Flint:  
   Flint Public Library (1967).  
   University of Michigan, Flint Library (1959).  
 Grand Rapids:  
   Calvin College Library (1967).  
   Grand Rapids Public Library (1876).  
 Houghton: Michigan Technological University Library (1876).  
 Jackson: Jackson District Library (1965).  
 Kalamazoo:  
   Kalamazoo Library System (1907).  
   Western Michigan University, Dwight B. Waldo Library (1963).

Lansing: Michigan State Library (unknown)–REGIONAL.  
 Livonia: Schoolcraft College Library (1962).  
 Marquette: Northern Michigan University, Olsen 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 System (1876).  
 Rochester: Oakland University, Kresge Library (1964).  
 Saginaw: Hoyt Public Library (1890).  
 Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).  
 University Center: Delta College Library (1963).  
 Warren: Warren Public Library, Arthur J. Miller Branch (1973).  
 Wayne: Wayne Oakland Federated Library System (1957).  
 Ypsilanti: Eastern Michigan University Library (1965).

## 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, Wilson Library (1907)–REGIONAL.  
 Moorhead: Moorhead State University Library (1956).  
 Morris: University of Minnesota at Morris Library (1963).  
 Northfield:  
   Carleton College Library (1930).  
   St. Olaf College, Rolvaag Memorial Library (1930).  
 St. Cloud: St. Cloud State University Library (1962).  
 St. Paul:  
   Minnesota Historical Society Library (1867).

Minnesota State Law Library (unknown).  
 St. Paul Public Library (1914).  
 University of Minnesota, St. Paul Campus Library (1974).  
 Saint 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).  
 Clinton: Mississippi College School of Law Library (1977).  
 Columbus: Mississippi State University for Women, J. C. Fant Memorial Library (1920).  
 Hattiesburg: University of Southern Mississippi Library (1935).  
 Jackson:  
   Jackson State College Library (1968).  
   Millsaps College, Millsaps-Wilson Library (1963).  
   Mississippi Library Commission (1947).  
   Mississippi State Law Library (unknown).  
 Lorman: Alcorn Agricultural and Mechanical College Library (1970).  
 State College: Mississippi State University, Mitchell Memorial Library (1907).  
 University:  
   University of Mississippi Library (1833)–REGIONAL.  
   University of Mississippi, School of Law Library (1967).

## MISSOURI

Cape Girardeau: Southeast Missouri State University, Kent Library (1916).  
 Columbia: University of Missouri Library (1862).  
 Fayette: Central Methodist College 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 Library (1917).  
   University of Missouri at Kansas City, General Library (1938).  
 Kirksville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).  
 Liberty: William Jewell College Library (1900).  
 Rolla: University of Missouri at Rolla Library (1907).  
 St. Charles: Lindenwood College, 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 (1866).  
   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).  
 Springfield:  
   Drury College, Walker Library (1874).  
   Southwest Missouri State College Library (1963).  
 Warrensburg: Central Missouri State College, Ward Edwards Library (1914).



## MONTANA

Billings: Eastern Montana College Library (1924).  
Bozeman: Montana State University Library (1907).  
Butte: Montana College of Mineral Science and Technology Library (1901).  
Helena:  
    Carroll College Library (1974).  
    Montana Historical Society Library (unknown).  
    Montana State Library (1966).  
    State Law Library of Montana (1977).  
Missoula: University of Montana Library (1909)-REGIONAL.

## NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).  
Crete: Doane College, Whitin Library (1944).  
Fremont: Midland Lutheran College Library (1924).  
Kearney: Kearney State College, Calvin T. Ryan Library (1962).  
Lincoln:  
    Nebraska Publications Clearinghouse, Nebraska Library Commission (1972)-REGIONAL.  
    Nebraska State Library (unknown).  
    University of Nebraska, Don L. Love Memorial Library (1907)-JOINT REGIONAL.  
Omaha:  
    Creighton University, Alumni Library (1964).  
    Omaha Public 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 District Library (1974).  
    University of Nevada at Las Vegas, James R. Dickinson Library (1959).  
Reno:  
    Nevada State Historical Society Library (1974).  
    University of Nevada Library (1907)-REGIONAL.

## NEW HAMPSHIRE

Concord:  
    Franklin Pierce Law Center Library (1973).  
    New Hampshire State Library (unknown).  
Durham: University of New Hampshire Library (1907).  
Franconia: Franconia College Library (1972).  
Hanover: Dartmouth College, Baker Library (1884).  
Henniker: New England College Library (1966).  
Manchester:  
    Manchester City Library (1884).  
    New Hampshire College, H.A.B. Shapiro Memorial Library (1976).  
    St. Anselm's College, Geise Library (1963).  
Nashua: Nashua Public Library (1971).

## NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).  
Bloomfield: Free Public Library of Bloomfield (1965).  
Bridgeton: Cumberland County Library (1966).  
Camden: Rutgers University-Camden Library (1966).

Convent Station: College of St. Elizabeth, Mahoney Library (1938).  
Dover: County College of Morris Library, Learning Resources Center (1975).  
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:  
    Free Public Library of Jersey City (1879).  
    Jersey City State College, Forrest A. Irwin Library (1963).  
Lawrenceville: Rider College Library (1975).  
Madison: Drew University, Rose Memorial Library (1939).  
Mahwah: Ramapo College Library (1971).  
Mount Holly: Burlington County Library (1966).  
New Brunswick:  
    Free Public Library (1908).  
    Rutgers University Library (1907).  
Newark:  
    Newark Public Library (1906)-REGIONAL.  
    Rutgers-The State University, John Cotton Dana Library (1966).  
Passaic: Passaic Public Library (1964).  
Phillipsburg: Phillipsburg Free Public Library (1976).  
Plainfield: Plainfield Public Library (1971).  
Pomona: Stockton State College Library (1972).  
Princeton: Princeton University Library (1884).  
Rutherford: Fairleigh Dickinson University, Messler Library (1953).  
Shrewsbury: Monmouth County Library (1968).  
South Orange: Seton Hall University Library (1947).  
Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).  
Toms River: Ocean County College Learning Resources Center (1966).  
Trenton:  
    New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).  
    Trenton Free Public Library (1902).  
Union: Kean College of New Jersey, Nancy Thompson Library (1973).  
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).  
Wayne: Wayne Public Library (1972).  
West Long Branch: 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, Zimmerman Library (1896)-REGIONAL.  
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 Library (1962).  
Santa Fe:  
    New Mexico State Library (1960)-REGIONAL.  
    Supreme Court Law Library (unknown).  
Silver City: Western New Mexico University, Miller Library (1972).



## NEW YORK

### Albany:

New York State Library (unknown)-REGIONAL.

State University of New York at Albany Library (1964).

### Auburn: Seymour Library (1972).

Bayside: Queensborough Community College Library (1972).

Binghamton: State University of New York at Binghamton Library (1962).

Brockport: State University of New York, Drake Memorial Library (1967).

### Bronx:

Herbert H. Lehman College Library (1967).

New York Public Library, Mott Haven Branch (1973).

Bronxville: Sarah Lawrence College Library (1969).

### Brooklyn:

Brooklyn College Library (1936).

Brooklyn Law School, Law Library (1974).

Brooklyn Public Library (1908).

Polytechnic Institute of Brooklyn, 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, Lockwood Memorial Library (1963).

Canton: St. Lawrence University, Owen D. Young Library (1920).

Cheektowago: Cheektowago Public Library (1978).

Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).

Cortland: State University of New York, College 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 (1974).

Elmira: Elmira College, Gannett-Tripp Learning Center (1956).

Farmingdale: State University Agricultural and Technical Institute at Farmingdale Library (1917).

Flushing: Queens College, Paul Klapper Library (1939).

Garden City: Adelphi University, Swirbul Library (1966).

Geneseo: State University College, Milne Library (1967).

Greenvale: C. W. Post College, B. Davis Schwartz Memorial Library (1965).

Hamilton: Colgate University Library (1902).

Hempstead: Hofstra University Library (1964).

### Ithaca:

Cornell University Library (1907).

New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).

### Jamaica:

Queens Borough Public Library (1926).

St. John's University Library (1956).

Kings Point: U.S. Merchant Marine Academy Library (1962).

Mount Vernon: Mount Vernon Public Library (1962).

New Paltz: State University College Sojourner Truth Library (1965).

### New York City:

City University of New York, City College Library (1884).

College of Insurance, Ecker Library (1965).

Columbia University Libraries (1882).

Cooper Union Library (1930).

Fordham University Library (1937).

Medical Library Center of New York (1976).

New York Law Institute Library (1909).

New York Public Library (Astor Branch) (1907).

New York Public Library (Lenox Branch) (1884).

New York University Libraries (1967).

New York University, Law Library (1973).

State University of New York, Maritime College Library (1947).

U.S. Court of Appeals Library (1976).

Newburgh: Newburgh Free Library (1909).

Niagara Falls: Niagara Falls Public Library (1976).

Oakdale: Dowling College Library (1965).

Oneonta: State University College, James M. Milne Library (1966).

Oswego: State University College, Penfield Library (1966).

Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).

### Potsdam:

Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).

State University College, 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 Library (1880).

St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).

Saratoga Springs: Skidmore College Library (1964).

Schenectady: Union College, Schaffer Library (1901).

Southampton: Southampton College Library (1973).

Staten Island (Grymes Hill): Wagner College, Horrmann Library (1953).

Stony Brook: State University of New York at Stony Brook Library (1963).

Syracuse: Syracuse University Library (1878).

Troy: Troy Public Library (1869).

Uniondale: Nassau Library System (1965).

### Utica:

Utica Public Library (1885).

Utica/Rome State University College Library (1977).

West Point: U.S. Military Academy Library (unknown).

Yonkers: Yonkers Public Library (1910).

Yorktown Heights: Mercy College at Fox Meadow Library.

## NORTH CAROLINA

Asheville: University of North Carolina at Asheville, 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 Louis Round Wilson Library (1884)-REGIONAL.

### Charlotte:

Public Library of Charlotte and Mecklenburg County (1964).

Queens College, Everette Library (1927).

University of North Carolina at Charlotte, Atkins Library (1964).

Cullowhee: Western Carolina University, Hunter Library (1953).

Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).

### Durham:

Duke University, William R. Perkins Library (1890).

North Carolina Central University, James E. Shepard Memorial Library (1973).

Elon College: Elon College Library (1971).

Fayetteville: Fayetteville State University, Chesnutt 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 System (1971).

Mount Olive: Mount Olive College, Moyer Library (1971).

Murfreesboro: Chowan College, Whitaker Library (1963).

Pembroke: Pembroke State University, Mary Livermore Library (1965).

#### Raleigh:

North Carolina State Library (unknown).

North Carolina State University, D. H. Hill Library (1923).

North Carolina Supreme Court Library (1972).

Wake County Public Libraries (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 System (1954).

Wake Forest University, Z. Smith Reynolds Library (1902).

## NORTH DAKOTA

#### Bismarck:

North Dakota State Law Library (unknown).

State Historical Society of North Dakota (1907).

State Library Commission Library (1971).

Veterans Memorial Public Library (1967).

Dickinson: Dickinson State College Library (1968).

#### Fargo:

Fargo Public Library (1964).

North Dakota State University Library (1907)-REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.

Grand Forks: University of North Dakota, Chester Fritz Library (1890).

Minot: Minot State College, Memorial Library (1925).

Valley City: State College Library (1913).

## OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).

#### Akron:

Akron Public Library (1952).

University of Akron Library (1963).

Alliance: Mount Union College Library (1888).

Ashland: Ashland College Library (1938).

Athens: Ohio University Library (1886).

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 Library (1929).

#### Cleveland:

Case Western Reserve University, Freiburger Library (1913).

Cleveland Heights-University Heights Public Library (1970).

Cleveland Public Library (1886).

Cleveland State University Library (1966).

John Carroll University, Grasselli Library (1963).

Municipal Reference Library (1970).

#### Columbus:

Capital University Library (1968).

Ohio State Library (unknown)-REGIONAL.

Ohio State University, William Oxley Thompson Memorial Library (1907).

Ohio Supreme Court Law Library (1973).

The Public Library of Columbus and Franklin County (1885).

#### Dayton:

Dayton and Montgomery County Public Library (1909).

University of Dayton, Albert Emanuel 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, Gordon Keith Chalmers Memorial Library (1873).

Granville: Denison University, William Howard Doane Library (1884).

Hiram: Hiram College, Teachout-Price Memorial Library (1874).

Kent: Kent State University Library (1962).

Marietta: Marietta College, Dawes Memorial Library (1884).

Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).

New Concord: Muskingum College Library (1966).

Oberlin: Oberlin College Library (1858).

Oxford: Miami University, Alumni Library (1909).

Portsmouth: Portsmouth Public Library (unknown).

Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).

Springfield: Warder Public Library (1884).

#### Steubenville:

College of Steubenville, Starvaggi Memorial Library (1971).

Public Library of Steubenville and Jefferson County (1950).

Tiffin: Heidelberg College, Leon A. Beeghly Library (1964).

#### Toledo:

Toledo-Lucas County Public Library (1884).

University of Toledo Library (1965).

Westerville: Otterbein College (1967).

Wooster: College of Wooster, the Andrews Library (1966).

#### Youngstown:

Public Library of Youngstown and Mahoning County (1923).

Youngstown State University, William F. Maag Library (1971).

## OKLAHOMA

Ada: East Central Oklahoma State University, Linscheid Library (1914).

Alva: Northwestern Oklahoma State University Library (1907).

Bartlesville: United States ERDA-BERC 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 (1893).

#### Oklahoma City:

Oklahoma County Libraries (1974).



Oklahoma City University Library (1963).  
 Oklahoma Department of Libraries (1893)-REGIONAL.  
 Shawnee: Oklahoma Baptist University Library (1933).  
 Stillwater: Oklahoma State University Library (1907).  
 Tahlequah: Northeastern Oklahoma State University, John  
 Vaughan Library (1923).  
 Tulsa:  
 Tulsa City-County Library Commission (1963).  
 University of Tulsa, McFarlin Library (1929).  
 Weatherford: Southwestern Oklahoma State University, Al  
 Harris Library (1958).

## OREGON

Ashland: Southern Oregon College Library (1953).  
 Corvallis: Oregon State University Library (1907).  
 Eugene: University of Oregon Library (1883).  
 Forest Grove: Pacific University Library (1897).  
 La Grande: Eastern Oregon College, Walter M. Pierce Library  
 (1954).  
 McMinnville: Linfield College, Northup Library (1965).  
 Monmouth: Oregon College of Education Library (1967).  
 Portland:  
 Department of Energy, Bonneville Power Administration  
 Library (1962).  
 Lewis and Clark College, Aubrey R. Watzek Library  
 (1967).  
 Library Association of Portland (1884).  
 Portland State University Library (1963)-REGIONAL.  
 Reed College Library (1912).  
 Salem:  
 Oregon State Library (unknown).  
 Oregon Supreme Court Library (1974).  
 Willamette University Library (1969).

## PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).  
 Allegheny: Allegheny County Law Library (1977).  
 Altoona: Altoona Public Library (1969).  
 Bethlehem: Lehigh University, Linderman Library (1876).  
 Blue Bell: Montgomery County Community College, Learning  
 Resources Center (1975).  
 Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).  
 Cheyney: Cheyney State College, Leslie Pinckney Hill Library  
 (1947).  
 Collegeville: Ursinus College, Myrin Library (1963).  
 Coraopolis: Robert Morris College Library (1978).  
 Doylestown: Bucks County Free Library, Center County Li-  
 brary (1970).  
 East Stroudsburg: East Stroudsburg State College, Kemp Li-  
 brary (1966).  
 Erie: Erie Public Library (1897).  
 Greenville: Thiel College, Langenheim Memorial Library  
 (1963).  
 Harrisburg: State Library of Pennsylvania (unknown)-REGION-  
 AL.  
 Haverford: Haverford College Library (1897).  
 Hazleton: Hazleton Area Public Library (1964).  
 Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley  
 Library (1962).  
 Johnstown: Cambria Public Library (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, Reis Library (1907).  
 Millersville: Millersville State College, Ganser Library (1966).  
 Monessen: Monessen Public Library (1969).

New Castle: New Castle Free 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 College Library (1974).  
 Temple University, Samuel Paley Library (1947).  
 Thomas Jefferson University, Scott Memorial Library  
 (1978).  
 U.S. Court of Appeals, Third Circuit (1973).  
 University of Pennsylvania, Biddle Law Library (1974).  
 University of Pennsylvania Library (1886).

Pittsburgh:  
 Bureau of Mines, Pittsburgh Research Center Library  
 (1962).  
 Carnegie Library of Pittsburgh, Allegheny Regional Branch  
 (1924).  
 Carnegie Library of Pittsburgh (1895).  
 La Roche College, John J. Wright Library (1974).  
 University of Pittsburgh, Hillman Library (1910).  
 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, Maltby Library  
 (1965).  
 Swarthmore: Swarthmore College Library (1923).  
 University Park: Pennsylvania State University Library (1907).  
 Villanova: Villanova University, School of Law Library (1964).  
 Warren: Warren Library Association, Warren Public Library  
 (1885).  
 Washington: Washington and Jefferson College, Memorial Li-  
 brary (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 Junior College Library (1963).  
 Youngwood: Westmoreland County Community College,  
 Learning Resource Center (1972).

## PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Li-  
 brary (1928).  
 Ponce: Catholic University of Puerto Rico Library (1966).  
 Rio Piedras: University of Puerto Rico General Library (1928).

## RHODE ISLAND

Kingston: University of Rhode Island Library (1907).  
 Newport: 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 Library (1965).  
 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 Library (1967).  
 College of Charleston, Robert Scott Small Library (1869).  
 The Citadel Memorial Library (1962).
- Clemson: Clemson University Library (1893).
- Columbia:  
 Benedict College, Learning Resources Center (1969).  
 Richland County Public Library (1978).  
 South Carolina State Library (before 1895).  
 University of South Carolina Undergraduate Library (1884).
- Conway: University of South Carolina, Coastal Carolina Regional Campus 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 Library (1967).
- Orangeburg: South Carolina State College, Whittaker Library (1953).
- Rock Hill: Winthrop College Library (1896).
- Spartanburg: Spartanburg County Public Library (1967).

## SOUTH DAKOTA

- Aberdeen: Northern State College Library (1963).
- Brookings: South Dakota State University, Hilton M. Briggs Library (1889).
- Pierre: South Dakota State Library (1973).
- Rapid City:  
 Rapid City Public Library (1963).  
 South Dakota School of Mines and Technology Library (1963).
- Sioux Falls:  
 Augustana College, Mikkelsen Library and Learning Resources Center (1969).  
 Sioux Falls Public Library (1903).
- Spearfish: Black Hills State College Library (1942).
- Vermillion: University of South Dakota, I. D. Weeks Library (1889).
- Yankton: Yankton College, Corliss Lay Library (1904).

## TENNESSEE

- Bristol: King College Library (1970).
- Chattanooga:  
 Chattanooga-Hamilton County Bicentennial Library (1908).  
 TVA 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 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 Library of Knoxville and Knox County, Lawson McGhee Library (1973).  
 University of Tennessee Law Library (1971).  
 University of Tennessee Library (1907).
- Martin: University of Tennessee at Martin Library (1957).

- Memphis:  
 Memphis and Shelby County Public Library and Information Center (1896).  
 Memphis State University, John W. Brister Library (1966).
- Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).
- Nashville:  
 Fisk University Library (1965).  
 Joint University Libraries (1884).  
 Public Library of Nashville and Davidson County (1884).  
 Tennessee State Law Library (1976).  
 Tennessee State Library and Archives, State Library Division (unknown).  
 Tennessee State University, Martha M. Brown Memorial Library (1972).  
 Vanderbilt University Law Library (1976).
- Sewanee: University of the South, Jesse Ball duPont Library (1973).

## TEXAS

- Abilene: 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 Library (1884).  
 University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).  
 University of Texas, School of Law Library (1965).
- Baytown: Lee College Library (1970).
- Beaumont: Lamar University Library (1957).
- Brownwood: Howard Payne University, Walker Memorial Library (1964).
- Canyon: West Texas State University Library (1928).
- College Station: Texas Agricultural and Mechanical University Library (1907).
- Commerce: East Texas State University Library (1937).
- Corpus Christi: Texas A&I University at Corpus Christi Library (1976).
- Corsicana: Navarro Junior College Library (1965).
- Dallas:  
 Bishop College, Zale Library (1966).  
 Dallas Baptist College Library (1967).  
 Dallas Public Library (1900).  
 Southern Methodist University, Fondren Library (1925).  
 University of Texas Health Science Center Library at Dallas (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 Couts 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).  
 University of Houston Library (1957).
- Huntsville: Sam Houston State University, Estill Library (1949).
- Irving: Irving Municipal Library (1974).



Kingsville: Texas Arts and Industries University Library (1944).  
 Lake Jackson: Brazosport College Library (1969).  
 Laredo: Laredo Junior College Library (1970).  
 Longview: Nicholson Memorial Public Library (1961).  
 Lubbock: Texas Tech University Library (1935)-REGIONAL  
 Marshall: Wiley College, Cole Library (1962).  
 Mesquite: Mesquite Public Library (1975).  
 Nacogdoches: Stephen F. Austin State University, Steen Library (1965).  
 Plainview: Wayland Baptist College, 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, Business and Science Department (1899).  
   St. Mary's University 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: University of Houston, Victoria Campus Library (1973).  
 Waco: Baylor University 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 Library (1962).  
 Provo:  
   Brigham Young University, Lee Library (1908).  
   Brigham Young University Law Library (1972).  
 Salt Lake City:  
   University of Utah, Spencer S. Eccles Medical Sciences Library (1970).  
   University of Utah, Law Library (1966).  
   University of Utah, Marriott Library (1893).  
   Utah State Library Commission, Documents 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).  
 Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

## VIRGIN ISLANDS

Charlotte Amalie (St. Thomas):  
   College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).  
   St. Thomas Public Library (1968).  
 Christiansted (St. Croix): Florence Augusta Stephens Williams Public Library (1974).

## VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).  
 Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).  
 Charlottesville:  
   University of Virginia, Alderman Library (1910)-REGIONAL.  
   University of Virginia Law Library (1964).  
 Chesapeake: Chesapeake Public Library System (1970).  
 Danville: Danville Community College Library (1969).  
 Emory: Emory and Henry College 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, Cyrus Hall McCormick Library (1910).  
 Martinsville: Patrick Henry Community College Library (1971).  
 Norfolk:  
   Armed Forces Staff College Library (1963).  
   Norfolk Public Library (1895).  
   Old Dominion University Library (1963).  
 Petersburg: Virginia State College, Johnston Memorial Library (1907).  
 Quantico:  
   Federal Bureau of Investigation Academy Library (1970).  
   Marine Corps Schools, James Carson Breckinridge Library (1967).  
 Reston: Department of the Interior, Geological Survey Library (1962).  
 Richmond:  
   State Law Library (1973).  
   University of Richmond, Boatwright Memorial Library (1900).  
   U.S. Court of Appeals, Fourth Circuit Library (1973).  
   Virginia Commonwealth University, James Branch Cabell Library (1971).  
   Virginia State Library (unknown).  
 Roanoke: Roanoke Public Library (1964).  
 Salem: Roanoke College Library (1886).  
 Williamsburg: William and Mary College Library (1936).  
 Wise: Clinch Valley College, John Cook Wyllie Library (1971).

## WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).  
 Cheney: Eastern Washington State College Library (1966).  
 Ellensburg: Central Washington University Library (1962).  
 Everett: Everett Public Library (1914).



Kingsville: Texas Arts and Industries University Library (1944).  
 Lake Jackson: Brazosport College Library (1969).  
 Laredo: Laredo Junior College Library (1970).  
 Longview: Nicholson Memorial Public Library (1961).  
 Lubbock: Texas Tech University Library (1935)-REGIONAL  
 Marshall: Wiley College, Cole Library (1962).  
 Mesquite: Mesquite Public Library (1975).  
 Nacogdoches: Stephen F. Austin State University, Steen Library (1965).  
 Plainview: Wayland Baptist College, 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, Business and Science Department (1899).  
   St. Mary's University 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: University of Houston, Victoria Campus Library (1973).  
 Waco: Baylor University Library (1905).  
 Wichita Falls: Midwestern University, Moffett Library (1963).

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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 Library (1962).  
 Provo:  
   Brigham Young University, Lee Library (1908).  
   Brigham Young University Law Library (1972).  
 Salt Lake City:  
   University of Utah, Spencer S. Eccles Medical Sciences Library (1970).  
   University of Utah, Law Library (1966).  
   University of Utah, Marriott Library (1893).  
   Utah State Library Commission, Documents Library (unknown).  
   Utah State Supreme Court Law Library (1975).

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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).  
 Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

## VIRGIN ISLANDS

Charlotte Amalie (St. Thomas):  
   College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).  
   St. Thomas Public Library (1968).  
 Christiansted (St. Croix): Florence Augusta Stephens Williams Public Library (1974).

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Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).  
 Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).  
 Charlottesville:  
   University of Virginia, Alderman Library (1910)-REGIONAL.  
   University of Virginia Law Library (1964).  
 Chesapeake: Chesapeake Public Library System (1970).  
 Danville: Danville Community College Library (1969).  
 Emory: Emory and Henry College 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, Cyrus Hall McCormick Library (1910).  
 Martinsville: Patrick Henry Community College Library (1971).  
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   Armed Forces Staff College Library (1963).  
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•**Clearwater**—128 North Osceola Avenue 33515, Area Code 813 Tel 461-0011

•**Jacksonville**—815 S. Maine Street, Suite 100, 32207, Area Code 904 Tel 791-2796, FTS 946-2796

•**Tallahassee**—Collins Bldg., Rm. G-20 32304, Area Code 904 Tel 488-6469, FTS 946-4320

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•**Fairfax**—8550 Arlington Blvd., 22031, Area Code 703 Tel 560-6460, FTS 235-1519

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•**Seattle**—Eric C. Silberstein, Director, Room 706, Lake Union Building, 1700 Westlake Avenue North 98109, Area Code 206 Tel 442-5616, FTS 399-5615, FOMC 399-5910/11

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**Expiration Date**  
Month/Year

--	--	--	--

Master Charge  
Interbank No.

--	--	--	--

**Deposit Account Number**

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ZIP

**BEFORE USING THIS FORM, READ IMPORTANT INFORMATION ON REVERSE SIDE  
PLEASE PRINT OR TYPE ALL INFORMATION ON THIS FORM.**

[illegible]

**WE REQUEST THAT YOU ORDER A MINIMUM OF \$1.00 WORTH OF MATERIALS.**

TOTAL ENCLOSED \$

SHIP TO: (If different from above)

ZIP

Unit of Issue

### Explanation

PK  
EA  
PD  
SE  
KT

Package containing multiple copies  
Each—single copy  
Pad containing multiple sheets  
Set of multiple items  
Kit of multiple items in a special container



## INFORMATION CONCERNING YOUR ORDER OR INQUIRY

Thank you for your interest in U. S. Government publications. If you have made a written inquiry, it is returned herewith for your reference. We have indicated the prices of publications currently available, or have provided the information requested to the best of our ability. Unless otherwise noted, prices are for single copies.

Regulations require payment in advance of shipment of publications. Please make checks or money orders payable to the Superintendent of Documents. You may charge your order using your Deposit Account, Master Charge, or Visa. Do not send currency (bills or coins) or postage stamps.

Shipping is by non-priority mail or United Parcel Service. First class mailing is available at a higher rate. Contact us for rates if you desire this service. (202-783-3238).

With the exception of specially priced publications and subscriptions, a discount of 25 percent is allowed on quantity purchases (100 or more copies of a single publication). The same discount applies to orders from a bookdealer (any quantity) when the publications are mailed to the dealer's normal place of business. No discount will be allowed when publications and subscriptions are mailed to a third party (unless in quantities of 100 or more per title).

**NON U. S. CUSTOMERS:** International mailing regulations require special handling for which we charge an additional 25 percent of the total cost of your order. Remittance is required in advance of shipping by draft on a United States or Canadian bank, by UNESCO coupons, or by International Postal Money Order made payable to the Superintendent of Documents. These orders are mailed via surface mail unless funds are sent to cover airmail postage. Foreign currency or checks will not be accepted. All orders must be in English.

## TO ORDER, USE FORM ON REVERSE SIDE

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1. *Please use separate forms for ordering publications and subscriptions.*
2. Type or print your complete name and address, your order number (if any), your Deposit Account number (if applicable), Visa or Master Charge number (if applicable), and date in proper places at the top of the form. If order is to be shipped to a third party, fill in address at bottom of form. We request you order a minimum of \$1.00 worth of materials. Please include office/home telephone no.
3. When ordering **publications**, type or print the stock number, unit of issue (see front), quantity, title, price and total payment enclosed.
4. When ordering **subscriptions**, or single issues of subscriptions, type or print the stock number, quantity, title, price, List ID (when available), and total payment enclosed. Allow 2—6 weeks plus mailing time for processing. All subscriptions are for one year, unless otherwise noted. Subscribers will be notified in ample time to renew.
5. Mail Original of Form to Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Retain the copy for your records.
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**C** . . . We are unable to identify the publication from the information furnished.

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**L** . . . The publication is not currently sold by this Office. We suggest you contact your local library which can refer you to a Federal Depository Library in your area for further assistance.

**S** . . . Publication has been replaced by another with similar but more recent information and it will be included in your shipment.

**T** . . . Publication has been replaced by another with similar but more recent information. Because of a difference in price, we are noting new ordering information on your request.

**Z** . . . Requested or pertinent information has been supplied. See attached.



Customer's Tele No. (Home/Office)

Superintendent of Documents  
U. S. Government Printing Office  
Washington, D. C. 20402

Credit  
Card No.

Expiration Date  
Month/Year

te				
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Master Charge  
Interbank No.

--	--	--	--

--	--	--	--	--	--	--	--

Quantity	Charges
_____	Enclosed
_____	To be mailed
_____	Subscriptions
Postage _____	
Foreign handling _____	
MMOB _____	
OPNR _____	
_____	UPNS
_____	Discount
_____	Refund

[illegible]

TOTAL ENCLOSED \$

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3. When ordering publications, type or print the stock number, unit of issue (see front), quantity, title, price and total payment enclosed.
4. When ordering subscriptions, or single issues of subscriptions, type or print the stock number, quantity, title, price, List ID (when available), and total payment enclosed. Allow 2-6 weeks plus mailing time for processing. All subscriptions are for one year, unless otherwise noted. Subscribers will be notified in ample time to renew.
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Customer's Tele No. (Home/Office)

Superintendent of Documents  
U. S. Government Printing Office  
Washington, D. C. 20402



Date..... Your Order Number.....

[illegible]

**Expiration Date**  
Month/Year

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Quantity	Charges
_____ Enclosed	
_____ To be mailed	
_____ Subscriptions	
Postage _____	
Foreign handling _____	
MMOB _____	
OPNR _____	
_____ UPNS	
_____ Discount	
_____ Refund	

ZIP

[illegible]

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4. When ordering **subscriptions**, or single issues of subscriptions, type or print the stock number, quantity, title, price, List ID (when available), and total payment enclosed. Allow 2—6 weeks plus mailing time for processing. All subscriptions are for one year, unless otherwise noted. Subscribers will be notified in ample time to renew.
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**Z** . . . Requested or pertinent information has been supplied. See attached.



**NTIS**

# ORDER FORM

Telephone: \_\_\_\_\_

Attention: \_\_\_\_\_

□ □   □ □   □ □ □ □

Date \_\_\_\_\_

Name \_\_\_\_\_

Organization \_\_\_\_\_

Address \_\_\_\_\_

City, State, ZIP \_\_\_\_\_

Signature \_\_\_\_\_

## ORDER OPTIONS

[illegible]

\$



**USER ROUTING CODE:**

NTIS can label each item for routing within your organization. If you want this service put your routing code in the box marked USER ROUTING CODE (Limit eight characters).

**SHIP & BILL SERVICE:**

Prepayment helps to expedite your order and can be accomplished through the use of an NTIS Deposit Account, check, money order, or charge card account number. • For "Ship and Bill," NTIS charges \$5 extra for each order (regardless of the number of items: \$5 extra for each NTISearch; • NTIS does not "Ship and Bill" for orders outside North America

**ORDERING MAGNETIC TAPE:  
(check model)**

☐ 7 track      ☐ 800 BPI      ☐ odd parity      ☐ 1600 BPI  
☐ 556 BPI      ☐ even parity      ☐ 9 track      ☐ 800 BPI (odd parity)

**ORDERING BY TITLE:**

If ordering without an NTIS order number (by title only) allow an additional two weeks.

**TITLE #1**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "1" in the NTIS Order Number block and complete the rest of the line.

**TITLE #2**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "2" in the NTIS Order Number block and complete the rest of the line.

**TITLE #3**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "3" in the NTIS Order Number block and complete the rest of the line.

**TITLE #4**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "4" in the NTIS Order Number block and complete the rest of the line.

**TITLE #5**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "5" in the NTIS Order Number block and complete the rest of the line.



**NTTS**

# ORDER FORM

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City, State, ZIP \_\_\_\_\_

## ORDER OPTIONS

It is vital that you order by NTIS order number or your order will be manually filled, causing a delay. You can opt for *airmail/first class delivery* as indicated below. Just check the *Priority Mail Services* box. If you're really pressed for time, call the NTIS Rush Handling Service (703) 487-4700 or (800) 336-4700. For a \$10 per copy charge your order will be mailed within 8 working hours. Or, you can pick up your order in the Washington Information Center & Bookstore or at our Springfield Operations Center within 24 hours for a \$6 per copy charge.

[illegible]

NTIS-173 (3/80)



**USER ROUTING CODE:**

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(check model)**

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☐ 556 BPI      ☐ even parity      ☐ 9 track      ☐ 800 BPI (odd parity)

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Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "1" in the NTIS Order Number block and complete the rest of the line.

**TITLE #2**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "2" in the NTIS Order Number block and complete the rest of the line.

**TITLE #3**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "3" in the NTIS Order Number block and complete the rest of the line.

**TITLE #4**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "4" in the NTIS Order Number block and complete the rest of the line.

**TITLE #5**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "5" in the NTIS Order Number block and complete the rest of the line.



**NTIS**

# ORDER FORM

Telephone: \_\_\_\_\_

Attention: \_\_\_\_\_

DTIC User Code \_\_\_\_\_

Contract Number \_\_\_\_\_

(last 6 characters only)

### For Government Users

(who report on SF-224)

(8 digit)

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(Enter if different from address at left)

Date \_\_\_\_\_

Name \_\_\_\_\_

## Organization

Address \_\_\_\_\_

City, State, ZIP \_\_\_\_\_

☐ Charge my NTIS deposit account no. \_\_\_\_\_

☐ Purchase order no. \_\_\_\_\_

☐ Check enclosed for \$ \_\_\_\_\_

☐ Ship & Bill. See reverse (not applicable outside North America).

☐ Charge to my ☐ American Express ☐ Visa ☐ Master Card

Account no. \_\_\_\_\_

Card expiration date \_\_\_\_\_

Signature \_\_\_\_\_

(Required to validate order)

## ORDER OPTIONS

It is vital that you order by NTIS order number or your order will be manually filled, causing a delay. You can opt for *airmail/first class delivery* as indicated below. Just check the *Priority Mail Services* box. If you're really pressed for time, call the NTIS Rush Handling Service (703) 487-4700 or (800) 336-4700. For a \$10 per copy charge your order will be mailed within 8 working hours. Or, you can pick up your order in the Washington Information Center & Bookstore or at our Springfield Operations Center within 24 hours for a \$6 per copy charge.

[illegible]

**\*\*ALL PRICES SUBJECT TO CHANGE.**

\*\*\*If ordering by title or if item ordered is a magnetic tape, please see reverse side.

Enter  
Grand  
Total

4

**USER ROUTING CODE:**

NTIS can label each item for routing within your organization. If you want this service put your routing code in the box marked USER ROUTING CODE (Limit eight characters).

**SHIP & BILL SERVICE:**

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Contract or Grant Number of Report

Date Published

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Personal Author

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**TITLE #2**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

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Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

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**TITLE #4**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "4" in the NTIS Order Number block and complete the rest of the line.

**TITLE #5**

Sponsor's Series #

Contract or Grant Number of Report

Date Published

Originator (Give specific laboratory, or division and location.)

Personal Author

Turn to other side. Write "5" in the NTIS Order Number block and complete the rest of the line.



**NTTS**

# ORDER FORM

Telephone: \_\_\_\_\_

Attention: \_\_\_\_\_

(last 6 characters only)

(8 digit)

□ □ □ □ □ □ □ □

Date \_\_\_\_\_

Name \_\_\_\_\_

Organization \_\_\_\_\_

Address \_\_\_\_\_

City, State, ZIP \_\_\_\_\_

Signature \_\_\_\_\_

(Required to validate order)

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Enter  
Grand  
Total

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Originator (Give specific laboratory, or division and location.)	Personal Author
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**TITLE #2**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "2" in the NTIS Order Number block and complete the rest of the line.

**TITLE #3**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "3" in the NTIS Order Number block and complete the rest of the line.

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Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "4" in the NTIS Order Number block and complete the rest of the line.

**TITLE #5**

Sponsor's Series #	Contract or Grant Number of Report	Date Published
--------------------	------------------------------------	----------------

Originator (Give specific laboratory, or division and location.)	Personal Author
--	-----------------

Turn to other side. Write "5" in the NTIS Order Number block and complete the rest of the line.

















# EDGE INDEX

## A Guide to Users of This Publication

### Descriptive

NBS Periodical and Non-Periodical Publications

Purchase Procedures and Document Availability

Citations (index code is shown within parentheses)

Journal of Research

Journal of Physical and Chemical Reference Data (JPCRD)

DIMENSIONS/NBS (DIM/NBS)

Monographs (Monogr.)

Handbooks (H)

Special Publications (SP)

Applied Mathematics Series (AMS)

National Standard Reference Data Series (NSRDS)

Building Science Series (BSS)

Federal Information Processing Standards Publications (FIPS PUBS)

Voluntary Product Standards (VPS)

Technical Notes (TN)

Consumer Information Series (CIS)

NBS Interagency Reports (NBSIR)

Grant/Contract Reports and Patents (GCR and/or NBS Patents)

NBS Papers Published in Non-NBS Media [5-digit arabic number]

Listing of NBS Papers by Major Subject Areas

### Indexes

Author Index

Key Word Index

Depository Libraries in the United States

District Offices of the U.S. Department of Commerce