NBS Special Publication 305
Supplement 15

Publications of the National Bureau of Standards 1983 Catalog

PUBLICATIONS

U.S. Department of Commerce
National Bureau of Standards

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards 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[2] — Radiation Research — Chemical Physics — Analytical Chemistry — Materials Science

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

Applied Mathematics — Electronics and Electrical Engineering[2] — Manufacturing Engineering — Building Technology — Fire Research — Chemical Engineering[2]

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.

[1]Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Washington, DC 20234.
[2]Some divisions within the center are located at Boulder, CO 80303.

NBS Special Publication 305
Supplement 15

Publications of the National Bureau of Standards 1983 Catalog

Rebecca J. Morehouse, Editor

Information Resources and Services Division
National Bureau of Standards
Washington, DC 20234

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WASHINGTON: 1984

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CONTENTS

A GUIDE TO USERS OF THIS PUBLICATION

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

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

SYMBOLS FOR NBS PUBLICATIONS

Symbols for the Periodicals

NBS periodicals	*Index symbol*	*Page number*
NBS Journal of Research (bimonthly)	J. Res. 88(1)	7
	J. Res. 88(2)	7
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Symbols for the Nonperiodicals

NBS nonperiodical series	*Index symbol*	*Page number*
Monographs	Monogr.	15
Handbooks	H	16
Special Publications	SP	17
Applied Mathematics Series	AMS	53
National Standard Reference Data Series	NSRDS	54
Building Science Series	BSS	55
Federal Information Processing Standards Publications	FIPS PUBS	57
Voluntary Product Standards	VPS	59
Technical Notes	TN	60
Consumer Information Series	CIS	63
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Symbols for the Papers Published in Non-NBS Media

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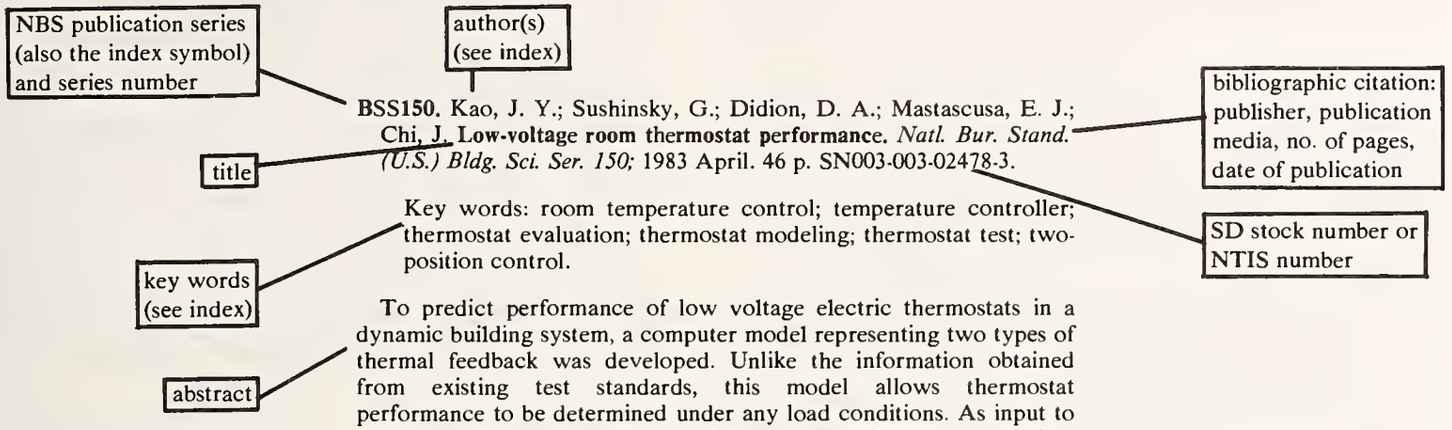
Professional journals, books, book chapters, proceedings, etc.	5-digit numbers (21542–22323)	97

HOW TO READ CATALOG ENTRIES

ABSTRACTS—SAMPLE ENTRIES

Example of NBS-published paper:

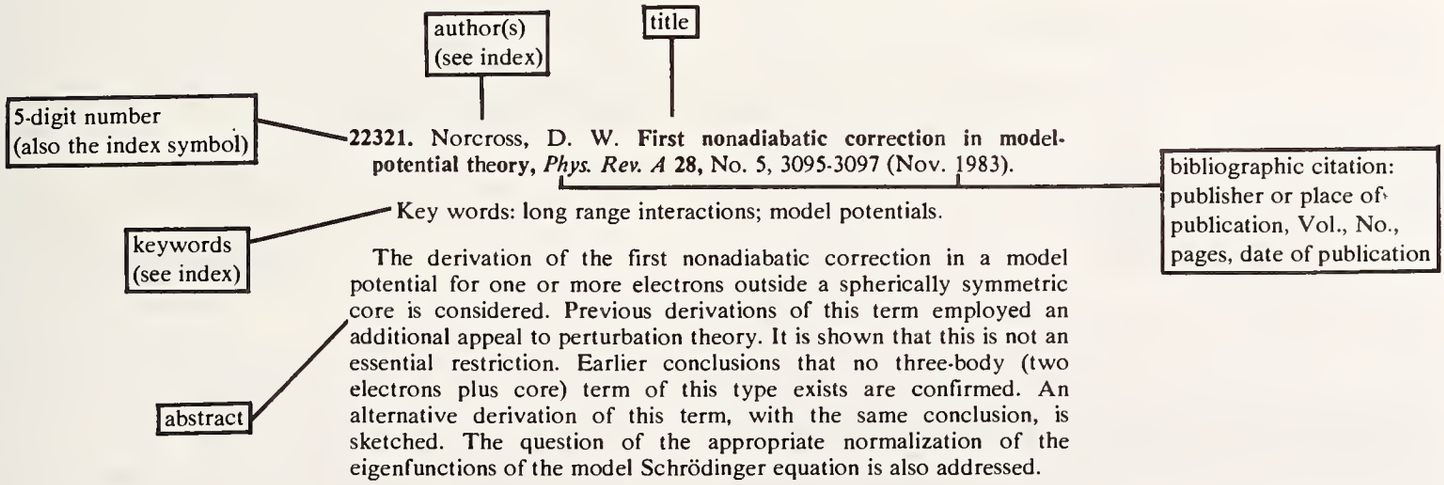


BSS150. Kao, J. Y.; Sushinsky, G.; Didion, D. A.; Mastascusa, E. J.; Chi, J. **Low-voltage room thermostat performance.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 150;* 1983 April. 46 p. SN003-003-02478-3.

Key words: room temperature control; temperature controller; thermostat evaluation; thermostat modeling; thermostat test; two-position control.

To predict performance of low voltage electric thermostats in a dynamic building system, a computer model representing two types of thermal feedback was developed. Unlike the information obtained from existing test standards, this model allows thermostat performance to be determined under any load conditions. As input to the model, the basic parameters of thermostat performance were first identified and then determined experimentally in a controlled laboratory facility. The experimental results from the tests were used as input parameters for the simulation model. Based upon the results from the simulation model and test results on four commercially-available thermostats, a switch-feedback model computer simulation is recommended for studying low-voltage room thermostat performance.

Example of NBS paper published in non-NBS media:



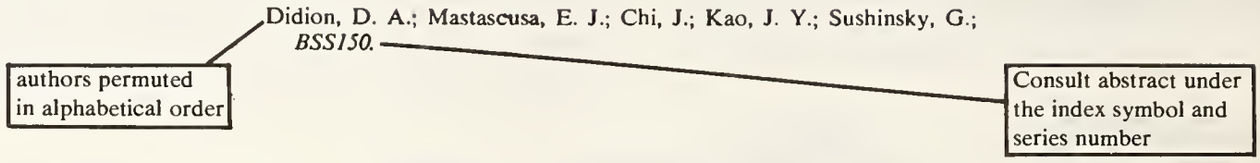
22321. Norcross, D. W. **First nonadiabatic correction in model-potential theory,** *Phys. Rev. A* **28,** No. 5, 3095-3097 (Nov. 1983).

Key words: long range interactions; model potentials.

The derivation of the first nonadiabatic correction in a model potential for one or more electrons outside a spherically symmetric core is considered. Previous derivations of this term employed an additional appeal to perturbation theory. It is shown that this is not an essential restriction. Earlier conclusions that no three-body (two electrons plus core) term of this type exists are confirmed. An alternative derivation of this term, with the same conclusion, is sketched. The question of the appropriate normalization of the eigenfunctions of the model Schrödinger equation is also addressed.

AUTHOR INDEX—SAMPLE ENTRIES

Example of NBS-published paper:



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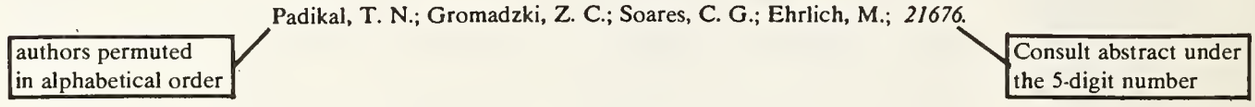
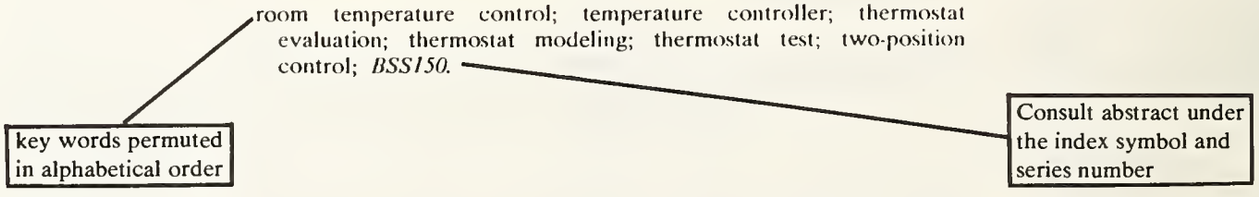
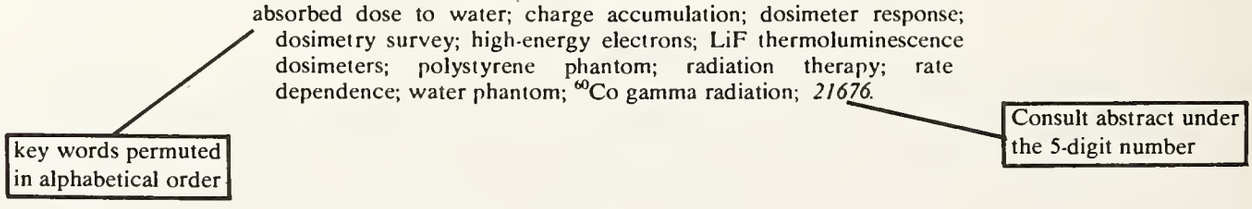


KEY WORD INDEX—SAMPLE ENTRIES

Example of NBS-published paper:



Example of NBS paper published in non-NBS media:



NBS PUBLICATION PROGRAM

1. INTRODUCTION

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

In 1983, 1,368 papers were published in the Bureau's own publications series and in non-NBS journals, books, and proceedings. This annual catalog, Publications of the National Bureau of Standards, lists the 1983 output of papers documenting the results of the Bureau's current programs. (Also included are those NBS papers published prior to 1983 but not reported in previous supplements of this annual catalog.) 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 recent Bureau publications in both NBS and non-NBS media. Issued six times a year.

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

3. NONPERIODICALS

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

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

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

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

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

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

Federal Information Processing Standards Publications (FIPS PUBS)—publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127),

and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

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

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

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

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

Grant/Contract Reports and NBS Patents—Grant/Contract Reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those contract reports not incorporated into the formal NBS publication series are available directly from the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

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

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

4. DOCUMENT AVAILABILITY AND PURCHASE PROCEDURES

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

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

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

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

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

How to Make Remittances to the Superintendent of Documents. Order forms are included at the end of this publication. Remittances for publications should be mailed to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, by money order, check, Master Card, or VISA. Be sure to give your credit card number and expiration date on all orders. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money order, draft on an American or Canadian bank, or UNESCO coupons.*

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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 RATE

Journal of Research of the National Bureau of Standards

	Domestic[1]	Foreign[2]
paper covers	$18	$22.50
bound volume (1 per yr)	(3)	(3)

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

[1] United States and its possessions.

[2] Foreign price includes the cost of the publication and postage.

[3] Prices vary. The Superintendent of Documents will furnish prices on request.

Journal of Physical and Chemical Reference Data

	U.S.A.	Foreign (surface mail)	Optional Air Freight Europe Mideast N. Africa	Optional Air Freight Asia and Oceania
Members (of ACS or of AIP member or affiliated society)	$48	$55	$66	$74
Regular rate	$199	$197	$208	$216

NOTE—Subscriptions should be sent with payment to the American Chemical Society, Periodicals Marketing Department, 1155 Sixteenth Street NW., Washington, DC 20036.

4.2 PRICES FOR NONPERIODICALS

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

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

4.3 FORMER NBS REFERENCE PUBLICATIONS

Certain NBS publications are out of print. NBS is able to offer the following information on some of these publications:

Circular 410, National Standard Petroleum Oil Tables. Information in this Circular was 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. Tables 5 and 7 of the ASTM Petroleum Measurement Tables are available from the ASTM.

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.

Circular 499, Nuclear Data. Replaced by Atomic Data and Nuclear Data Tables, published by Academic Press, 111 Fifth Avenue, New York, NY 10003.

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.

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 in hardcopy and N67-14099 in both hardcopy and 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.

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

NBS Handbook 28, Parts 1, 2, and 3, Screw Thread Standards. Federal Government responsibility for screw thread standards resides with the General Services Administration (GSA). Standards are 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.

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

Handbook 46, Code for Protection Against Lightning. A United States of America Standards Institute Code for Protection Against Lightning (NFPA-78-1980) is available from the American National Standards Institute, 1430 Broadway, New York, NY 10018, as ANSI/NFPA78-1980.

Handbook 48, Control and Removal of Radioactive Contamination in Laboratories. Reprints of this Handbook were issued as NCRP Report 8, by 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 were issued as NCRP Report 9, by NCRP Publications, P.O. Box 30175, Washington, DC 20014.

Handbook 53, Recommendations for the Disposal of Carbon-14 Wastes. Reprints of this Handbook were issued as NCRP Report 12, by 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. Reprinted as NCRP Report 51, Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities, by NCRP Publications, P.O. Box 30175, Washington, DC 20014.

Handbook 58, Radioactive Waste Disposal in the Ocean. Reprints of this Handbook were issued as NCRP Report 16, by NCRP Publications, P.O. Box 30175, Washington, DC 20014.

Handbook 59, Permissible Dose from External Sources of Ionizing Radiations. Reprints of this Handbook were issued as NCRP Report 39, by NCRP Publications, P.O. Box 30175, Washington, DC 20014.

Handbook 63, Protection Against Neutron Radiation up to 30 MeV. Reprints of this Handbook were issued as NCRP Report 38, by NCRP Publications, P.O. Box 30175, Washington, DC 20014.

Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes. Reprints of this Handbook were issued as NCRP Report 37, by 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 were issued as NCRP Report 22, by 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.

Handbook 73, Protection Against Radiations from Sealed Gamma Sources (Supersedes H54). Reprints of this Handbook were issued as NCRP Report 40, by 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 as ANSI/NBS Handbook H74-1960 (R1970).

Handbook 75, Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays. Reprints of this Handbook were issued as NCRP Report 25, by 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. Contact NCRP Publications, P.O. Box 30175, Washington, DC 20014.

Handbook 80, a Manual of Radioactivity Procedures. Reprints of this Handbook were issued as NCRP Report 58. Write NCRP Publications, P.O. Box 30175, Washington, DC 20014.

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

Handbook 84, Radiation Quantities and Units. Reprints of this Handbook were issued as ICRU Report 33, by ICRU Publications, P.O. Box 30165, Washington, DC 20014.

Handbook 85, Physical Aspects of Irradiation. Reprints of this Handbook were issued as ICRU Report 10b, by ICRU Publications, P.O. Box 30165, Washington, DC 20014.

Handbook 86, Radioactivity. Reprints of this Handbook were issued as ICRU Report 10C, Radioactivity by

ICRU Publications, P.O. Box 30165, Washington, DC 20014.

Handbook 87, Clinical Dosimetry. Information in this Handbook has been incorporated in ICRU Reports 23, 24, 29 (ICRU Publications, P.O. Box 30165, Washington, DC 20014).

Handbook 88, Radiobiological Dosimetry. Reprints of this Handbook were issued as ICRU Report 30, Quantitative Concepts and Dosimetry in Radiobiology by ICRU Publications, P.O. Box 30165, Washington, DC 20014.

Handbook 89, Methods of Evaluating Radiological Equipment and Materials. Reprints of this Handbook were issued as ICRU Report 10F, by ICRU Publications, P.O. Box 30165, Washington, DC 20014.

Handbook 96, Inspection of Processed Photographic Record Films for Aging Blemishes. Reprints of this Handbook were issued as PH 1.28-1976 by 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. Issued as NCRP Report 51, Radiation Protection Design Guidelines for 0.1–100 MeV Particle Accelerator Facilities from NCRP Publications, P.O. Box 30195, Washington, DC 20014.

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

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

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.

4.4 ANNOUNCEMENTS OF NBS PUBLICATIONS

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

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

Monthly Catalog of United States Government Publications. Issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Catalog of All Publications. There are almost 20,000 titles available from the Superintendent of Documents. It does not publish a single hardcopy catalog listing all of these items. It does, however, publish a total sales catalog in microform. The GPO Sales Publications Reference File (PRF) is a subscription that catalogs all publications currently offered for sale by the Superintendent of Documents. Annual subscriptions are available. The list ID is (PRF). To order this item use the forms in the back of this catalog.

Commerce Publications Update. Biweekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards publications, as well as those of other offices of the Department of Commerce. Contact the Office of Information Services, U.S. Department of Commerce, Washington, DC 20230.

NBS Catalogs of NBS Publications. These catalogs list all NBS publications through December 31, 1983. The catalogs are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, or NTIS, Springfield, VA 22161, or may be consulted in a library which maintains sets of National Bureau of Standards publications.

Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947, 375 pages including subject and author indexes. Brief abstracts are included for the period January 1, 1941 to June 30, 1947 ..... *

Supplement to Circular 460: Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957. 373 pages, including subject and author indexes ..... *

Miscellaneous Publication 240: Publications of the National Bureau of Standards, July 1, 1957 to June 30, 1960. First NBS Catalog to include titles of papers published in outside journals 1950 to 1959, 391 pages including subject and author indexes ..... *

Supplement to Miscellaneous Publication 240: Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by others, 1960 through 1965. 740 pages including subject and author indexes ..... *

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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 ..... *
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4.5 DEPOSITORY LIBRARIES IN THE UNITED STATES

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

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

It is sometimes impossible to obtain desired publications by purchase from the Superintendent of Documents. Stocks may have been exhausted or the document may be permanently out of print. The depositories provide a valuable service by keeping such publications permanently available. Every Government publication cannot be consulted at all depository libraries. Designated Regional Depositories are required to receive and retain one copy of all Government publications made available to depository libraries either in printed or microfacsimile form. All other libraries are allowed to select the classes of publications best suited to the interest of their particular clientele.

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

4.6 U.S. DEPARTMENT OF COMMERCE DISTRICT OFFICES

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

5. TITLES AND ABSTRACTS OF NBS PUBLICATIONS, 1983

5.1 PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 88, JANUARY-DECEMBER 1983

January-February 1983

Tryon, P. V.; Jones, R. H. **Estimation of parameters in models for cesium beam atomic clocks.** *J. Res. Natl. Bur. Stand. (U.S.). 88(1):* 3-16; 1983 January-February.

Key words: atomic clocks; Kalman filter; maximum likelihood; missing observations; random walks; state space; time series analysis; unequally spaced data.

This paper is intended to serve as an introduction to the use of the Kalman filter in modeling atomic clocks and obtaining maximum liklihood estimates of the model parameters from data on an ensemble of clocks. Tests for the validity of the model and confidence intervals for the parameter estimates are discussed. Techniques for dealing with unequally spaced and partially or completely missing multivariate data are described. The existence of deterministic frequency drifts in clocks is established and estimates of the drifts are obtained.

Jones, R. H.; Tryon, P. V. **Estimating time from atomic clocks.** *J. Res. Natl. Bur. Stand. (U.S.). 88(1):* 17-24; 1983 January-February.

Key words: atomic clocks; Kalman recursion; maximum likelihood estimation; missing observations; nonlinear estimation; state space; time series analysis; unequally spaced data.

A Kalman recursive algorithm for estimating time from an ensemble of atomic clocks has been developed. The algorithm allows for the addition or deletion of clocks at any time, and provides automatic error detection and correction. The observations consist of time differences between clocks and may be taken at unequally spaced time points. Maximum likelihood estimates of the unknown parameters are obtained with confidence intervals, as well as hypothesis tests to determine whether the estimated parameters are significantly different from zero. The program is operational on the National Bureau of Standards' Time and Frequency Division's PDP 11/70.

Eckerle, K. L.; Weidner, V. R.; Hsia, J. J.; Kafadar, K. **Measurement assurance program transmittance standards for spectrophotometric linearity testing: Preparation and calibration.** *J. Res. Natl. Bur. Stand. (U.S.). 88(1):* 25-36; 1983 January-February.

Key words: experimental design; filter uniformity; linearity testing; measurement assurance program; neutral density glass; passband effects; polarization effects; polynomial fitting; spectrophotometry; statistics; transmittance standards.

A Measurement Assurance Program for spectrophotometry is being established in order to assist laboratories involved in spectrophotometric calibrations. This paper deals with the preparation and calibration of neutral density glass filters for checking the linearity of photometric response, as applied to spectral transmittance measurements. Several sets of filters were prepared from suitable neutral glass to provide nominal transmittances of 92, 70, 50, 25, 10, 1, and 0.1% at a wavelength of 548.5 nm. These filter sets will be available in three sizes: these are, 38 mm diameter aperture in 51×51 mm holder, 25 mm diameter aperture in 51×28 mm holder, and 30×8 mm aperture in a cuvette holder. The filters were calibrated for spectral transmittance on the NBS Reference Spectrophotometer for high accuracy transmittance measurements. Measurements were made with a 1.5 mm passband collimated sample beam. The filters were checked for uniformity and measurements were made to determine the effects of sample beam polarization. The transmittance data for the wavelength range of interest were analyzed by statistical methods to determine the effects of passband for a range of 1.5 mm to 10.5 nm passband. The results of these measurements are presented in tabular and graphical detail for the master filter set.

Kafadar, K.; Eberhardt, K. R. **Statistical analysis of some gas chromatography measurements.** *J. Res. Natl. Bur. Stand. (U.S.). 88(1):* 37-46; 1983 January-February.

Key words: exploratory analysis; linear models; median polish; robust estimates; statistical methods; uncertainty statement.

The National Bureau of Standards has certified Standard Reference Materials (SRMs) for the concentration of polychlorinated biphenyls (PCBs) in hydrocarbon matrices (transformer and motor oils). The certification of these SRMs involved measurements of extremely small concentrations of PCBs made by gas chromatography. Despite the high accuracy of the measurement technique, the correlated data cannot be analyzed in a routine independent manner. A linear model for the measurements is described; its complexity encourages the use of simpler exploratory methods which reveal unexpected features and point the way towards obtaining valid statistical summaries of the data.

March-April 1983

Tschiegg, C. E.; Greenspan, M.; Eitzen, D. G. **Ultrasonic continuous-wave beam-power measurements; International intercomparison.** *J. Res. Natl. Bur. Stand. (U.S.). 88(2):* 91-103; 1983 March-April.

Key words: intercomparison of standards; ultrasonic power standards; ultrasonic transducers.

Some quartz transducers designed and fabricated at the National Bureau of Standards as transmitters of ultrasonic power appear to be sufficiently stable and linear to serve as standards. Therefore, an international intercomparison of measurements of the continuous-wave (cw) power emitted by these standards was arranged. Each of the seven participating laboratories performed such measurements using one or more methods representing its practice and reported the results to the National Bureau of Standards which served as the pilot laboratory. We present the results mostly in the form of tables. Some remarks on stability are appended.

Kafadar, K. **The efficiency of the biweight as a robust estimator of location.** *J. Res. Natl. Bur. Stand. (U.S.). 88(2):* 105-116; 1983 March-April.

Key words: bisquare weight function; biweight scale estimate; median absolute deviation; M-estimator; tuning constant.

The biweight is one member of the family of M-estimators used to estimate location. The variance of this estimator is calculated via Monte Carlo simulation for samples of sizes 5, 10, and 20. The scale factors and tuning constants used in the definition of the biweight are varied to determine their effects on the variance. A measure of efficiency for three distributional situations (Gaussian and two stretched-tailed distributions) is determined. Using a biweight scale and a tuning constant of $c=6$, the biweight attains an efficiency of 98.2% for samples of size 20 from the Gaussian distribution. The minimum efficiency at $n=20$ using the biweight scale and $c=4$ is 84.7%, revealing that the biweight performs well even when the underlying distribution of the samples has abnormally stretched tails.

Marinenko, G.; Koch, W. F.; Etz, E. S. **High precision coulometric titration of uranium.** *J. Res. Natl. Bur. Stand. (U.S.). 88(2):* 117-124; 1983 March-April.

Key words: amperometry; coulometric titration; electrogeneration; high-precision coulometry; hydrogen peroxide; standard reference material; titanium; titanous ion; uranium; uranium oxide.

An improved method for the coulometric assay of uranium and uranium oxide has been developed based on the electrogeneration of Ti(III) in H_2SO_4, using Fe(II) as a catalyst. The endpoint is determined amperometrically. Hydrogen peroxide is used as the oxidant in the dissolution of the uranium to avoid interferences from nitrate. The precision of the method as indicated by the standard deviation of an individual observation ranged from 0.008 weight percent for the analysis of the metal to 0.02 weight percent for the analysis of the oxides.

May-June 1983

Koch, W. F. **The determination of trace levels of cyanide by ion chromatography with electrochemical detection.** *J. Res. Natl. Bur. Stand. (U.S.). 88(3):* 157-161; 1983 May-June.

Key words: air-particulate; cyanide; electrochemical detection; environmental monitoring; ion chromatography; trace analysis.

An improved method for the determination of trace quantities of free cyanide has been developed using ion chromatography with electrochemical detection. Detection limits of 1 μg/L have been achieved with linearity of response over the range 1 to 1000 μg/L. The precision of replicate injections is 0.6 percent, expressed as the relative standard deviation. The method has been applied to the analysis of dust samples.

Roncier, M.; Philippe, R.; Saint-Just, J.; Dewerdt, F.; Siegwarth, J. D.; LaBrecque, J. F. **Estimated uncertainty of calculated liquefied natural gas density from a comparison of NBS and Gaz De France densimeter test facilities.** *J. Res. Natl. Bur. Stand. (U.S.). 88(3):* 163-170; 1983 May-June.

Key words: absolute densimeter; calculation method; correlation method; density measurement; liquefied natural gas; LNG densimeter test facility.

Liquefied natural gas (LNG) densities can be measured directly but are usually determined indirectly in custody transfer measurement by using a density correlation based on temperature and composition measurements. An LNG densimeter test facility at the National Bureau of Standards uses an absolute densimeter based on the Archimedes principle, while a test facility at Gaz de France uses a correlation method based on measurement of composition and density. A comparison between these two test-facilities using a portable version of the absolute densimeter provides an experimental estimate of the uncertainty of the indirect method of density measurement for the first time, on a large (32 L) sample. The two test facilities agree for pure methane to within about 0.02%. For the LNG-like mixtures consisting of methane, ethane, propane, and nitrogen with the methane concentrations always higher than 86%, the calculated density is within 0.25% of the directly measured density 95% of the time.

Payne, B. F. **The application of back-to-back accelerometers to precision vibration measurements.** *J. Res. Natl. Bur. Stand. (U.S.). 88(3):* 171-174; 1983 May-June.

Key words: accelerometers; calibration; exciters; shakers; standards; vibration.

Precision vibration measurements depend on accurate and repeatable calibration methods. Standardization of calibration test equipment and measurement techniques ensures more accurate and repeatable measurements. The use of the back-to-back accelerometer as a laboratory standard has become widespread. However, this use has been somewhat limited because of inadequate calibration methods. Recent developments in improved calibration methods have given the back-to-back accelerometer a greater potential as an accurate, repeatable, and stable vibration standard. As a vibration standard, the back-to-back accelerometer should prove to be a valuable asset for laboratories involved in vibration measurements and vibration transducer calibrations. By adapting existing techniques of laser interferometric calibration to the special geometry of the back-to-back accelerometer, improved accuracy (over existing methods) can be obtained over the range of 2–15,000 Hz and extension to 20,000 Hz is a good possibility. Recent work at NBS in this area is presented along with a description of a sample back-to-back transducer calibration.

Marshak, H. **Nuclear orientation thermometry.** *J. Res. Natl. Bur. Stand. (U.S.). 88(3):* 175-217; 1983 May-June.

Key words: gamma-ray anisotropy thermometry; gamma-rays; low temperature physics; low temperature thermometry; nuclear orientation; nuclear orientation thermometry; nuclear spin system; radioactivity; thermal equilibrium.

Low temperature nuclear orientation thermometry, in particular γ-ray anisotropy thermometry, is discussed both from a theoretical and practical point of view. Detailed information is given on the most often used γ-ray anisotropy thermometers, along with a comprehensive description of the γ-ray anisotropy technique. The ^{60}Co in (hcp) cobalt single crystal γ-ray anisotropy thermometer is discussed in considerable detail since it is used more frequently in comparison experiments with other primary thermometers. Recent experimental results using γ-ray anisotropy thermometers are also reviewed.

July-August 1983

Haynes, W. M.; Frederick, N. V. **Apparatus for density and dielectric constant measurements to 35 MPa on fluids of cryogenic interest.** *J. Res. Natl. Bur. Stand. (U.S.). 88(4):* 241-252; 1983 July-August.

Key words: Clausius-Mossotti function; compressed fluid; concentric cylinder capacitor; density; dielectric constant; excess volume; magnetic suspension densimeter; methane-ethane mixture; saturated liquid; vapor pressure.

An apparatus has been developed for simultaneous measurements of fluid densities and dielectric constants at temperatures from 70 to 320 K and at pressures to 35 MPa. A magnetic suspension technique, based on an application of Archimedes' principle, is employed in the density determination, while a concentric cylinder capacitor is used for obtaining the dielectric constant data. The apparatus can be used not only for determining densities and dielectric constants of compressed gases and liquids (including mixtures), but for saturated liquid and vapor properties as well. Also included is the capability for acquiring liquid-vapor equilibrium data for mixtures. The total uncertainty of a single density measurement is estimated to be approximately 0.1% for densities as low as 50 kg/m^3; at lower densities, the uncertainty increases. The imprecision of the density data is typically less than 0.02%. The total uncertainty in the dielectric constants is approximately 0.01%. Experimental data for a 0.85 CH_4+0.15 C_2H_6 mixture are given here to demonstrate the performance of the apparatus.

Houck, J. C.; Molinar, G. F.; Maghenzani, R. **An intercomparison of pressure standards between the Instituto di Metrologia "G. Colonnetti" and the National Bureau of Standards.** *J. Res. Natl. Bur. Stand. (U.S.). 88(4):* 253-259; 1983 July-August.

Key words: effective area; intercomparison; piston gauge; pressure; primary standard; transfer standard.

Intercomparisons were performed between a primary standard gas piston gauge of the Instituto di Metrologia "G. Colonnetti" (IMGC) and two gauges at the National Bureau of Standards. The agreement between the average pressure generated by the IMGC primary standard and the NBS transfer gauge was within 7 ppm (over the range 0.75 to 5.0 MPa) and the agreement between the IMGC primary standard and the NBS primary standard was within 6 ppm (over the range 0.5 to 1.5 MPa). The agreement is well within the estimated uncertainties of the gauges: 24 ppm for the IMGC primary gauge, 30 ppm for the NBS transfer gauge, and 28 ppm for the NBS primary gauge.

Mahajan, B. M. **Analysis of liquid flow-induced motion of a discrete solid in a partially filled pipe.** *J. Res. Natl. Bur. Stand. (U.S.). 88(4):* 261-288; 1983 July-August.

Key words: analysis; flow; force; liquid; model; momentum; partially-filled; pipe; solid; solid-liquid channel flow; steady; uniform; velocity.

An analysis is presented for the liquid flow-induced motion of a solid in partially filled pipes. A general equation of the flow-induced motion of a solid is developed. Two alternate force models, one (F_v) based on free stream velocity and another (F_m) based on free stream momentum flux, are formulated to simplify the general equation.

The equation of motion is solved for the motion of a cylindrical solid with steady-uniform liquid flows and the effects of relevant variables on the motion of a solid are predicted. The variables considered include: volume rate of liquid flow, Q; pipe diameter, D; Manning coefficient, n; and slope, S; solid diameter, d; length, L; specific gravity, σ; coefficient of friction between a solid and the pipe wall, η; and the two force functions, F_v and F_m.

The flow rate, Q_t, required to initiate the motion of a solid increases

with an increase in D, n, d, L, σ, and η_s, and decreases with an increase in S. The force function F_m predicts a lower value of Q_t than does the force function F_v.

The velocities of a solid increase with an increase in Q and S and decrease with an increase in D, n, d, L, σ, and η. The force function F_m predicts higher values of the velocity of a solid than does the force function F_v.

The effects of the variables Q_o, D, S, d, L, and η_s on the velocities of a solid are qualitatively consistent with the available experimental data. The qualitative agreement between the predicted results and experimental data demonstrate the validity of the analysis presented.

September-October 1983

Ramsey, N. F. **History of atomic clocks.** *J. Res. Natl. Bur. Stand. (U.S.). 88(5):* 301-320; 1983 September-October.

Key words: accuracy; atomic beam; clocks; frequency; frequency stabilization; laser; magnetic resonance; maser; microwave absorption; molecular beam; optical pumping; reproducibility; stability; superconducting cavities; time; trapped-ion devices.

The history of atomic and molecular standards of time and frequency is traced from the earliest work on molecular and atomic beam resonance techniques to more recent developments that promise improved standards in the future. The various devices currently used as standards are discussed in detail from an historical prospective. The latter part of the article is devoted to a discussion of prospective developments which hold promise for major improvements in accuracy, stability and reproducibility.

Marx, E.; Mulholland, G. W. **Size and refractive index determination of single polystyrene spheres.** *J. Res. Natl. Bur. Stand. (U.S.) 88(5):* 321-338; 1983 September-October.

Key words: dielectric spheres; inverse electromagnetic scattering; light scattering; Mie scattering; particle size; polystyrene latex; refractive index.

The intensity of the light scattered from individual dielectric spheres was measured as a function of the scattering angle, for light polarized parallel and perpendicular to the scattering plane. These sets of data were used to determine the radius and refractive index of the spheres by fitting the data to the scattering function obtained from Mie theory. The light was produced by a He-Cd laser ($\lambda = 441.6$ nm). Measurements were performed on particles of six discrete sizes with radii in the range 117–1175 nm. Several different measures of the quality of fit were examined, and the least-squares fit, unweighted or weighted with a factor $\sin^2(\theta/2)$, was found to be the best. The values obtained for the index of refraction were found to be within 1% of the published bulk value 1.615. The measured radii differed by several percent from those specified by the manufacturer. Several sources of error were analyzed, and their effects were simulated in numerical experiments. The largest source of error in the instrument was a discrepancy between the actual scattering angle and the reading provided by the instrument. Less significant was the noise introduced by the motion of the particle within the laser beam. A calibration eliminated most of the error in the scattering angle. The precision and accuracy of this technique are estimated to be 0.2% and 0.9%, respectively, of the particle size for particles of a nominal radius of 457 nm.

Smith, J. C. **The force-elongation curve of a thin fibrous network.** *J. Res. Natl. Bur. Stand. (U.S.). 88(5):* 339-350; 1983 September-October.

Key words: nonwoven fabrics, tensile behavior; paper fibers, adhesion; paper fibers, bonding; paper pulps, characterization; paper, tensile behavior.

Specimens from low-density weblike handsheets were tested in a tensile tester. In a test the direction of extension was frequently reversed and the specimen reextended to obtain a series of force-elongation curves. For Kraft woodpulp specimens the force-elongation behavior was well represented by an exponential equation involving three parameters: a modulus of elasticity C_2, a length parameter x_c related to average segment length between network bonds, and an elongation value x_0 at which the curve starts. The unstrained length of a specimen l increases, and the parameters x_c and C_2 tend to decrease with each successive reextension curve. For a series of specimens of increasing area density representative values of x_c/l tend to decrease and C_2 to increase. For a series of specimens made from pulps beaten increasing amounts representative values of x_c/l tend to decrease and C_2 to increase. Some features of the tensile behavior can be modeled by a system of parallel filaments of equal length to which longer parallel filaments with an exponential length distribution have been added. Upon extension the filaments assume load successively, thus simulating the force-elongation behavior of a paper network. By thinking in terms of this model it is possible to anticipate intuitively much of the behavior of a paper network.

November-December 1983

Domen, S. R. **A polystyrene-water calorimeter.** *J. Res. Natl. Bur. Stand. (U.S.). 88(6):* 373-387; 1983 November-December.

Key words: absorbed dose; calorimeter; heat defect; polystyrene; temperature drifts; thermistor; water.

The paper describes a new type of calorimeter that can be quickly put into operation for determining absorbed dose at a point in polystyrene. It also describes a unique method of decreasing drifts in electrical signals caused by temperature gradients. Two calibrated thermistors were placed close together between sandwiched polystyrene discs that were immersed in water. The assembly was irradiated with gamma rays from a cobalt-60 source. The dose rate was about 14 mGy/s and exposure times were about 100 s. The standard deviation for a daily set of measurements was about 0.7%. A zero heat defect for polystyrene was assumed. A calculation converted the measurements to absorbed dose in water. The dose in water determined in this way, and with a graphite calorimeter, is 3–4% lower than that measured in an all-water calorimeter previously reported. Drifts in electrical signals are eliminated by a resistance-capacitance circuit placed across a Wheatstone bridge. The rate of potential change across the bridge (caused by the circuit) is adjusted to have an opposite effect to the drifts in electrical signals produced by temperature gradients within the calorimeter. The method can be applied to other calorimeters.

Swaffield, J. A.; Bridge, S. **Applicability of the Colebrook-White formula to represent frictional losses in partially filled unsteady pipeflow.** *J. Res. Natl. Bur. Stand. (U.S.). 88(6):* 389-393; 1983 November-December.

Key words: drains; partially filled pipeflow; pipe flow function; plumbing drainage.

The use of Manning's n as a friction factor is shown to be unsuitable in the case of small bore (less than about one meter diameter) partially filled pipeflow, particularly for relatively smooth materials such as glass and cast-iron. The Colebrook-White equation with the roughness coefficient k is presented in a form suitable for inclusion in a computer program to solve the partially filled unsteady pipeflow equations by means of the method of characteristics. Results are presented which show that the Colebrook-White equation provides substantially improved predictions of the wave velocity along the pipe. It provides slightly improved predictions for the maximum depth of flow along the pipe.

Leighton, F. T. **Circulants and the characterization of Vertex-Transitive graphs.** *J. Res. Natl. Bur. Stand. (U.S.). 88(6):* 395-402; 1983 November-December.

Key words: circulant; multidimensional circulant; point-symmetric; regular group; starred polygon; vertex-transitive.

In this paper, we extend the notion of a circulant to a broader class of vertex-transitive graphs, which we call multidimensional circulants. This new class of graphs is shown to consist precisely of those vertex-transitive graphs with an automorphism group containing a regular abelian subgroup. The result is proved using a theorem of Sabidussi which shows how to recover any vertex-transitive graph from any transitive subgroup of its automorphism group. The approach also allows a short proof of Turner's theorem that every vertex-transitive graph on a prime number of nodes is a circulant.

Leighton, F. T. **On the decomposition of vertex-transitive graphs into multicycles.** *J. Res. Natl. Bur. Stand. (U.S.). 88(6):* 403-410; 1983 November-December.

Key words: Cayley graph; circulant; cycle decomposition; edge-transitive graph; grouplike set; line-symmetric graph; multicycle; multidimensional circulant; point-symmetric graph; starred polygon; symmetric graph; vertex-transitive graph.

In this paper, we prove that every vertex-transitive graph can be expressed as the edge-disjoint union of symmetric graphs. We define a multicycle graph and conjecture that every vertex-transitive graph can be expressed as the edge-disjoint union of multicycles. We verify this conjecture for several subclasses of vertex-transitive graphs, including Cayley graphs, multidimensional circulants, and vertex-transitive graphs with a prime or twice a prime number of nodes. We conclude with some open questions of interest.

5.2 PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 12, JANUARY-DECEMBER 1983

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

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

Volume 12, No. 1

Levelt Sengers, J. M. H.; Kamgar-Parsi, B.; Balfour, F. W.; Sengers, J. V. **Thermodynamic properties of steam in the critical region.** *J. Phys. Chem. Ref. Data. 12(1):* 1-28; 1983.

Key words: critical parameters; critical region; energy; equation of state; latent heat; scaling laws; specific heat; speed of sound; steam; thermodynamic function; thermodynamic tables; vapor pressure; water.

An analysis is presented of the experimental data on thermodynamic properties in the critical region of steam. The model used is that of revised and extended scaling, as given by the modern theory of critical phenomena. All thermodynamic properties are given in closed (parametric) form. The model has, in addition to three universal constants that are given by theory, sixteen adjustable parameters that were obtained by least-squares fit to *PVT* and speed-of-sound data. It is valid in the range 200–420 kg/m^3 in density and 644–693 K in temperature. It accurately represents the experimental data for equation of state, vapor pressure, latent heat, specific heats C_p and C_v and speed of sound. Our analysis permits new estimates of the critical parameters of steam, and has led to a number of conclusions regarding the mutual consistency of the experimental data. Tabulated values of the thermodynamic properties of steam are appended to the paper.

Gaur, U.; Wunderlich, B. B.; Wunderlich, B. **Heat capacity and other thermodynamic properties of linear macromolecules. VII. Other carbon backbone polymers.** *J. Phys. Chem. Ref. Data. 12(1):* 29-63; 1983.

Key words: enthalpy; entropy; fusion; glass transition; halogenated polymers; heat capacity; linear macromolecule; polyalkenes; polybenzoates; polystyrenes; vinylidene polymers; vinyl polymers.

The heat capacity of poly-1-butene, poly-1-pentene, poly-1-hexene, polyisobutylene, poly(4-methyl-1-pentene), polybutadiene, *cis*-1, 4-poly(2-methylbutadiene), polycyclopentene, poly(vinyl fluoride), poly(vinylidene fluoride), polytrifluoroethylene, polytetrafluoroethylene, poly(vinyl chloride), poly(vinylidene chloride), polychlorotrifluoroethylene, poly(vinyl alcohol), poly(vinyl acetate), poly(α-methylstyrene), poly(o-methylstyrene), poly(o-chlorostyrene) and a series of poly(vinyl benzoate)s is reviewed on the basis of 62 measurements reported in the literature. A set of recommended data has been derived for each polymer. Entropy and enthalpy functions have been calculated for poly-1-hexene, polyisobutylene, *cis*-1, 4-poly(2-methylbutadiene), poly(vinyl chloride), and poly(α-methylstyrene). This paper is seventh in a series which will ultimately cover all heat capacity measurements on linear macromolecules.

Gaur, U.; Lau, S.; Wunderlich, B. B.; Wunderlich, B. **Heat capacity and other thermodynamic properties of linear macromolecules. VIII. Polyesters and polyamides.** *J. Phys. Chem. Ref. Data. 12(1):* 65-89; 1983.

Key words: amorphous; crystal; enthalpy; entropy; fusion; glass transition; heat capacity; nylon; polyamide; polyester; polypeptide; thermodynamic properties.

Heat capacity of polyglycolide, poly(ε-caprolactone), poly(ethylene terephthalate), poly(ethylene sebacate), polyglycine, poly(L-alanine), poly(L-valine), nylon 6, nylon 6.6, and nylon 6.12 is reviewed on the basis of measurements on 35 samples reported in the literature. All heat capacity data are compiled and a set of recommended data have been derived for each polymer. Crystallinity dependence is critically evaluated for poly(ethylene terephthalate). Enthalpy and entropy functions are calculated for amorphous poly(ethylene terephthalate). This is the eighth paper in a series of publications which will ultimately cover all heat capacity measurements of linear macromolecules.

Gaur, U.; Lau, S.; Wunderlich, B. **Heat capacity and other thermodynamic properties of linear macromolecules. IX. Final group of aromatic and inorganic polymers.** *J. Phys. Chem. Ref. Data. 12(1):* 91-108; 1983.

Key words: enthalpy; entropy; germanium polymers; glass transition; heat capacity; linear macromolecules; polycarbonate; poly(dimethyl siloxane); polyheteroarylene; polyphenylenediamide; polysulfone; silicon polymer.

In this final review, a series of polymers which include aromatic rings and/or inorganic chain atoms are treated. Heat capacities of poly(4,4′-isopropylidenediphenylene carbonate), polyphenylenediamides, polyheteroarylenes, poly(dimethyl siloxane), poly(diethyl siloxane), poly(trimethylsilyl ethylene), poly(dimethylphenylsilyl ethylene), poly(dimethylbenzylsilyl ethylene), poly(vinylene diphenylsilylene), poly(vinylene diphenylgermylene), poly(diethnyl diphenysilylene), poly(diethnyl diphenylgermylene), poly(2,3,4,5-tetraphenyl-1, 1-diethylgermocyclopentadiene), poly(phenylsilsesquioxane), poly[ethylene-*N*-(β-trimethylsilylethyl) imine] and polysulfones have been reviewed on the basis of measurements on 36 samples reported in the literature. All heat capacity data are compiled and a set of recommended data are derived. Enthalpy and entropy functions are calculated for poly(4,4′-isopropylidenediphenylene carbonate) and poly(dimethyl siloxane).

Gallagher, J. W.; Beaty, E. C.; Dutton, J.; Pitchford, L. C. **An annotated compilation and appraisal of electron swarm data in electronegative gases.** *J. Phys. Chem. Ref. Data. 12(1):* 109-152; 1983.

Key words: air; carbon dioxide; electron diffusion; electron drift velocity; electronegative gases; electron swarm coefficients; electron transport; halogenated hydrocarbons; nitrogen oxides; nitrogen trifluoride; oxygen; sulphur hexafluoride; water.

Available data on the electron transport properties and electron swarm coefficients are discussed for the following electronegative gases: SF_6, CF_4, C_2F_6, C_3F_8, C_4F_{10}, CCl_2F_2, O_2, air, H_2O, CO_2, F_2, NF_3, Cl_2, Br_2, I_2, N_2O, NO, HCl, NH_3. Graphical presentations comparing measured and calculated data are given for the electron drift velocity, the ratio of diffusion to mobility, the electron attachment and ionization coefficients, and the electron growth constant as functions of E/N, the reduced field strength, for each gas. Graphs of the detachment and excitation coefficients are presented where these data are available. Data originally reported in terms of rate coefficients as functions of mean electron energy are graphically presented in that form. Recommendations concerning reliability are made.

Volume 12, No. 2

Battino, R.; Rettich, T. R.; Tominaga, T. **The solubility of oxygen and ozone in liquids.** *J. Phys. Chem. Ref. Data. 12(2):* 163-178; 1983.

Key words: aqueous solutions; biological fluids; gas solubility; hydrocarbons; mixed solvents; organic solvents; oxygen; ozone; seawater; water.

This review covers the solubility of oxygen and ozone in liquids as a function of temperature and pressure. Solubility data for individual systems were critically evaluated and recommended or tentative values presented in many cases. The trend of solubilities in homologous series or related solvents is discussed. Liquids include water; seawater; aqueous salt solutions; mixed solvents; hydrocarbons; organic compounds containing oxygen, halogen, sulfur, nitrogen, or silicon; olive oil; and human blood. For ozone, only its solubility in water is presented.

Swenson, C. A. **Recommended values for the thermal expansivity of silicon from 0 to 1000 K.** *J. Phys. Chem. Ref. Data. 12(2):* 179-182; 1983.

Key words: high temperature expansivity; silicon; standard expansivities; thermal expansivity.

Silicon, a high melting point, low expansivity, cubic material which can be obtained readily in high purity form, provides an excellent thermal expansion standard. Various absolute determinations of the thermal expansivity of both single crystal and polycrystalline silicon are used to establish a smooth relationship from 90 to 850 K which is believed to be reliable to roughly 10^{-18} K^{-1}, and which is extrapolated to 1000 K. Values also are suggested for temperatures to absolute zero.

Ho, C. Y.; Ackerman, M. W.; Wu, K. Y.; Havill, T. N.; Bogaard, R. H.; Matula, R. A.; Oh, S. G.; James, H. M. **Electrical resistivity of ten selected binary alloy systems.** *J. Phys. Chem. Ref. Data. 12(2):* 183-322; 1983.

Key words: alloy systems; alloys; conductivity; critically evaluated data; data analysis; data compilation; data synthesis; electrical conductivity; electrical resistivity; metals; recommended values; resistivity.

This work compiles, reviews, and discusses the available data and information on the electrical resistivity of ten selected binary alloy systems and presents the recommended values resulting from critical evaluation, correlation, analysis, and synthesis of the available data and information. The ten binary alloy systems selected are the systems of aluminum–copper, aluminum–magnesium, copper–gold, copper–nickel, copper–palladium, copper–zinc, gold–palladium, gold–silver, iron–nickel, and silver–palladium. The recommended values for each of the ten binary alloy systems except three (aluminum–copper, aluminum–magnesium, and copper–zinc) are given for 27 compositions: 0 (pure element), 0.5, 1, 3, 5, 10(5)95, 97, 99, 99.5, and 100% (pure element). For aluminum–copper, aluminum–magnesium, and copper–zinc alloy systems, the recommended values are given for 26, 12, and 11 compositions, respectively. For most of the alloy systems the recommended values cover the temperature range from 1 K to the solidus temperature of the alloys or to about 1200 K. For most of the nine elements constituting the alloy systems, the recommended values cover the temperature range from 1 K to above the melting point into the molten state. The estimated uncertainties in most of the recommended values are about ±3% to ±5%.

Martin, W. C.; Zalubas, R. **Energy levels of silicon, Si I through Si XIV.** *J. Phys. Chem. Ref. Data. 12(2):* 323-380; 1983.

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

Energy level data are given for the atom and all positive ions of silicon ($Z=14$). 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 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 or quoted wherever available. Ionization energies are given for all spectra.

Smith, B. D.; Muthu, O.; Dewan, A. **Evaluation of binary *PTxy* vapor-liquid equilibrium data for C_6 hydrocarbons. Benzene+hexane.** *J. Phys. Chem. Ref. Data. 12(2):* 381-387; 1983.

Key words: activity coefficients; benzene; excess Gibbs function; hexane; vapor-liquid equilibrium.

The binary *PTxy* vapor-liquid equilibrium data for the benzene+hexane system are evaluated. The needs for new experimental data are defined.

Smith, B. D.; Muthu, O.; Dewan, A. **Evaluation of binary excess enthalpy data for C_6 hydrocarbons. Benzene+hexane.** *J. Phys. Chem. Ref. Data. 12(2):* 389-393; 1983.

Key words: benzene; excess enthalpy; heat of mixing; hexane.

The excess enthalpy data for the benzene+hexane system are evaluated. The needs for new experimental data are defined.

Smith, B. D.; Muthu, O.; Dewan, A. **Evaluation of binary excess volume data for C_6 hydrocarbons. Benzene+hexane.** *J. Phys. Chem. Ref. Data. 12(2):* 395-401; 1983.

Key words: benzene; excess volume; hexane; volume change of mixing.

The excess volume data for the benzene+hexane system are evaluated. The needs for new experimental data are defined.

Volume 12, No. 3

Pine, A. S.; Coulombe, M. J.; Camy-Peyret, C.; Flaud, J. M. **Atlas of the high-temperature water vapor spectrum in the 3000 to 4000 cm^{-1} region.** *J. Phys. Chem. Ref. Data. 12(3):* 413-465; 1983.

Key words: difference-frequency laser; Doppler-limited resolution; high temperatures; infrared spectrum; OH stretching fundamentals; water vapor.

An atlas of the high-temperature (1200 K) absorption spectrum of water vapor in the 3000 to 4000 cm^{-1} region is presented. The infrared spectrum was recorded at Doppler-limited resolution using a tunable difference-frequency laser spectrometer. The spectral region scanned encompasses the strong OH stretching fundamentals, ν_1 and ν_3, and the bending overtone, $2\nu_2$, as well as associated hot bands. Almost all the lines have been assigned using a model Hamiltonian which yields very satisfactory agreement between calculated and observed line positions for J up to 27 or K_a up to 14. The calculated eigenvectors applied to the transition moment operator predict the measured line intensities quite closely. This work should serve as a reference for analyzing spectra from high-temperature sources such as combustion exhausts and cool stars.

Schaupp, D.; Schumacher, M.; Smend, F.; Rullhusen, P. **Small-angle Rayleigh scattering of photons at high energies: Tabulations of relativistic HFS modified atomic form factors.** *J. Phys. Chem. Ref. Data. 12(3):* 467-512; 1983.

Key words: atomic form factor; cross sections; gamma rays; photons; Rayleigh scattering; tabulations; x rays.

Tabulations are presented of relativistic Hartree-Fock-Slater modified atomic form factors from $x=0$ to 100 $Å^{-1}$ for all elements from $Z=1$ to $Z=100$. These modified form factors represent the atomic Rayleigh scattering amplitudes with good accuracy at energies well above the K-shell binding energies and small momentum transfers and therefore should be used instead of the normal relativistic atomic form factors in the MeV energy range.

Kamgar-Parsi, B.; Levelt Sengers, J. M. H.; Sengers, J. V. **Thermodynamic properties of D_2O in the critical region.** *J. Phys. Chem. Ref. Data. 12(3):* 513-529; 1983.

Key words: critically evaluated data; critical parameters; critical region; energy; enthalpy entropy; equation state; heavy steam; heavy water; sound velocity; specific heat; thermodynamic properties.

An analysis is presented of the thermodynamic properties of D_2O in the critical region. It is shown that the data can be represented by the same revised and extended scaled fundamental equation formulated earlier for the thermodynamic properties of H_2O in critical region. The equation is valid in the range 220–465 kg/m^3 in density and 638–683 K in temperature. Tabulated values of the thermodynamic properties of D_2O in the critical region are presented. A comparison with a comprehensive analytic fundamental equation, recently

formulated by Hill and co-workers, is included in the paper.

Cohen, N.; Westberg, K. R. **Chemical kinetic data sheets for high-temperature chemical reactions.** *J. Phys. Chem. Ref. Data. 12(3):* 531-590; 1983.

Key words: chemical kinetic data; data compilation and evaluation; rate coefficient; rate constant; reaction rate; review.

A new program for the compilation and evaluation of chemical kinetic data is described. Rate coefficient measurements are assessed for probable accuracy and precision. Transition-state theory is often used to extrapolate measurements to higher temperatures. For every reaction reviewed, a recommended rate coefficient is given in the form $k=AT^n\times\exp(-B/T)$. Pertinent data and conclusions are summarized on a two-page Data Sheet, each sheet covering one reaction or occasionally two or three closely related reactions. Twenty-seven Data Sheets are presented for reactions important in modeling and understanding chemical lasers, hydrogen-oxygen combustion, hydrocarbon oxidation, and aluminum or boron propellant systems.

Janz, G. J.; Tomkins, R. P. T. **Molten salts: Volume 5, Part 2. Additional single and multi-component salt systems. Electrical conductance, density, viscosity and surface tension data.** *J. Phys. Chem. Ref. Data. 12(3):* 591-815; 1983.

Key words: density; electrical conductance; fused salts; molten salts; phase diagrams; surface tension; viscosity.

Evaluated data for the four properties, density, surface tension, viscosity, and electrical conductance are reported for salt systems in which both the anionic and cationic species may differ. This contrasts with the systems in the preceding publications in this series in which the anionic species were, in general, the same in the binary mixtures. The results are reported in equation form, with brief tables of numerical values. A cross index by salt system was compiled and is included for ease of accessing the data tables.

Vargaftik, N. B.; Volkov, B. N.; Voljak, L. D. **International tables of the surface tension of water.** *J. Phys. Chem. Ref. Data. 12(3):* 817-820; 1983.

Key words: critically evaluated data; internationally agreed-upon data; surface tension as a function of temperature; surface tension of water.

This paper presents a table for the surface tension of water from 0.01 to 374°C and an interpolating equation which represents the values in the table to well within their estimated uncertainties. The table of values and the interpolating equation are those recommended by the International Association for the Properties of Steam (IAPS) in its recent official release. The experimental measurements of the surface tension of water and their uncertainties are discussed, as is the development of the IAPS tables.

Volume 12, No. 4

Janev, R. K.; Bransden, B. H.; Gallagher, J. W. **Evaluated theoretical cross section data for charge exchange of multiply charged ions with atoms. I. Hydrogen atom-fully stripped ion systems.** *J. Phys. Chem. Ref. Data. 12(4):* 829-872; 1983.

Key words: charge exchange; cross sections; hydrogen atom; fully stripped ions; multiply charged ions.

The existing theoretical cross section data for the charge exchange process of multiply charged fully stripped ions with hydrogen atoms are evaluated in the energy range from $\sim$10 eV/u to $\sim10^3$ keV/u. The evaluation has been performed on the basis of both pure theoretical arguments and comparison with the most accurate experimental cross sections. The ionic charge state ranges from $Z=2$ to $Z=54$. The theoretical methods for calculation of the charge exchange cross sections are briefly discussed, and their regions of validity and the accuracy of the produced data are assessed.

Gallagher, J. W.; Bransden, B. H.; Janev, R. K. **Evaluated theoretical cross section data for charge exchange of multiply charged ions with atoms. II. Hydrogen atom-partially stripped ion systems.** *J. Phys. Chem. Ref. Data. 12(4):* 873-890; 1983.

Key words: charge exchange; cross section; ions; multiply charged ions; partially stripped ions.

The existing theoretical cross section data for charge exchange of partially stripped ions on atomic hydrogen are evaluated in the energy range from $\sim$10 eV/u to $\sim10^3$ keV/u. The evaluation has been carried out by using both pure theoretical arguments and comparison with the most accurate experimental data. Ions with atomic numbers $Z=3$–8, 10, 12, 13, 14, 16, 18, 22, 26, 30, 36, 41, 42, 48, 54, 73, and 74, in charge states q between $q=2$ and $q=(Z-1)$, have been examined. A brief discussion of the evaluation criteria is also given.

Bell, K. L.; Gilbody, H. B.; Hughes, J. G.; Kingston, A. E.; Smith, F. J. **Recommended data on the electron impact ionization of light atoms and ions.** *J. Phys. Chem. Ref. Data. 12(4):* 891-916; 1983.

Key words: cross sections; electron impact ionization; isoelectronic sequence; rate coefficients.

Experimental and theoretical cross section data for electron impact ionization of light atoms and ions have been assessed. Based on this assessment and, in some cases, on the classical scaling laws, a recommended cross section has been produced for each species. This has been used to evaluate recommended Maxwellian rate coefficients over a wide range of temperatures. Convenient analytical expressions have been obtained for the recommended cross sections and rate coefficients. The data are presented in both graphical and tabular form and estimates of the reliability of the recommended data are given.

Holland, P. M.; Eaton, B. E.; Hanley, H. J. M. **A correlation of the viscosity and thermal conductivity data of gaseous and liquid ethylene.** *J. Phys. Chem. Ref. Data. 12(4):* 917-932; 1983.

Key words: critical point enhancement; correlated data; data evaluation; ethylene; thermal conductivity coefficient; viscosity coefficient.

Data for the viscosity and thermal conductivity coefficient of gaseous and liquid ethylene have been evaluated and represented by an empirical function, developed in previous work. Tables of values are presented for the range 110–500 K for pressures to 50 MPa ($\approx$500 atm). Both the viscosity and thermal conductivity coefficients are estimated to have uncertainties of about $\pm5\%$ increasing to 10% in the dense liquid. It is stressed that the data base could be improved. As in our work with other fluids, the anamalous contribution to the thermal conductivity in the vicinity of the critical point is included.

Matsunaga, N.; Nagashima, A. **Transport properties of liquid and gaseous D_2O over a wide range of temperature and pressure.** *J. Phys. Chem. Ref. Data. 12(4):* 933-966; 1983.

Key words: critically evaluated data; deuterium oxide; diffusion coefficient; heavy water; kinematic viscosity; Prandtl number; thermal conductivity; thermal diffusivity; transport properties; viscosity.

Data for the viscosity and thermal conductivity of dense gaseous and liquid heavy water (D_2O) have been reviewed and critically evaluated. Selected data were fitted to equations, from which tables of values were generated from temperatures up to 500°C and for pressures up to 100 MPa for the viscosity and up to 550°C and 100 MPa for the thermal conductivity. The uncertainties of the tabular values were estimated. The present paper is intended to explain the background of the International Representations of the viscosity and thermal conductivity of heavy water substance of the International Association for the Properties of Steam. With the aid of the present correlations the kinematic viscosity, thermal diffusivity, and Prandtl number have been calculated. The present status of the gaseous diffusion coefficient is also briefly reviewed.

Pedley, J. B.; Marshall, E. M. **Thermochemical data for gaseous monoxides.** *J. Phys. Chem. Ref. Data. 12(4):* 967-1031; 1983.

Key words: computer methods; critically evaluated data; dissociation energies; enthalpy functions; free energy functions; gaseous diatomic monoxides; molecular parameters; standard

enthalpies of formation.

Values for standard enthalpies of formation and dissociation energies for gaseous diatomic monoxides have been selected by critical assessment of experimental data from the literature. Gibbs energy functions, $(-(G^\circ_T - H^\circ_{298})/T)$, and enthalpy functions, $(H^\circ_T - H^\circ_{298})$, have been calculated from literature values for molecular parameters. Computer methods of storage, processing and retrieval are described and the resulting data are given in tables 4 to 11.

Chao, J.; Lin, C. T.; Chung, T. H. **Vapor pressure of coal chemicals.** *J. Phys. Chem. Ref. Data. 12(4):* 1033-1063; 1983.

Key words: aromatic hydrocarbons; benzene derivatives; coal chemicals; Cox equation; cycloalkanes; cycloalkenes; heterocyclic nitrogen compounds; heterocyclic oxygen compounds; heterocyclic sulfur compounds; naphthalene derivatives; vapor pressure; vapor pressure equation.

The vapor pressure data on 324 coal compounds are collected and analyzed. The adopted data sets for each substance are weighted and combined to fit into a Cox vapor pressure equation, $\log_{10}P = (1-D/T) \times 10^{(A+BT+CT2)}$ by the least-squares methods. The results of the literature review and the evaluated values of coefficients for the vapor pressure equations are presented in separate tables. For ease of presentation, the coal compounds are divided into seven groups, based upon their molecular structures. They are (1) benzene and its derivatives, (2) naphthalene and its derivatives, (3) saturated ring compounds, (4) unsaturated ring compounds, (5) heterocyclic sulfur compounds, (6) heterocyclic nitrogen compounds, and (7) heterocyclic oxygen compounds.

5.3 MONOGRAPHS

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

Monogr. 172. Haynes, W. M.; McCarty, R. D.; Hiza, M. J. **Liquefied natural gas densities: Summary of research program at the National Bureau of Standards.** *Natl. Bur. Stand. (U.S.) Monogr. 172;* 1983 October. 241 p. SN003-003-02528-3.

Key words: binary mixtures; density; experimental data; liquefied natural gas; magnetic suspension densimeter; multicomponent mixtures; prediction methods; pure fluids.

This report summarizes the results of a project concerning the densities of liquefied natural gas (LNG) and its components. This project, initiated in the Properties of Fluids Section of the Cryogenics Division of the National Bureau of Standards in July 1972, was carried out under the sponsorship of a consortium of eighteen energy companies.

The experimental part of this project has included the following accomplishments: (a) development of a magnetic suspension densimeter for absolute density measurements on liquids, including liquid mixtures in equilibrium with their vapor, at temperatures from 90 to 300 K; (b) orthobaric liquid density measurements on the major components of LNG, which include nitrogen (95–120 K), methane (105–160 K), ethane (100–270 K), propane (100–288.7 K), isobutane (115–300 K), and normal butane (135–300 K); (c) orthobaric liquid density measurements on approximately thirty-five binary mixtures of the above components for all combinations except nitrogen + butane systems, primarily in the temperature range of 105 to 130 K; and (d) orthobaric liquid density measurements on twenty-seven multicomponent mixtures (105–120 K), including several LNG-like mixtures with up to eight components. The total uncertainty of a single density measurement is approximately 0.1 percent at low temperatures and decreases to approximately 0.06 percent at room temperature. The estimated standard deviation of a single density measurement is less than 0.02 percent.

The density data have been used to optimize, test, and compare several mathematical models as to their suitability for the calculation of LNG densities for custody transfer. Models selected for optimization and testing included an extended corresponding states method, a hard sphere model, a cell model, and an empirical model due to Klosek and McKinley. The ultimate goal of this project was to produce one or more mathematical models that could be used to predict the density of any LNG mixture to within an uncertainty of 0.1 percent from an input of pressure, temperature, and composition. After revisions based on the new experimental data from this project, each of the models investigated here satisfy this goal for typical LNG compositions. The limitations and ranges of validity of the various models are discussed. Also presented are techniques for predicting LNG densities from dielectric constant measurements and from excess volume calculations.

The last section of this report consists of publications that provide a complete and detailed account of the results of this project.

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

H44, 1984. Warnlof, O. K., ed. **Specifications, tolerances, and other technical requirements for weighing and measuring devices.** (Superseding Handbook 44, 1983 Edition.) *Natl. Bur. Stand. (U.S.) Handb. 44, 1984 Edition;* 1983 November. 220 p. SN003-003-02533-0.

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

Handbook 44 was first published in 1949, having been preceded by similar handbooks of various designations and in several forms, beginning in 1918. This 1984 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 68th National Conference on Weights and Measures during its annual meeting in 1983. Handbook 44 is published in its entirety each year following the annual meeting of the National Conference on Weights and Measures.

H130, 1984. Brickenkamp, C. S., ed. **Uniform laws and regulations.** (Superseding Handbook 130, 1983 Edition.) *Natl. Bur. Stand. (U.S.) Handb. 130, 1984 Edition;* 1983 October. 108 p. SN003-003-02523-2.

Key words: basic weights and measures law; method of sale of commodities; open dating; packaging and labeling; pattern approval regulation; registration of service persons; type evaluation; unit pricing; Weighmaster Law.

This Handbook compiles the latest Uniform Laws and Regulations adopted by the National Conference on Weights and Measures (NCWM). Each Edition is developed by the Committee on Laws and Regulations of the NCWM with the assistance of the Office of Weights and Measures of the National Bureau of Standards. The compilation itself was approved by the NCWM in 1979, and this Edition includes amendments adopted at the annual meeting in 1983. The title of the Handbook and the titles of the laws and regulations compiled in it were changed at the 1983 annual meeting of the NCWM. A new regulation, the "Uniform Regulation for National Type Evaluation," was adopted in 1983 and is included in this compilation.

H141. Klote, J. H.; Fothergill, J. W., Jr. **Design of smoke control systems for buildings.** *Natl. Bur. Stand. (U.S.) Handb. 141;* 1983 July. 284 p. SN003-003-02534-8.

Key words: analysis of smoke control systems; buildings; design criteria; smoke control systems.

This book consolidates and systematically presents data and calculational procedures necessary to smoke control systems designers and discusses design criteria. The book was originally intended for use by mechanical engineers. However, it may also be useful to fire-protection engineers and code officials. Included are discussions of the driving forces of smoke movement, the principles of smoke control, calculation of effective flow areas, concept of symmetry, and design parameters. A computer program for analysis of smoke control systems is presented. Concepts of stairwell pressurization and zone smoke control are presented. Numerous hand calculated examples and computer calculated examples are included.

5.5 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.

SP260-81. Burke, R. W.; Mavrodineanu, R. **Standard reference materials: Accuracy in analytical spectrophotometry.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-81;* 1983 April. 140 p. SN003-003-02484-8.

Key words: absorbance; accuracy; antimony; arsenic; cobalt; comparative measurements; copper; high-accuracy spectrophotometry; nickel; polarization; scatter; spectral bandpass; spectrophotometric determinations; standard reference materials; stray light; transmittance; transmittance stability; wavelength accuracy.

This publication describes the activities undertaken since 1969 within the Center for Analytical Chemistry at the National Bureau of Standards (NBS) in the field of high-accuracy spectrophotometry. The first part of this work presents a summary of the Standard Reference Materials (SRMs) that have been developed for checking the proper functioning of ultraviolet and visible spectrophotometers and includes a description of the high-accuracy spectrophotometer specially constructed in the Center for Analytical Chemistry and subsequently used for performing all of the transmittance measurements. The second part of this publication is devoted to a critical discussion of the analytical factors that can affect the accuracy of selected spectrophotometric procedures that have been widely used at NBS in the characterization of various SRMs.

SP260-82. Weidner, V. R. **Standard reference materials: White opal glass diffuse spectral reflectance standards for the visible spectrum (SRMs 2015 and 2016).** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-82;* 1983 April. 33 p. SN003-003-02489-9.

Key words: diffuse; reflectance; spectrophotometry; standard; translucency; Vitrolite.

Vitrolite white opal glass has been calibrated for use as diffuse spectral reflectance standards since 1944. Its uniformity and long-term durability make it useful as an everyday working standard for spectrophotometric measurements in the visible spectral range. However, its translucency can introduce some errors in such measurements if improperly used. Prior to 1965 the Vitrolite reflectance standards were issued with diffuse reflectance values relative to freshly smoked magnesium oxide. Since that date the calibration of these standards is reported on an absolute reflectance scale or one which is relative to a perfect diffuser. Since the completion of the NBS Reference Spectrophotometer for diffuse reflectance measurements in 1975, work on the perfection of techniques for determining a more accurate absolute reflectance scale has made it possible to further improve these measurements. As a result of this effort, the Vitrolite reflectance standards are now more accurately characterized and are being issued as a Standard Reference Material.

SP260-83. Bowers, G. N., Jr.; Alvarez, R.; Cali, J. P.; Eberhardt, K. R.; Reeder, D. J.; Schaffer, R.; Uriano, G. A.; Elser, R.; Ewen, L. M.; McComb, R. B.; Rej, R.; Shaw, L. M. **Standard reference materials: The measurement of the catalytic (activity) concentration of seven enzymes in NBS human serum SRM 909.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-83;* 1983 June. 108 p. SN003-003-02499-6.

Key words: enzyme; enzyme (catalytic) activity; human serum; interlaboratory reproducibility; reference method; standard reference material.

We determined the catalytic (activity) concentrations of seven enzymes (ACP, ALP, ALaAT, AspAT, CK, LDH and γ-GT) in the NBS lyophilized human serum Standard Reference Material (SRM 909). SRM 909 enzyme activity values should provide the basis for compatibility among methods for determining enzyme values in serum. Separate teams of clinical chemistry experts selected and carried out the analyses for the individual enzymes. The methods used are primarily those recommended by the Standards Committees of the AACC and/or the IFCC, as candidate reference methods; however, a reaction temperature set-point of 29.77 °C (the gallium melting point) was used. This monograph describes the serum reconstitution protocol, the specific enzyme methods, and the results of the third (and last) round of the interlaboratory test program, which we used to derive mean values for enzyme catalytic (activity) concentrations in SRM 909. Interlaboratory standard deviations of less than 10% were achieved. Measurements made one year after the conclusion of the interlaboratory study showed unchanged enzyme activities, within the uncertainties of the original assigned values.

SP260-84. Gills, T. E.; Seward, R. W.; Collins, R. J.; Webster, W. C. **Standard reference materials: Sampling, materials handling, processing, and packaging of NBS sulfur in coal standard reference materials.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-84;* 1983 August. 62 p. SN003-003-02520-8.

Key words: bituminous coal; blending; drying; hammermilling; homogeneity; processing; sampling; screening; standard reference materials; sub-bituminous; sulfur.

This publication describes in detail the performance of a grant given to Valley Forge Laboratories, Inc., by the National Bureau of Standards, to obtain and prepare four standard reference coals, with nominal sulfur contents of 0.5, 2.0, 3.0, and 4.5 percent to be issued as SRMs 2682, 2683, 2684, and 2685, respectively. All activities pertaining to the sampling, preparation, packaging, and homogeneity testing of the coal SRMs are documented in this report, including a separate description of each of the four coal sampling activities. Protocols used in the development of these Standard Reference Materials are similar to those used in other NBS SRM preparation procedures to ensure that materials used for SRMs have the highest possible homogeneity and stability.

SP260-85. Swyt, D. A. **Standard reference materials: A look at techniques for the dimensional calibration of standard microscopic particles.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-85;* 1983 September. 150 p. SN003-003-02521-6.

Key words: dimensional measurement; electron microscopy; flow-through particle counters; latex spheres; light scatter; micrometrology; microscopic spheres; Mie scattering; optical microscopy; particle standards; particle size calibration; polymer spheres; scanning electron microscope; transmission electron microscope.

This report surveys generic techniques for the dimensional calibration of microscopic particle size standards. It notes some user needs and available instrumentation, documentary standards, and commercial, sized particles. It discusses the elements of the measurement process, including the particle and medium, size-dependent phenomena, shape factors, single-number indices of average size, and means of length calibration. The report examines systematic differences among published results of electron microscopy, light scattering, particle counter, and other measurements on widely-used commercial polymer spheres. It concludes that the definitive calibration of narrow-distribution polymer spheres, a prerequisite first step toward calibration of irregularly-shaped matter, would best involve a three-element approach involving the techniques named.

SP260-86. Hicho, G. E.; Eaton, E. E. **Standard reference materials: A standard reference material containing 2.5 percent austenite (SRM 488).** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-86;* 1983 December. 23 p. SN003-003-02541-1.

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

This Standard Reference Material, SRM 488, is intended for the calibration of x-ray diffraction equipment used in determining the amount of retained austenite in hardened steels. The SRM was produced using powder metallurgical techniques and involved blending 2 1/2 percent by weight AISI type 310 stainless steel powder (austenitic) with AISI type 430 stainless steel powder (ferritic). From this blend, 389 compacts were produced and subsequently examined for nickel content by x-ray fluorescence spectrometry. A calibration curve was established using 13 compacts randomly selected from the population of 389. The curve relates the weight percent nickel obtained from x-ray fluorescence measurements

to the volume percentage austenite as determined by quantitative microscopy measurements of the area percent. The curve was then used to assign the certified values to the remaining compacts. This SRM may be used as an x-ray diffraction standard for retained austenite or in very special cases as an x-ray fluorescence standard for nickel content.

SP260-87. Mangum, B. W. **Standard reference materials: SRM 1969: Rubidium Triple-Point Standard—A temperature reference standard near 39.30°C.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-87;* 1983 December. 36 p. SN003-003-02544-5.

Key words: melting-point temperature; rubidium; SRM 1969; temperature fixed point; temperature reference point; triple-point temperature.

Previous work has demonstrated the practicability of using the triple point of rubidium as a temperature reference point. As a result of that work, Standard Reference Material (SRM) 1969—the Rubidium Triple-Point Standard, has been developed. This publication reports results of an investigation of 100 SRM 1969 cells; it describes SRM 1969, the tests which were performed on the cells, the conditions under which the cells were tested, the results of the tests, and the recommended procedure for the use of SRM 1969 in calibrating thermometers. For the 100 cells, the temperatures of the midpoints of the plateaus of the melting curves ranged from 39.280°C to 39.313°C, with a mean value of 39.303°C. The melting ranges of the samples varied from approximately 8 mK to approximately 24 mK, with mean value of 14 mK. Only two cells had melting ranges greater than 20 mK, one being 21 mK and the other 24 mK. An estimated uncertainty of ±0.010°C is assigned to the midpoint temperatures of the plateaus of all cells except for those two cells. Thus, in using SRM 1969 cells for the calibration of thermometers, a calibration at any point on the plateau of the melting curve should provide a temperature (the value specified on the Certificate accompanying each cell) with an uncertainty no greater than ±0.010°C. With special care, a thermometer can be calibrated against an SRM 1969 cell to an uncertainty as small as ±0.005°C in the National Bureau of Standards (NBS) assigned value. The use of SRM 1969 in clinical and biomedical laboratory applications should significantly enhance the accuracy of temperature measurements in the region of body temperature.

SP305. Supplement 14. Morehouse, R. J., ed. **Publications of the National Bureau of Standards 1982 Catalog.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 305, Suppl. 14;* 1983 June. 436 p. SN003-003-02501-1.

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

The 14th Supplement to Special Publication 305 lists the 1982 papers which reflect the results of the National Bureau of Standards programs. Also included are those NBS papers published prior to 1982 but not reported in previous supplements of SP305. In addition to bibliographic data, key words, and abstracts for each publication and/or paper, the catalog provides an author and key word index.

SP400-75. Mattis, R. L. **Semiconductor measurement technology: A FORTRAN program for analysis of data from microelectronic test structures.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 400-75 (Supersedes NBSIR 82-2492);* 1983 July. 66 p. SN003-003-02512-7.

Key words: computer program; correlation coefficient; data management; outlier; process validation wafer; statistical analysis; test structures; two-dimensional arrays; wafer map.

A computer program, STAT2, is described which performs the following functions: reads data as a two-dimensional array; calculates mean, sample standard deviation, and median; identifies outliers; calculates replacement values for outliers; makes gray-tone, numerical and contour data maps on a line printer; makes a numerical map on the user's terminal; makes a histogram on a line printer; constructs a data base for examining correlations among various data sets; and searches the data base for correlations using several selective keys. The emphasis in this document is on program usage, and detailed descriptions of the commands are given. Data input requirements are addressed. Guidance regarding several types of program modifications is provided.

SP446-7. Raufaste, N.; Olmert, M., eds. **Building technology project summaries 1982–1983.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 446-7;* 1983 June. 138 p. Available from: NTIS; PB 83-259622.

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

The Center for Building Technology (CBT) provides the technical and scientific bases for criteria and standards that improve the usefulness, safety and economy of buildings. The Center's activities support building technology programs of the Federal, State, and local governments; assist design professions, building officials and the research community by providing criteria that improve buildings; and assist manufacturers of building products by developing criteria for evaluating innovative building materials. This report summarizes the Center's projects for calendar years 1982-83; it provides the reader with a broad overview of CBT's research.

SP457-7. Beavers, L., ed. **Building Technology Publications 1982—Supplement 7.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 457-7;* 1983 June. 78 p. SN003-003-02503-8.

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

This report presents NBS' Center for Building Technology (CBT) publications for 1982. It is the seventh supplement to NBS Special Publication 457, *Building Technology Publications*, and lists CBT reports issued during January 1-December 31, 1982. It includes titles and abstracts of each CBT publication and those papers published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

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

SP500-100. Fiorello, M.; Eirich, P. L.; Kay, P. **Computer science & technology: Toward an improved FIPS cost-benefit methodology, Phase I: Descriptive models—Data processing operations.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-100;* 1983 January. 68 p. SN003-003-02461-9.

Key words: computer security; computer standards; cost-benefit analysis; data processing management; data processing operations; data processing standards; descriptive models; impact assessment; information systems.

This report presents a set of functional-flow descriptive models that can be used to categorize the operational activities of Federal data processing users. Data processing applications may be conceptually represented in descriptive model form by combining one or more of the basic models. The comprehensive framework for data processing operations provided by these descriptive models can be used in the identification of impacts from standards and guidelines and in the preparation of cost-benefit impact assessments. The framework provides both macro and micro levels of detail in order to link the descriptive models to additional data processing issues, such as computer security issues.

SP500-101. Geller, S. B. **Computer science & technology: Care and handling of computer magnetic storage media.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-101;* 1983 June. 135 p. SN003-003-02486-4.

Key words: archival storage; care and handling; certification/evaluation; clean rooms; computer tape, magnetic; environmental effects; flexible disks; magnetic fields, effects of; rehabilitation, computer tape; scheduled maintenance, computer tape; storage media, computer magnetic; tape management systems.

This Special Publication deals with the physical/chemical preservation of computer magnetic storage media—principally computer magnetic tapes—and their stored data, through the

application of proper care and handling methods under various conditions. It emphasizes the media handling methods and environmental conditions which should be instituted during the course of controllable day-to-day and long-term archival storage activities. It also considers measures which can be initiated during media transit and in the aftermath of catastrophic or uncontrollable events. However, the publication does not address the problem of computer storage system security from the viewpoint of data theft or intentional data modification.

SP500-102. Gilbert, D.; Parker, E.; Rosenthal, L. **Computer science & technology: Microcomputers: A review of Federal agency experiences.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-102;* 1983 June. 146 p. SN003-003-02492-9.

Key words: Federal agency microcomputer experience; microcomputer experience; microcomputer management issues; microcomputer technical considerations.

This document presents the results of a recent study which reviewed Federal agency experience with microcomputers during the period of August 1982–January 1983. Its intended audience are all those who are interested in microcomputer-based technology and want to benefit from the current Federal experience. Interviews conducted with the Federal agencies are presented in detail, summarized, and tabulated. Related management and technical issues are identified and discussed. The study found that many Federal users are eagerly looking for guidance in selecting and using microcomputer systems. Incentive based support to end users appears to by a major tool available to agencies for managing the new technology. Emphasis is being placed on off-the-shelf software packages. Appendices of this document provide the reader with an initial road map to sources of information.

SP500-103. Kay, P.; Powell, P., eds. **Computer science & technology: Future information processing technology—1983.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-103;* 1983 August. 243 p. SN003-003-02504-6.

Key words: computers; cost estimation; distributed processing systems; end-user computing; Federal ADP regulations; general-purpose computer systems; information processing industry; management strategies; microcomputers; office systems; technology forecasting.

The document contains the 1983 Technical Forecast for the information processing industry through 1997. It consists of six parts. Part I forecasts the underlying technologies of hardware and software, contains a discussion of changes in the information industry and market, and forecasts products and systems of the future, e.g., general-purpose systems, distributed processing systems, office systems. Part II contains Federal agency staff comments on Part I. Part III summarizes a teleconference in which a number of industry ADP users and vendors reviewed Part I. Part IV provides cost estimates for computer systems, subsystems, and terminals through 1997. Part V discusses the current and potential rules and regulations of the Federal environment and how they may affect the Federal inventory of ADP equipment. Part VI discusses management strategies for the new information technologies with emphasis on microprocessors.

SP500-104. Mobray, D., ed. **Computer science & technology: Proceedings of the Computer Performance Evaluation Users Group (CPEUG) 19th Meeting.** Proceedings of the Computer Performance Evaluation Users Group (CPEUG) 19th Meeting; 1983 October 25-28; San Francisco, CA. *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-104;* 1983 October. 236 p. SN003-003-02516-0.

Key words: acquisition; benchmarking; capacity planning; cost accounting and chargeback; data communications; end-user computing; local area networks; microcomputers; modeling techniques; office automation; software engineering.

These Proceedings record the papers that were presented at the Nineteenth Meeting of the Computer Performance Evaluation Users Group (CPEUG 83) held October 25-28, 1983 in San Francisco, CA. CPEUG 83 recognized the rapid introduction of sophisticated end-user technology into the information processing environment and addressed the challenges posed to the CPE community. CPEUG 83 offered topics ranging from microcomputers to supercomputers. The increasingly complex area of data communications was presented as well as topics in office automation, software improvement and engineering, capacity planning, and quality assurance. The program was divided into three parallel sessions and included technical papers, case studies, tutorials, and panels. Technical papers are presented in the Proceedings in their entirety. *These proceedings include the following papers (indented):*

SP500-104; 1983 October. 24-31. Arthurs, E.; Chesson, G. L.; Stuck, B. W. **Theoretical performance analysis of virtual circuit LAN sliding window flow control.**

Key words: sliding window protocol; virtual circuit LAN.

A transmitter breaks a message up into packets and transmits the packets to a receiver over a single virtual circuit within a local area network. The receiver has a finite amount of storage capacity for buffering messages. A *sliding window protocol* turns the transmitter on and off to insure there is always storage room in the receiver for packets. Mean throughput rate and delay statistics are studied as a function of model parameters.

SP500-104; 1983 October. 32-55. Watson, W. B. **Modelling and monitoring a LAN, one experience.**

Key words: discrete event simulation; Hyperchannel based network; model validation; network monitoring; network performance evaluation.

This is a partial summary of efforts to design, model, measure and optimize a large, Hyperchannel-based, local network. I elaborate upon the cyclic interaction of these four activities and contrast our successes and failures in each with its costs.

SP500-104; 1983 October. 56-63. Ziegler, C. **Queue length characteristics at very fast, constant service time merger nodes.**

Key words: merger nodes; queue length characteristics.

This paper concerns itself with the determination of the steady-state queue length distributions at very fast merger nodes that are present within queueing networks. We study a network with a tree topology in which a given server at a node of the network provides each of its customers with an equal, constant amount of service time. A very fast merger node is defined as a node at which the service rate is greater than or equal to the sum of the service rates of the channels feeding into the merger node. Inputs following general, independent probability distributions are considered. A condition for absolute stability at the merger node is derived. The exact queue length distribution is found for a subset of these fast merger nodes via a combinatorial analysis of possible arrival patterns of customers into the merger node.

SP500-104; 1983 October. 64-77. Hartrum, T. C.; Magavero, G. **The application of multivariate statistical techniques to computer performance evaluation using simulated data.**

Key words: automatic interaction detection; canonical correlation analysis; cluster analysis; computer performance evaluation; discriminant analysis; factor analysis; multilinear; multivariate statistical techniques; performance modeling; regression; ridge regression.

This paper considers the application of multivariate statistical techniques to the analysis of data for use in computer performance evaluation (CPE). Traditionally, multilinear regression analysis has been used in the analysis of CPE data. More recently cluster analysis has found applications in this field, both in workload analysis and in performance modeling. However, both approaches have problems when applied to the type of data often encountered in CPE studies. In recent years, several new statistical techniques have been developed to overcome or compensate for these problems. Although these techniques have been used in a variety of business and social applications, little has been reported on their applicability to CPE. This study considered a total of seven multivariate statistical techniques: multilinear regression (as a baseline technique), cluster analysis, ridge regression, automatic interaction detection (AID), canonical correlation analysis, factor analysis, and discriminant analysis. Each technique was examined for its theoretical capabilities and expected usefulness in a CPE

environment. Then each technique was applied to several sets of CPE data. In order to conduct a controlled experiment, the data was generated by CPESIM, a simulation of a multiuser mainframe computer system. Based on the results of their application to simulated CPE data, it was found that all of the techniques could be useful to varying degrees and in varying ways. Some gave better predictability than regression, based on the r-squared value, some gave a better analysis of interrelationships between parameters, and so forth. Because of their individual natures, then, each technique was found to be most useful to particular types of problems. Thus a given CPE problem might not be able to use all of the techniques. As a whole, however, these techniques should be considered by anyone performing statistical analysis of computer system data.

SP500-104; 1983 October. 78-85. Ferrari, D.; Lee, T. P. **Improving the accuracy of a working-set-oriented generative model of program behavior.**

Key words: generative model; program behavior; working set policy; workload characterization.

An experiment based on trace-driven simulation is carried out to study various improvement strategies for a working-set-oriented generative model. Working set size strings extracted from a real program trace are used as inputs to the generative model. The memory demand and page fault rate of these artificial memory reference strings are compared with those of the original real reference string under the working set policy. The same strings are also tested under two different memory management policies: the page fault frequency policy and the least recently used policy. Artificial strings generated with proper strategies behave quite well under both the working set and the page fault frequency policies. However, they behave less than satisfactorily under the least recently used policy.

SP500-104; 1983 October. 86-91. Stroup, O. R. **Software improvement program.**

Key words: automated verification; COBOL; DMA; FORTRAN; modern programming; programming standards; software conversion; software improvement; SPERRY 1100; structured programming.

This paper summarizes DMA's approach to upgrade its SPERRY Scientific and Technical software while modernizing the Agency's software practices. The objectives of the five-year software improvement program are: increased productivity; improved software quality, maintainability, reliability, and portability; and standardization of software development practices. Both current problems and the program to introduce a modern programming environment, improve existing software and upgrade personnel skills to support the new environment are detailed.

SP500-104; 1983 October. 92-107. Houtz, C. A. **Software Improvement Program (SIP): A treatment for software senility.**

Key words: Software Engineering Technology (SET); software improvement; Software Improvement Program (SIP); software obsolescense; stepwise refinement.

ADP organizations are plagued with high maintenance costs, long delays in responding to users' changing needs, and continued development and maintenance of antiquated, outmoded, and relatively obsolete software. This software can be thought of as being in an advanced state of software senility, a degenerative condition, which if not corrected, will eventually render the software totally useless. A reversal of this situation requires a Software Improvement Program (SIP), which is a treatment for the ills of software senility, and offers a cure for many of the software problems from which most ADP organizations are suffering. A SIP is an incremental and evolutionary approach to modernizing software to maximize its value, quality, efficiency, and effectiveness, while simultaneously preserving the value of past software investments and enabling the organization to capitalize on today's modern ADP technology, as well as future technological advances in the field. This paper describes the SIP philosophy and presents a strategy for implementing a dynamic, ongoing SIP coupled with a sound Software Engineering Technology (SET), to attack the causative factors of the ever-growing software crisis.

SP500-104; 1983 October. 108-115. Walker, M. G. **Software improvement through automated normalization.**

Key words: automated normalization; software improvement.

Many major ADP centers have a decade or more invested in their applications software and the organizations they support are almost totally dependent upon its operation. The software "works" in that its logic is basically correct and it supports the organization's mission. In most centers, merely keeping the software operational is such a difficult task that any change to the baseline, either to enhance or add functions, is reasonably perceived as both risky and expensive. However, the software must be improved to keep ADP costs low and service reliable. Software improvement is the process of modernizing software by retaining its fundamental logic while upgrading its reliability, economy, and flexibility. The goal of improvement is to posture software to take advantage of new technology.

SP500-104; 1983 October. 116-134. Orchard, R. A. **Algebraic models for CPU sizing.**

Key words: algebraic models; average CPU utilization; CPU.

This paper describes a CPU sizing methodology developed by the author for a corporate Performance and Configuration Group. The objective of this study was to effectively predict CPU utilization and total workload turnaround time for future batch workloads. This was accomplished through the implementation of certain algebraic models which successfully model the various components (i.e., CPU, I/O, etc.) of a computer system, capturing the dynamic interrelationship of hardware configuration, operating system logic and application workload. The result of this work is an algorithm which will accurately forecast average CPU utilization, volume independent CPU utilization, initiator turnaround and workload turnaround time for a given workload on various CPU models (3031, 168-3, 168-3 MP, 3033, 3033 MP). From a planning viewpoint, this information is extremely important in determining hardware needs as application workload characteristics change.

SP500-104; 1983 October. 135-149. Johnson, L. A.; Milligan, W. R. **Establishing a software engineering technology (SET).**

Key words: software engineering; Software Engineering Technology (SET); software management; software tools.

This paper will discuss the concept of software engineering as provided by Dr. Barry Boehm as "the application of science and mathematics by which the capabilities of computer equipment are made useful to man via computer programs, procedures, and associated documentation." It can serve as a starting point for developing and institutionalizing a modern Software Engineering Technology (SET). The document defines key elements which comprise a SET and suggests a method for formulation of these elements into a technology that encompasses all of the primary stages of the software life cycle. It presents a discussion of the types modern day software engineering practices. The approach emphasizes the incremental integration of software tools into the technology as a means of increasing productivity, establishing regularity and uniformity, and improving control over software systems.

SP500-104; 1983 October. 150-160. von Mayrhauser, A. **Characteristics of software development team structures and their impact on software development.**

Key words: software development; structured design; structured programming; structured testing; structured walkthrough; team structures.

Several of the team structures proposed in the literature such as Chief Programmer Team, Surgical Team, Revised Chief Programmer Team advocate a separation of tasks for a programming team resulting in specific roles for the members on the team. An analysis of these roles with respect to personality and task requirements is presented which enables a better

tailoring of these team concepts to specific projects with a given staff. Based on the definitions of the various roles of the different team structures requirements for a particular position are derived and suggestions are made how to select the most appropriate team structure for different types of projects and known people characteristics. Depending on how well team structure and its requirements match problem and people characteristics indicators can be derived pointing out possible problem areas before they occur so that corrective action can be taken before schedules and/or budgets are overrun and team members become dissatisfied.

SP500-104; 1983 October. 163-167. Georgatos, E. P. **Information centers: The user's answer to the computer room.**

Key words: data bases; data manipulation; DP department; implementation plan; information center; Information Technology Center (ITC); modifications; networking; office automation; personal computers; publicity; staffing; stand-alone; testing; user needs; users; work environment.

New "Information Centers," which utilize and promote personal computer use, have gained popularity in many large businesses and are now finding their way into the Federal Government. Their most interesting feature is that the users operate the equipment themselves. While the Centers aren't capable of doing the large jobs currently handled by the typical DP department, they are introducing the user to personal computing and to more advanced data processing theories. This paper briefly describes the Information Center concept and discusses the establishment of a Center at the Veterans Administration in Washington, DC.

SP500-104; 1983 October. 169-176. Campbell, M. **An organization model and case study for microcomputer CPE.**

Key words: end user; microcomputer; microcomputer laboratory; model; objective oriented management; organizational tensions; organization development; productivity; reference system; team work; technology.

In this paper, computer performance evaluation is viewed from the perspective of assimilating the microcomputer into the organization.

It presents a way of thinking about problems and answers. It does this by presenting a model and some sample components of the model.

The approach is an attempt to fit some microcomputer issues into the framework of organization development styles.

SP500-104; 1983 October. 178-183. Acklen, T. H. **Data processing user service—A problem; A proposed solution.**

Key words: communications networks; data manipulation capabilities; data repositories; programming productivity aids; responsiveness; software improvement plan; systems development methodology.

While data processing technology continues to progress at an ever increasing pace, techniques employed by data processing organizations to extend these technological benefits to users remains basically static. Users are buffered by analysts and programmers from the equipment's capabilities. Maintenance of existing systems places a growing burden on the data processing organization, and the development of new applications is people-intensive and protracted. Users are becoming more dissatisfied with the data processing organization's inability to respond to their demands. As a result, users are in many instances, trying to use microcomputers to fulfill their own needs. Such maverick efforts, although potentially beneficial to a particular user, could introduce disarray into an organization's efforts to establish integrated information systems.

This paper proposes a series of actions which should improve the data processing organization's ability to serve the user community. The underlying strategy of these actions is to enable users, within the context of an overall data processing plan, to provide for many of their own needs thus permitting the data processing organization to concentrate on the more complex tasks. The overall objective is to insure more responsive and less costly data processing support.

SP500-104; 1983 October. 184-186. Vincent, D. R. **Standard costing for ADP services.**

Key words: accounting methodologies; ADP services; data processing; data transfer; information resource characteristics; management of the database; standard costing; storage of the information asset.

This paper is an initial exploration into the area of standard costing for ADP services. Historically, data processing expenses have been regarded as variable, depending on hardware and software procurement and usage. This paper takes the position that information systems expenses are relatively fixed, and that *information* is the resource to be managed, as opposed to hardware and/or software.

SP500-104; 1983 October. 187-196. DeJesus, E. G.; Riesberg, C. J. **Automating configuration management.**

Key words: change control; inventory management; software distribution; validation testing.

The ability to manage Software and Hardware Changes at remote sites is one of the most critical components in any computer network. Four major elements of configuration management are addressed: Change Control, Validation Testing, Inventory Management and Software Distribution.

The first element, Change Control, provides a complete audit trail (document tracking) of change requests from conception to implementation, regardless of origin (self or user initiated). The control includes, but is not limited to, automatic numbering, cataloging incomplete requests and journalizing historical data upon completion.

The second element, Validation Testing, provides for internal software driven flexible benchmark type testing; or an external remote terminal emulator which again uses the flexible benchmark concept but adds stress testing capability.

The third element, Inventory Management, deals with the particular applicability of the change to the site taking into consideration the hardware configuration.

The fourth element, Software Distribution, handles automatic shipment of bundled software to sites configured on line. Further, it provides automatic preparation for shipment via the most expeditious means available to sites not accessable through the computer network.

SP500-104; 1983 October. 197-214. Cabrera, L. F. **The terminal probe method revisited. Some statistical considerations.**

Key words: benchmarking; generalized linear models, installation comparisons; linear predictor; performance; performance indices; terminal probe; UNIX operating system; work load estimators.

The Terminal Probe method has recently been used to compare selected performance indices of different interactive computer installations. Since these comparisons have been done under the "natural" work load of the systems several validity questions arise.

In this paper we present results which summarize our experience in 10 systems with more than 11,000 measurements made over a span of two years. We analyze the empirical behavior of response time and find system independent statistical properties which enable us to attain predetermined confidence intervals for our values. Moreover, we have found a family of statistical models which fit our data in a comprehensive way: not only the mean and variance of our response time distributions are well approximated but the modelled distributions fit the observed ones. Thus, ordered statistics can also be obtained.

We may now control the data gathering period better, and, what is more, we have a predetermined statistical confidence in our curves. Thus, the robustness of the method is justified for comparisons.

SP500-104; 1983 October. 215-217. Gaffney, J. E., Jr. **Some elements of software function and cost analysis as related to performance.**

Key words: costing; lifecycle management; requirements; software management.

This paper provides some elements of modern software function and cost analysis. Proper emphasis on the software process is basic to ensuring that the software will perform as specified. Subjects covered are: the establishment of requirements, life cycle management and costing. They are all attributes of the software management process.

SP500-104; 1983 October. 218-233. Kazlauski, F. A. **Benchmark and conversion tool: Test data reduction program.**

Key words: benchmark; COBOL; conversion; coverage; extract; reduced.

The Test Data Reduction Program (TDRP) is a software tool for use as a COBOL program conversion aid or benchmark testing aid. It ensures that newly developed, enhanced or converted COBOL programs are tested as thoroughly as required by employing existing production data files and utilizing fewer computer resources. It is used to extract appropriate data records from the production data file and create a reduced data file. The reduced data file will achieve the same level of testing coverage as the original production file and may be used for future program testing.

SP500-105. Skall, M., ed. **Computer science & technology: Guide to software conversion management.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-105;* 1983 October. 220 p. SN003-003-02515-1.

Key words: conversion costs; conversion execution; conversion planning; conversion preparation; conversion requirements; documentation; project management.

This guideline was developed to provide federal ADP managers a better understanding of the entire process of software conversion. Software conversions have life cycles with distinct phases and activities that occur in each phase. Understanding the order or sequence of a conversion and of the associated costs should help managers to plan and execute software conversions efficiently, effectively, and with minimum operations disruption to Federal agencies. Although extensive references were consulted in preparing this guideline, the most important sources were interviews conducted at 14 Federal agencies that had completed or were involved in software conversion projects. These interviews influenced the structure and organization of this guideline in an attempt to present, in logical order, activities that must be performed to achieve a successful conversion.

SP500-106. Martin, R. J.; Osborne, W. M. **Computer science & technology: Guidance on software maintenance.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-106;* 1983 December. 74 p. SN003-003-02535-6.

Key words: adaptive maintenance; corrective maintenance; management; perfective maintenance; software engineering; software maintenance; software maintenance management; software maintenance tools.

This report addresses issues and problems of software maintenance and suggests actions and procedures which can help software maintenance organizations meet the growing demands of maintaining existing systems. The report establishes a working definition for software maintenance and presents an overview of current problems and issues in that area. Tools and techniques that may be used to improve the control of software maintenance activities and the productivity of a software maintenance organization are discussed. Emphasis is placed on the need for strong, effective technical management control of the software maintenance process.

SP500-107. Park, J. R. **Computer science & technology: A bibliography of the literature on optical storage technology.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 500-107;* 1983 December. 179 p. SN003-003-02539-9.

Key words: bibliography; computer disk; magnetooptic; materials; OD^3; optical computer disk; optical data disk; optical digital data disk; optical disk; optical storage; video disc; video disk.

This bibliography contains nearly 700 references related to optical storage and retrieval of digital computer data. The citations are divided into two major groupings: General Literature and Patent Literature Documents. Annotations are provided under the General Literature for many of the references in the critical area concerned with the media used for the optical recording and playback of optical digital data disks. The documents have been classified into several broad categories for the user's convenience. Access to the individual citations for each category is obtained through cross indexes which facilitate the rapid selection of pertinent articles. In addition to the categorical classifications, several other indexes are included in this bibliography.

SP637, Vol. 2. Chamberlain, G. E.; Day, G. W.; Franzen, D. L.; Gallawa, R. L.; Kim, E. M.; Young, M. **Optical fiber characterization: Attenuation, frequency domain bandwidth, and radiation patterns.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 637, Vol. 2;* 1983 October. 239 p. Available from: NTIS; PB 84-158914.

Key words: attenuation; bandwidth; core diameter; far field; measurements; near field; optical fiber.

This is the second volume of a series intended to describe optical fiber measurement systems developed at the National Bureau of Standards. The topics covered in this volume are attenuation, bandwidth (frequency domain), and far-field near-field radiation patterns. Each chapter includes a tutorial section and a detailed description of the apparatus. The volume concludes with a glossary of optical communications terms.

SP638. Bennett, H. E.; Guenther, A. H.; Milam, D.; Newnam, B. E., eds. **Laser induced damage in optical materials: 1981.** Proceedings of a Symposium held at the National Bureau of Standards; 1981 November 17-18; Boulder, CO. *Natl. Bur. Stand. (U.S.) Spec. Publ. 638;* 1983 September. 651 p. SN003-003-02513-5.

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

The Thirteenth Annual Symposium on Optical Materials for High Power Lasers (Boulder Damage Symposium) was held at the National Bureau of Standards in Boulder, CO, November 17-18, 1981. 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, the Office of Naval Research, and the Air Force Office of Scientific Research. Approximately 200 scientists attended the Symposium, including representatives of the United Kingdom, France, Japan, West Germany, the Peoples Republic of China, Sweden, and the USSR. The Symposium was divided into sessions concerning Materials and Measurements, Mirrors and Surfaces, Thin Films, and finally Fundamental Mechanisms. 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 μm 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, Arthur H. Guenther of the Air Force Weapons Laboratory, David Milam of the Lawrence Livermore National Laboratory, and Brian E. Newnam of the Los Alamos National Laboratory were co-chairmen of the Symposium. The Fourteenth Annual Symposium is scheduled for November 15-17, 1982, at the National Bureau of Standards, Boulder, CO. *These proceedings include the following papers (indented):*

SP638; 1983 September. 31-40. Dyumaev, K. M.; Manenkov, A. A.; Maslyukov, A. P.; Matyushin, G. A.; Nechitailo, V. S.; Prokhorov, A. M. **Transparent polymers as a new class of optical materials for lasers.**

Key words: absorbing defects; bulk damage; laser-induced damage; polymer materials; surface damage.

Possibilities of using transparent polymer materials for production of different optical elements (active elements with lasing dyes, bleachable Q-switching filters, etc.) for high-power lasers are discussed. Laser damage resistance of various polymers is particularly investigated. The dependences of laser-induced damage threshold on the initial monomer purity, chemical composition and temperature of polymers, frequency and duration of laser pulses, on the focal spot, as well as statistics and morphology of damages, the accumulation effect in damage in a multiple irradation regime, light nonlinear scattering and subthreshold UV-glow have been investigated to elucidate the mechanisms of laser-induced damage in polymers.

Absorbing defects of different kinds have been established to play an initiating role in the damage process. Purification of the initial monomers was found to result in high values of laser damage thresholds of polymers comparable with those for crystals and glasses, although considerable differences are revealed in the polymer damage characteristics compared to other optical materials.

Analysis of these peculiarities is presented and it is concluded that the molecular characteristics of plasticating agents are decisive in the mechanism of microdamage appearance initiated by absorbing defects, and that visco-elastic properties of polymers have a considerable effect on the growth of damages from micro- to macrodimensions.

A theoretical model of laser damage, as well as practical, effective ways of increasing laser damage resistance of polymer materials are discussed.

SP638; 1983 September. 41-52. Fernelius, N. C.; Dempsey, D. V.; O'Quinn, D. B.; Gangl, M. E.; Knecht, W. L. **Survey of 1.3 μm window materials continued.**

Key words: As_2S_3; HBL glass; infrared materials; iodine laser; laser calorimetry; $LiYF_4$; MgF_2; MgO; optical absorption coefficients; YAG; $Y_3Al_5O_{12}$; YLF;ZnS.

The purpose of this work is to screen candidate materials for use in the iodine laser which operates at 1.315 μm. The results presented here are the effective optical absorption coefficient, β_{eff}, measured by laser rate calorimetry using a Quantronix Nd:YAG laser modified to operate at 1.319 μm. Here we extend the measurements reported last year to new materials. These include MgF_2, MgO, Kigre Q-98 phosphate glass, YAG ($Y_3Al_5O_{12}$), water clear ZnS, CdTe, Schott IRG-N6 CaAl silicate, IRG-7 lead silicate, IRG-9 fluorophosphate glasses, and Hughes HBL glass. Spectral transmission scans using a Beckman 5270 and a Perkin-Elmer 180 spectrophotometer are presented for some of the less common materials. We also take this opportunity to report remeasured absorption values for data reported last year.

SP638; 1983 September. 53. Willingham, C.; Klein, C.; Pappis, J. **Multispectral chemically vapor-deposited ZnS: An initial characterization.**

Key words: chemical vapor deposition; multispectral; polycrystallinity laser damage tests; ZnS.

Standard-grade chemically vapor-deposited (CVD) ZnS has a dark orange, yellow milky appearance and exhibits a substantial amount of scatter in the near infrared, which limits its usefulness at the shorter wavelengths. Recently, we have succeeded in developing a "multispectral" CVD-ZnS material configuration, which is colorless and shows evidence of much improved transmittance throughout the spectral range of interest. In this paper, we report on work that has been carried out in the context of assessing the properties of this material, particularly with regard to (a) *Infrared absorption.* Thermocouple calorimetry measurements conducted at 1.3, 2.7, and 3.8 μm indicate that multispectral CVD ZnS has effective absorption coefficients of 1×10^{-3} cm^{-1} or less, thus establishing this material as a credible candidate for chemical-laser window applications. (b) *Elastic behavior.* Measurements of Young's modulus (87.6 GPa) and Poisson's ratio (0.318) in conjunction with sound-velocity measurements in the longitudinal mode (5.47 km/sec) demonstrate that multispectral CVD ZnS behaves precisely as predicted for a randomly-oriented single-phase polycrystalline aggregate of cubic ZnS. (c) *Fracture mechanics.* The results of Knoop hardness, flexural strength, and laser-damage experiments will be presented; we will also discuss techniques for improving the fracture toughness.

SP638; 1983 September. 54-64. Drexhage, M. G.; Bendow, B.; El-Bayoumi, O.; Brown, R. N.; Banerjec, P. K.; Loretz, T.; Moynihan, C. T.; Shaffer, J. J.; Temple, P. A.; Bennett, H. E. **Progress in the development of multispectral glasses based on the fluorides of heavy metals.**

Key words: fluoride glasses; infrared absorption; infrared glasses; infrared materials; multispectral glasses.

Considerable progress has been made recently both in the characterization of existing heavy metal fluoride glasses and in the development of new compositions with extended IR transmission. We here report results of continuing investigations of optical and physical characteristics of fluorozirconate type glasses, including absorption, scattering, and mechanical properties. We also report IR edge measurements of new fluoride glasses based on ThF_4 and BaF_2, which display extended IR transparency and potentially lower minimum absorption compared to fluorozirconates. These developments indicate that heavy metal fluoride glasses are highly promising for a variety of multispectral applications.

SP638; 1983 September. 65-75. Van Stryland, E. W.; Williams, W. E.; Soileau, M. J.; Smirl, A. L. **Optical damage, nonlinear transmission, and doubling efficiency in $LiIO_3$.**

Key words: laser induced damage; $LiIO_3$; nonlinear absorption; second harmonic generation; transient gratings.

Laser-induced damage thresholds of single crystal $LiIO_3$ have been studied using picosecond pulses at 1.06 μm and 0.53 μm. These thresholds depend on wavelength, crystal orientation, and on the number of times the sample has been irradiated. In addition, the doubling efficiency at high irradiance levels was observed to be a decreasing function of irradiance beyond a critical value. We present evidence to show that this results from the onset of optical parametric down conversion. In separate nonlinear transmission studies, reversible nonlinear transmission of 1.06 μm light was measured, and in self-diffraction experiments, both reversible and irreversible optically-induced complex index of refraction changes at 0.53 μm were observed.

SP638; 1983 September. 76-86. Gorshkov, B. G.; Epifanov, A. S.; Manenkov, A. A.; Panov, A. A. **Studies of laser-produced damage to transparent optical material in the UV region and in crossed UV-IR beams.**

Key words: crossed laser beams; d.c. photoconductivity; electron avalanche; frequency dependence of damage thresholds; seeding electrons; UV laser-produced damage.

The values of the damage thresholds of some alkali halide crystals, sapphire and fused quartz at $\lambda=0.266$ μm are presented.

The role of electron avalanche in the damage of real wide-gap dielectrics in the UV region is discussed.

Some peculiarities of the interaction of intense UV radiation with dielectrics (nonlinear absorption, photoionization of impurities, self-focusing and others) are considered.

Experiments on laser damage induced by two synchronous, crossed laser beams with different frequencies ($\lambda_1=1.06$ μm and $\lambda_2=0.266$ μm) are described. This method makes it possible to establish the influence of "seeding" electrons on the development of laser-produced damage, as well as to determine if the damage mechanisms are similar at different frequencies.

In order to record directly and estimate concentrations of the free carriers excited by UV laser radiation, d.c. photoconductivity experiments have been carried out.

SP638; 1983 September. 87-95. Marrs, C. D.; Faith, W. N.; Dancy, J. H.; Porteus, J. O. **Laser damage measurements at 492 nm using a flashlamp-pumped dye laser.**

Key words: damage thresholds; defect damage; diamond-turned mirrors; dielectric mirrors; dye laser; metal mirrors; multithresholds; pulsed laser damage; thin films; visible reflectors.

A triaxial flashlamp-pumped dye laser has been developed into a characterizable source for laser damage studies. The temperature of the dye is maintained constant to ±0.2°C via three heat exchangers and flow regulation of the dye, coolant, and refrigerant. Using LD 490 laser dye and maintaining a temperature of 1.1±0.2°C cooler than the temperature of the coolant, the laser produces 0.18 J, 0.5 μsec pulses at 492 nm. The pulse-to-pulse energy stability is ±3%. The spatial profile of the focused beam was measured in orthogonal directions in the plane of damage of the focus lens. The orthogonal profiles were flat-topped Gaussians with $1/e^2$ widths of 270 μm. Laser damage measurements have been performed at 492 nm on high reflectance dielectric mirrors, and no correlation was found between the reflectance or total integrated scatter and the axial fluence at which damage was observed. The damage morphology observed on the dielectric mirrors was dominated by failure of the coating at defects (selective damage sites). In addition, multithreshold laser damage measurements were performed on polished bulk Mo and on the following diamond-turned metals: bulk Al alloy, bulk Cu, electrodeposited Ag, and electrodeposited Au. Comparisons are made between calculated and experimentally measured slip and melt thresholds.

SP638; 1983 September. 96-102. Maldutis, E. K.; Balickas, S. K.; Kraujalis, R. K. **Accumulation and laser damge in optical glasses.**

Key words: accumulative damage; glass; optical damage; structural changes.

Bulk damage of the optical glasses by single and multiple periodic laser pulses of nanosecond duration has been investigated. In the case of multiple irradiation, damage is shown to occur with the energies considerably lower than the damage threshold by a single pulse.

The dependence of the accumulating damage threshold on the number and frequency of the irradiation pulses, the wavelength of laser radiation and the conditions of its focussing into the volume of the sample has been observed.

The bulk damage of glass K-8 induced by a single pulse of radiation with 1.06 μm and 0.53 μm wavelength is shown to be determined by different mechanisms. By employing absorptive-spectral analysis, the degradation of the medium under laser irradiation with intensity ten times lower than damage threshold was observed. The mechanisms of the accumulation and bulk damage are also discussed.

SP638; 1983 September. 103-113. Walser, R. M.; Becker, M. F.; Sheng, D. Y. **Laser damage of crystalline silicon by multiple 1.06 μm, picosecond pulses.**

Key words: crystalline silicon; damage kinetics; damage morphology; damage nuclei; laser damage; nonequilibrium phase transition; picosecond pulses; resonant surface plasmons.

Recent studies have shown that the iso-intensity damage kinetics of crystalline silicon irradiated by picosecond 1.06 μm pulses could be fit to the equations of classical nucleation and growth. These results suggested that laser damage be viewed as a non-equilibrium phase transition in which the threshold intensity produced excursions across a first order phase boundary into a metastable region of the material phase diagram.

In the present work we discuss a simplified electronic phase diagram for silicon that we believe is relevant to the picosecond damage experiments. The physics of the metastable region are as yet uncertain, but its presence requires that the statistics of laser damage be determined by the activated nucleation of embryos (charge density fluctuations) to near liquid phase charge densities.

The thermodynamic perspective suggests a new laser damage mechanism in which incident photons are resonantly absorbed by the collective electronic oscillations (surface plasmons) of critical embryos. Evidence supporting this mechanism has been obtained from high resolution SEM studies of the damage morphology showing that a coherent radiative interaction occurred between resonant surface plasmon embryos on adjacent sites just prior to liquid-like phase nucleation. Calculations show that the surface plasmon of a spherical embryo with a near liquid charge density of $\sim 2\times 10^{22}/cm^3$ is resonantly coupled to the laser photons.

SP638; 1983 September. 114-118. Franck, J. B.; Soileau, M. J. **A technique for increasing the optical strength of single-crystal NaCl and KCl through temperature cycling.**

Key words: annealing; baking; bulk; damage threshold; potassium chloride; single crystal; sodium chloride; surface.

This paper relates a technique for increasing the optical strength of NaCl and KCl single-crystal samples. The 1.06-μm pulsed laser damage thresholds were increased by factors as large as 4.6 for some bulk NaCl single crystal, namely the laser grade NaCl purchased from Harshaw Chemical Company. The bulk laser damage breakdown threshold (LDBT) of the crystal was measured prior to an after heat treatment using a Nd:YAG laser operating at 1.06 μm in the TEM_{oo} spatial mode with a pulse width of 9 nsec, full width at half maximum. After the LDBT of the untreated sample was measured, it was mounted in a quartz tube and placed in an oven for the heat treatment. The quartz tube was continuously flushed with dry nitrogen gas throughout the heat treatment cycle. The sample was slowly heated to a predetermined annealing temperature: for NaCl, up to 800°C (approximately 1°C below its melting temperature). The sample was maintained at this temperature for a short time and was then removed from the oven to allow rapid cooling. Samples taken to near-melt temperature required repolishing because of surface sublimation, which occurs at elevated temperatures. After repolishing, the bulk LDBT was remeasured and found to be up to 4.6 times greater than the value measured for the untreated crystal. For samples annealed at lower temperatures, bulk and surface LDBT's were studied; for cleaved and polished surfaces, changes in the damage morphology were found.

SP638; 1983 September. 119-128. Swain, J. E.; Stokowski, S. E.; Milam, D.; Rainer, F. **Improving the bulk laser-damage resistance of KDP by baking and pulsed laser irradiation.**

Key words: bulk laser-damage; damage threshold improvement; potassium dihydrogen phosphate; pulse duration dependence of damage.

Isolated bulk damage centers are produced when KDP crystals are irradiated by 1-ns 1064-nm pulses. We have tested about 100 samples and find the median threshold to be 7 J/cm^2 when the samples are irradiated only once at each test volume (1-on-1 tests). The median threshold increased to 11 J/cm^2 when the test volumes were first subjected to subthreshold laser irradiation (n-on-1 tests). We baked several crystals at temperatures from 110 to 165°C and remeasured their thresholds. Baking increased thresholds in some crystals, but did not change thresholds of others. The median threshold of baked crystals ranged from 8–10 J/cm^2 depending on the baking temperature. In crystals that had been baked, subthreshold irradiation produced a large change in the bulk damage threshold, and reduced the volume density of damage centers relative to the density observed in unbaked crystals. The data is summarized in the table.

SP638; 1983 September. 129-140. Fernelius, N. C. **Surface-to-bulk optical absorption on uncoated sapphire and zinc selenide using pbotoacoustic chopping frequency studies.**

Key words: Al_2O_3; Bennett-Forman theory; CO_2 laser; McDonald-Wetsel theory; Nd:YAG laser; optical absorption coefficient; optoacoustic; photoacoustic; Rosencwaig-Gersho theory; sapphire; surface optical absorption; ZnSe.

Experimental photoacoustic (PA) signal amplitude and phase angle data were taken on uncoated CVD ZnSe at 10.6 μm and on (0001) oriented single crystal sapphire (Al_2O_3) at 1.3 μm. The data were interpreted using the Rosencwaig-Gersho theory, the McDonald-Wetsel composite-piston model and the Bennett-Forman theory. A modified version of the Rosencwaig-Gersho theory was developed which explicitly incorporates surface absorption. It was also applied to these cases. Comparisons are made with some multithickness sample studies on related materials.

SP638; 1983 September. 142-151. Quimby, R. S.; Bass, M.; Liou, L. **Calorimetric measurement of temperature dependent absorption in copper.**

Key words: absorption; calorimetry; copper; temperature.

This paper reports the temperature dependence of optical absorption in copper as measured by laser rate calorimetry. It is found that the measured values of the temperature dependence agree well with the predictions of the simple Drude theory for wavelengths of 10.6 μm and 1.08 μm. At 0.647 μm the temperature dependence is stronger, due to the effect of interband transitions. Absolute values of the absorptance are measured to be somewhat higher than predicted by the simple Drude theory, indicating the importance of the anomalous skin effect and possibly other absorption mechanisms. After cycling to a temperature of 200°C or greater, a permanent increase in the room temperature absorptance is observed. This increased absorption is pronounced at 1.08 μm and 0.647 μm, whereas it is not observable at 10.6 μm. The permanent change is correlated with a change in the observed microstructure of the surface.

SP638; 1983 September. 152-159. Wu, S. T.; Bass, M.; Stone, J. P. **Reversible and irreversible changes in NaCl and KCl absorption during multiple pulse 10.6 μm irradiation.**

Key words: alkali halide absorption; fatigue damage threshold; multipulse laser damage; pulsed laser calorimetry.

Repetitively pulsed laser calorimetry was used to detect both reversible and irreversible increases in the 10.6 μm absorption of NaCl and KCl. The irreversible changes are first noted at the same intensity that is found to cause damage after multiple irradiations. Just below this intensity damage is not detected even after $\sim$1800 pulses. As a result of this work, a redefinition of the fatigue threshold is necessary as it must be distinguished from the breakdown damage threshold studied in earlier research.

SP638; 1983 September. 160-170. Koumvakalis, N.; Lee, C. S.; Bass, M. **Intensity dependent absorption and laser induced catastrophic damage in diamond turned and mechanically polished Cu mirrors at 1.06 μm.**

Key words: absorptance; copper; damage; diamond-turned; pulsed calorimetry; stress.

Intensity dependent absorption and multiple pulse induced failure of mechanically polished and diamond turned Cu mirrors were investigated at 1.06 μm. A Q-switched single longitudinal and single transverse mode Nd:YAG laser operating at 10 Hz was the irradiation source in the experiments. Repetitively pulsed calorimetry was used to measure the absorption and to record the onset of the multiple pulse-induced failure at high intensities. The absorptance was found to increase with increasing intensity. The change was compared to that predicted by the Drude model where the increase in absorptance is related to temperature. A spot size dependence of the laser damage intensities was observed which is suggestive of the role of laser induced stresses in the failure process.

SP638; 1983 September. 171-174. Harris, R. J.; Gangl, M. E. **Thermo-optic coefficient ($\partial n/\partial T$) of 1.3 μm laser window materials.**

Key words: laser windows; optical properties; thermo-optic; $\partial n/\partial T$.

The thermo-optic coefficient ($\partial n/\partial T$) of several 1.3 μm laser window materials has been measured in the visible and near infrared spectral regions. These materials include CaF_2, Al_2O_3, MgO, MgF_2, YAG, YLF, water clear ZnS, Kigre Q-98 glass, Corning CORTRAN glasses, and LiF. The measurements were made in the temperature range of 25 to 100 degrees C using a laser interferometric technique. The lasers used were HeNe lasers operating at 0.6328 μm, 1.15 μm, and 3.39 μm and a Nd:YAG laser operating at 1.3 μm.

SP638; 1983 September. 175-189. Miles, P. **Polarization sensitive laser calorimetry.**

Key words: ballistic laser; calorimetry measurements; laser calorimetry; polarization.

Techniques used currently to determine bulk and surface laser absorption coefficients of highly transparent materials have drawbacks both inherent and practical that limit their accuracy. Conventional bar calorimetry attempts a two-coefficient characterization of nine separate physical absorption sites. Photoacoustic techniques require in situ calibration sensitive to sample geometry and material.

This paper proposes a new technique in which a set of conventional ballistic laser calorimetry measurements are made on a single prismatic sample. Systematic changes in the polarization and direction of propagation of the laser beam can lead to an explicit determination of individual surface and bulk absorption coefficients. An equilateral prism sample provides a set of independent measurements sufficient to establish the bulk absorption in each of three internal paths and two absorption components on each of the three surfaces. This geometry can be used, in principle, for materials with refractive indices less than 2; more practically, for indices less than 1.7. For higher indices, a truncated prism is proposed which allows seven independent measures to deduce eight absorption components. An assumption of constant surface anisotropy is proposed to complete the analysis. Design criteria for the prism shape are presented, along with analytical expressions for all relevant absorption experiments, and for the simplest cases of uniform, isotropic high and low index materials.

SP638; 1983 September. 190-198. Tirri, B. **Polarization monitor for thin film depositions.**

Key words: ellipsometer; multilayer coding; phase retarders; polarization monitor.

An automatic ellipsometer has been designed, fabricated and integrated into a large vacuum chamber to monitor the deposition of multilayer phase retarders. This technique offers several advantages over conventional monitoring techniques. Precise control of the phase retardance properties of multilayer coatings is possible due to the sensitivity for the ellipsometric parameters Δ and ψ to the changes in film thickness. Phase measurements of several multilayer coating designs deposited using this monitoring technique are presented.

SP638; 1983 September. 199-204. Kwok, M. A.; Herbelin, J. M.; Ueunten, R. H.; Segal, G. I. **Cavity phase shift method for high reflectance measurements.**

Key words: laser applications; midinfrared optics; reflectance measurement.

The cavity phase shift method can measure high reflectances on spherical surfaces with good spatial resolution. Successful demonstration at 2.9 microns wavelength is described. A reflectance of 0.9920 ± 0.0050 has been measured.

SP638; 1983 September. 205-222. Stowell, W. K.; Orazio, F. D., Jr.; Silva, R. M. **Instrumentation of a variable angle scatterometer.**

Key words: light scatter; scatter measurement; scatterometer; surface damage; surface quality; surface scatter.

The problem of light scatter from optical surfaces is amplified to a critical level for the optics used in Ring Laser Gyros (RLG). Preparation of these optics is slow, laborious and very expensive. Further, the resulting surfaces are very fragile and extremely difficult to handle without damage. These concerns have led to the development of a scatterometer at the RLG Lab, Wright-Patterson AFB, which can detect light scatter from the so-called "supersmooth" optics used in RLG's without first overcoating with metals. A HeNe laser is used to illuminate a 0.5 μm diameter spot on the surface of the test mirror or mirror substrate. The incident angle can be varied to accommodate different mirror designs. The test piece can be maneuvered with five degrees of freedom, four of which are computer controlled to facilitate scanning. Scatter measurements are made with a photomultiplier detection system which has a sensitivity of ten parts per billion per steradian. For these optics the standard process for determining substrate surface quality prior to applying the dielectric coatings is to coat the surface with silver and make a scatter measurement. The silver is then removed by etching and the dielectric coatings are applied. Using the

scatterometer we have been able to measure surface scatter without first coating the surface with silver. This equipment has yielded evidence that virtually all the techniques now used to characterize these surfaces damage them, including the technique of coating with silver. Subjecting these optics to vibration, thermal cycling, multiple cleaning steps of almost any type and some classes of shipping containers, all seam to attack the Beilby layer in a way that increases the scatter substantially.

SP638; 1983 September. 223-228. Herbelin, J. M.; McKay, J. A. **Development of laser mirrors of very high reflectivity using the cavity-attenuated phase-shift (CAPS) method.**

Key words: cavity phase shift method; optical coatings; optics cleaning.

It has been possible to obtain mirrors of very high reflectivity by following the simple four-step procedure described herein. The key to success is the ability to measure the scattering and other losses of the substrates and dielectric coatings to ensure that the specifications are being met. These measurements are especially critical in the important cleaning process. The cavity-attenuated phase-shift (CAPS) method is ideally suited for performing these important measurements, permitting us to obtain mirrors with reflectivities of $R = 0.99975 \pm 0.00005$.

SP638; 1983 September. 229-237. Figueira, J. F.; Thomas, S. J.; Harrison, R. F. **Damage thresholds to metal mirrors by short-pulse CO_2 laser radiation.**

Key words: CO_2 lasers; grazing incident; laser induced damage; metal mirrors; multiple-shot threshold.

Measurements of damage to metal surfaces induced by intense nonosecond pulses of ir radiation are reported. Single-shot damage thresholds of Cu, stainless steel, molybdenum and aluminum surfaces have been measured for various angles of incidence and the predicted increase in damage thresholds for grazing incidence optical components have been experimentally verified for the first time at 10-μm.

Multiple-shot damage tests have also been performed and practical/lifetime curves for Cu mirrors have been established. Scanning electron micrographs of the mirror show the damage mechanism to be the development of a fine scale (1 μm) microstructure on the copper surface.

SP638; 1983 September. 239-245. Decker, D. L.; Porteus, J.´O. **Laser damage to metal mirrors at nonnormal incidence.**

Key words: laser-induced damage; melt threshold; metal mirrors; nonnormal incidence; optical absorptance.

Virtually all laser damage experiments have been performed at normal incidence. However, many applications are for nonnormal incidence, and, obviously, it would be appropriate to characterize the surfaces with the intended geometry and polarization.

This paper presents damage threshold data on bare diamond-machined copper at 45-degree angle of incidence at 3.8 μm wavelength. Within experimental uncertainty, the melt threshold for p-polarization is identical to that obtained at normal incidence on the same surface. The threshold for s-polarization is a factor of two larger. The experimental values are compared with theoretical melt threshold calculations and are found to be in reasonable agreement. The polarization dependence is seen to arise from the fundamental infrared optical properties of metals. The relationship between normal incidence and 45-degree incidence thresholds provides a valuable cross-check on the systematic errors in laser damage measurements.

SP638; 1983 September. 246-257. Draper, C. W.; Bernasek, S. L. **Directed energy production of novel metallic surfaces.**

Key words: laser beams; metals; surface alloying; surface properties.

SP638; 1983 September. 258-261. Bilibin, S. V.; Egorov, V. N.; Katsnelson, A. A.; Kovalev, V. I.; Kolesova, N. S.; Sidorov, Y. S.; Tkachenko, N. L.; Faizullov, F. S. **The effect of the treatment and ageing on KCl surface breakdown threshold.**

Key words: alkali halides; baking; destructed layer depth; grinding grain size; KCl; laser damage; surface breakdown; TEA CO_2 laser.

The breakdown thresholds of bare surfaces of KCl windows treated in different ways were measured with a gain-switched-pulse CO_2 laser at 10.6 μm. The studies indicated that grinding abrasive grain size and moisten-cooling liquid determine the destructed layer depth and the breakdown threshold for freshly polished KCl surfaces. The ageing of these samples decreases breakdown thresholds considerably. The high-temperature baking of KCl samples before final polishing increases the surface breakdown threshold up to bulk damage for freshly polished and twice for aged samples as compared with those unbaked.

SP638; 1983 September. 262-266. Vora, H.; Anderson, R. H.; Stokes, R. J. **Surface finishing using soft abrasives.**

Key words: float polishing; gallium arsenide; mechano-chemical polishing; sapphire; silicon; silicon nitride; surface characterizations; surface finishing; tape-cast alumina.

In an effort to produce scratch- and damage-free flat surfaces, two non-conventional polishing techniques, mechano-chemical and float, were recently introduced by Yasunaga et al. and Namba and Tsuwa, respectively. The emphasis in both these techniques is on employing an abrasive whose hardness is less than that of the workpiece. This paper describes the results of our efforts to apply these techniques to tape-cast alumina, hot-pressed Si_3N_4, sapphire and single crystals of silicon and gallium arsenide. Samples of polished materials were observed to be scratch free, and in the case of single crystals, very smooth with peak-to-peak roughness of $\leqslant$40 Å. The polished surfaces have been characterized using several techniques, including reflection high-energy electron diffraction (RHEED), interferometry, profilometry, electron spectroscopy for chemical analysis and Auger electron spectroscopy.

SP638; 1983 September. 268-272. Kumar, B.; Fernelius, C.; Detrio, J. A. **Effects of deuterium treatments on the optical properties of fused silica.**

Key words: fused silica; hydrogen-deuterium exchange treatments; OD^- absorption bands; OH^- absorption bands; SiO_2; 1.3 μm optical absorption.

Flame produced fused silica, the process used by all American manufacturers, contains a large amount of OH^-. The fundamental OH^- vibration in SiO_2 is at 2.75 μm and its first overtone is at 1.38 μm. Much of the optical absorption at 1.3 μm is due to the wing of the 1.38 μm absorption band. Stone and Burrus described a deuterium treatment given optical fibers to transform the OH^- absorption to OD^- whose fundamental is at 3.72 μm and first overtone at 1.85 μm. Here we describe some related treatments given to Suprasil II window samples. Spectral traces show that the 1.38 μm absorption peak is diminished while a new absorption peak appears at 1.85 μm. Similar changes appear in the spectrum between 2 and 4 μm. 1.3 μm laser rate calorimetry performed before and after treatment on the sample showing the most complete $H \leftrightarrow D$ exchange exhibited a drop in absorption value to about 1/5. Thus we conclude that over 80% of the optical absorption in Suprasil II at 1.3 μm is due to the OH^- molecule. The method offers a way of improving the performance of flame produced fused silica windows used at 1.3 μm.

SP638; 1983 September. 273-278. Porteus, J. O.; Faith, W. N.; Allen, S. D. **Laser desorption analysis of H_2O and other contaminants from optical surfaces.**

Key words: laser conditioning; laser-induced desorption; optical surfaces; selective damage; surface contamination; surface defects; water desorption.

Contamination at surfaces and interfaces is known to cause lowered damage threshold in high power laser optical components; therefore, it is important to be able to identify and measure the amount of adsorbed species. A technique has been developed for detecting water and other adsorbed molecules on optical surfaces at incident intensities below the damage

threshold. A pulsed laser is focused onto the optical surfaces of interest in a UHV chamber. The laser energy absorbed in the surface layer causes desorption of the contaminants. Detection and identification of the desorbed species are via a quadrupole mass analyzer. As water and other contaminants such as hydrocarbons are strong optical absorbers in the 2.8- to 3.8-μm wavelength region, an HF/DF laser was chosen for the initial investigation. H_2O, OH, and other species have been observed from both coated and uncoated optical surfaces. Surface mapping of adsorbed H_2O with a 121-μm focal spot shows considerable variation with spatial position. This effect may be associated with surface microcracks and other defects which may precipitate laser damage. Possible applications are characterization of laser optical components and laser cleaning of optical surfaces prior to film deposition.

SP638; 1983 September. 280-297. Hoenig, S. A. **Electrostatic technology for control of dust and hydrocarbon vapors in high power laser systems.**

Key words: contamination; dust; electrostatics; lasers; mirrors; telescopes.

The application of electrostatic techniques has been investigated as a repulsion system to keep dust off mirrors that might be used in high power laser systems. A demonstration unit for a 30 cm mirror was built and shipped to Kirtland Air Force Base, New Mexico as part of the program.

SP638; 1983 September. 298-303. Decker, D. L.; Hodgkin, V. A. **Laser mirror operation at cryogenic temperatures.**

Key words: absorption; bare metal surfaces; cryogenic temperatures; dielectric-enhanced mirror; Drude theory; laser mirrors.

It has been suggested many times that operation of laser mirrors at low temperatures could result in significant performance improvements. Specifically for metal mirrors, the advantage perceived is in decreased absorption and increased thermal conductivity. For dielectric-enhanced mirrors, presumably a similar advantage would be present in lowering both the absorption of the initial metal film and perhaps lowering absorption in the dielectric films as well. From an engineering point of view, this proposition is not entirely academic, at least for space applications, where entirely passive methods of cooling could be employed.

This paper presents experimental absorptance vs wavelength and temperature data over the range from 1 to 10 μm and from room temperature to 80°K. Included in this study are silver samples prepared by different techniques including diamond single-point machining. Also included are similar data for a multilayer dielectric mirror. Theoretical interpretation of the performance of both mirror types is made with recommendations for actual use.

SP638; 1983 September. 304-312. Shaffer, J. J.; Bennett, J. M.; Bennett, H. E. **Dimensional stability of Zerodur and ULE mirrors undergoing thermal cycling.**

Key words: expansion coefficient; fused quartz; optical figure; thermal distortion; ULE quartz; Zerodur.

Zerodur and ULE quartz have been shown to have exceptional dimensional stability over extended time periods and to be insensitive to small temperature variations when they are maintained near room temperature. However, it is not clear what their dimensional stability will be after cycling through a more extended range of temperatures such as might occur during bakeout and film deposition when applying dielectric multilayer high-reflectance coatings. Since mirrors are required to maintain tolerances as severe as $\lambda/100$ visible equivalent in some laser applications, the safe limits for temperature cycling are of considerable interest, and a preliminary experiment was performed to investigate this question. During the experiment, a convenient method for interferometrically verifying the thermal expansion coefficient of these low-expansion materials was developed and will be described. In one series of experiments, a 6-inch-diameter Zerodur optical flat of the highest quality having a better than $\lambda/40$ average peak-to-valley optical figure was oven heated to a peak temperature and then allowed to cool in air. No permanent change was observed up to a temperature of 200°C, but at 250°C the mirror took a permanent set. After the 300°C cycle, this set increased to $\lambda/5$. Under similar conditions, the ULE sample was unaffected; it was then water quenched after heating, a much more severe test. Even at oven temperatures of 350°C, the ULE sample developed no permanent set. These experiments suggest that caution should be employed when heating Zerodur mirrors above 150 to 200°C. There is no comparable restriction on ULE mirrors.

SP638; 1983 September. 313-327. Apollonov, V. V.; Chyotkin, S. A.; Khomich, V. Y.; Prokhorov, A. M. **Thermo-elastic action of the powerful high repetition rate laser radiations on the solid state surface.**

Key words: CW; optical deformation; pulsed; surfaces; thermo-elastic stress.

The phenomena of the thermoelastic behavior of materials under powerful, high-repetition-rate laser radiation are discussed. An analysis is based on the Duamel integrals for the thermo-stress characteristics which correspond to CW and high-repetition-rate laser irradiations.

Relationships for the upper-level laser intensities which are connected with admissible elastic surface distortion, plastic flow of the material, fatigue distributions, and melting of the surface layer are calculated.

SP638; 1983 September. 328-338. Appollonov, V. V.; Bystrov, P. I.; Chyotkin, S. A.; Goncharov, V. G.; Khomich, V. Y.; Prokhorov, A. M. **The promising use of some heat carriers in high intensity laser optics.**

Key words: cooled mirrors; high-power mirrors; liquid metal cooling; thermal distortion of mirrors.

Heat and thermodeformation characteristics of laser mirrors based on powder and felt porous structures cooled by dielectric and liquid metal heat carriers are theoretically investigated. In the case of the heat carriers considered, it is possible to widely vary the regimes of intense heat mass transfer in porous heat exchangers of laser mirrors, whereas use of liquid metal cooling with porous structure fabricated from low coefficient thermal expansion material opens new possibilities in development of especially accurate reflectors with very high optical damage thresholds.

SP638; 1983 September. 339-343. Rainer, F.; Milam, D.; Lowdermilk, W. H. **Laser damage thresholds of thin film optical coatings at 248 nm.**

Key words: antireflection coatings; damage thresholds; high reflection coatings; KrF lasers; laser damage; optical coatings; thin films.

We have measured the laser-induced damage thresholds for 248 nm wavelength light of over 100 optical coatings from commercial vendors and research institutions. All samples were irradiated once per damage site with temporally multi-lobed, 20-ns pulses generated by a KrF laser. The survey included high, partial, and dichroic reflectors, anti-reflective coatings, and single layer films. The samples were supplied by ten vendors. The majority of samples tested were high reflectors and antireflective coatings. The highest damage thresholds were 8.5 to 9.4 J/cm^2 respectively. Although these represent extremes of what has been tested so far, several vendors have produced coatings of both types with thresholds which consistently exceed 6 J/cm^2. Repeated irradiations of some sites were made on a few samples. These yielded no degradation in threshold, but in fact some improvement in damage resistance. These same samples also exhibited no change in threshold after being retested seven months later.

SP638; 1982 September. 344-349. Hart, T. T.; Lichtenstein, T. L.; Carniglia, C. K. **Effects of undercoats and overcoats on damage thresholds of 248 nm coatings.**

Key words: antireflection coating; electric field; laser damage; laser reflector; optical coating; overcoat; undercoat.

Previous experiments have demonstrated that 1064 nm high reflectors benefit from the addition of halfwave silica overcoats, and that 1064 nm antireflection coatings can be improved by adding halfwave silica undercoats or barrier layers. In each case, a statistical improvement of about 50% has been observed. This paper reports similar results for coatings designed for 248 nm. The high reflectors were scandia/magnesium fluoride quarterwave stacks. Three design variations were tested: with no overcoat, with a halfwave silica overcoat, and with a halfwave magnesium fluoride overcoat. The presence of the overcoat more than doubled the threshold of the reflectors. The highest threshold, 8.5 joules/sq.cm, was measured on a reflector with a magnesium fluoride overcoat. Two material combinations were used for the four-layer antireflection coatings: scandia/silica and scandia/magnesium fluoride. Each of these combinations was coated without a barrier layer, with a silica barrier layer, and with a magnesium fluoride barrier layer. The barrier layer was an undercoat with a halfwave optical thickness. Varying degrees of improvement in thresholds, ranging up to 50%, were found in all cases with barrier layers. The highest thresholds exceeded 6 joules/sq.cm for scandia/silica coatings with silica barrier layers.

SP638; 1983 September. 350-361. Foltyn, S. R.; Newnam, B. E.; Jolin, L. J. **Laser damage results and analyses for ultraviolet reflectors under multiple-shot irradiation.**

Key words: fluoride coatings; KrF lasers; multiple-shot laser damage; oxide coatings; repetition-rate effect; spotsize effect; ultraviolet reflectors.

In a continuing program intended to evaluate and optimize multi-layer dielectric reflectors for the ultraviolet, additional results are reported.

Standard test conditions at the 248 nm KrF wavelength are a nominal pulsewidth of 10 ns at a 35 Hz pulse repetition frequency. The 0.6 mm mean spot diam (I_0/e^2) is effectively increased by testing ten sites at each fluence, with each surviving site irradiated for 1000 shots. In this manner, 50 to 100 sites are tested on each reflector. By plotting the fraction of sites which damaged (%) vs laser test fluence (J/cm^2) and employing a linear regression fit to the data, a threshold (0% intercept) and an upper limit (100% intercept) are obtained. Emerging correlations between the slope of the data and physical properties of the coatings are discussed.

We have previously reported damage thresholds averaging 1.5 J/cm^2 with a high of 3.0 J/cm^2 for a ThF_4/Cryolite reflector. Presently, we routinely observe thresholds of 3.0 J/cm^2 up to a high of 5.5 J/cm^2 for oxide films, particularly those employing Al_2O_3 or Sc_2O_3 as the high-index component.

As an initial attempt to ascertain the possible effect of pulse repetition rate, some samples were tested at both 35 pps and 2 pps. Within our experimental uncertainty, no difference in threshold was observed.

SP638; 1983 September. 363-379. Newnam, B. E.; Foltyn, S. R.; Jolin, L. J.; Carniglia, C. K. **Multiple-shot ultraviolet laser damage resistance of nonquarterwave reflector designs for 248 nm.**

Key words: damage thresholds; electric-field suppression; multiple shots; nanosecond pulses; nonquarterwave designs; scandium oxide; standing-wave electric fields; thin films; ultraviolet reflectors.

The damage resistance of multilayer dielectric reflectors designed for 248 nm has been substantially increased by use of nonquarterwave (QW) thicknesses for the top few layers. These designs minimize the peak standing-wave electric field in the high-index layers, which have proven to be weaker than the low-index components.

Previous damage tests of infrared- and visible-wavelength reflectors based on these designs have produced variable results. However, at the ultraviolet wavelength of 248 nm, 99% reflectors of Sc_2O_3, MgF_2, and SiO_2 strongly demonstrated the merit of non-QW designs. Four sets of reflectors of each of four designs (all QW thickness; one modified-pair substitution; two modified-pair substitution; one modified pair plus an extra half-wave layer of Sc_2O_3) were tested for damage resistance with a KrF laser operating at 35 pps with a pulsewidth of 8 ns and spot-size diameter of 0.6 mm. Each of 50 sites were irradiated for 1000 shots or until damage occurred.

On the average, the reflectors with one-modified-thickness pair had a 50% higher threshold (10 of 10 sites survived) than the all-quarterwave design. Addition of a second modified-layer pair resulted in no further increase in threshold but the saturation fluence (10 of 10 sites damage) was 110% higher. Reflectors with an additional half-wave of Sc_2O_3 had lower thresholds of the order of 10% as expected. The thresholds correlated best with the peak-field model, whereas the best model correlating the saturation fluences involved the sum of the upper two scandia layer thicknesses.

SP638; 1983 September. 380-386. Loudiana, M.; Schmid, A.; Dickinson, J. T. **Degradation of dielectric films by XeF excimer intermediates.**

Key words: chemical sputtering; excimer lasers; laser material degradation; UV mirrors.

Many excimer laser designs require optical component surfaces to be in contact with both optical radiation and reactive components of the gain medium. The resulting environmental degradation of coatings on mirrors or windows is analyzed by isolating intermediates from the XeF gain medium and measuring quantitatively corrosive interaction between these species and the dielectric surfaces. Particular attention will be given to SiO_2 films whose reaction with XeF_2 and NF_2 with and without additional stimulation by ions will be surveyed. Temperature effects of the film substrate as well as the importance of synergistic effects for the stability of the SiO_2 coatings will be discussed.

SP638; 1983 September. 387-396. Amimoto, S. T.; Whittier, J. S.; Whittaker, A.; Chase, A.; Hofland, R., Jr.; Bass, M. **Pulsed D_2-F_2 chain-laser damage to coated window and mirror components.**

Key words: acid resistance; adhesion strength; carbyne (carbon) coatings; coating absorption; DF-chain laser; laser damage; laser mirrors; laser windows.

Large-spot laser damage thresholds have been measured for bowl-feed-polished CaF_2 and sapphire windows (bare and antireflection-coated) and for highly-polished copper mirrors (bare and carbyne-coated) at DF chain-laser wavelengths (3.58–4.78 μm). The chain reaction between F_2 and D_2 was initiated by a mangetically-confined electron beam, producing DF-laser outputs of 10–20 J in pulses of 0.6–0.9 μsec (FWHM) duration. Energy extracted from a transmission-coupled unstable resonator was focussed using a CaF_2 lens. A soft-aperture technique was employed to suppress effects of Fresnel diffraction so that uniform (top-hat) intensity profiles were obtained along the focussing beam. With this laser system, commercially-available antireflection-coated CaF_2 and Al_2O_3 samples were measured to have damage thresholds in the range 21–27 J/cm^2. Significantly larger damage thresholds were found for uncoated, polished samples of Al_2O_3, but damage resistance of uncoated polished CaF_2 was measured to be equal to that of the best antireflection-coated CaF_2 samples. A highly polished copper mirror was found to have the highest damage threshold of all the materials tested (58 J/cm^2). Carbyne films of diamond-like hardness, a type of carbon coating, were applied to polished copper mirrors and bowl-feed-polished CaF_2 surfaces. Such carbyne coatings as were prepared in this work contained numerous carbon-bearing particles that were easily damaged ($\sim$10 J/cm^2). However, regions of the irradiated carbyne film that were free of carbon particles withstood high laser fluences (25 J/cm^2), suggesting that improvements in carbyne film preparation would yield attractive protective coatings of high damage resistance at DF wavelengths.

SP638; 1983 September. 397-412. Porteus, J. O.; Archibald, P. C.; Bethke, J. W.; Dancy, J. H.; Faith, W. N.; Franck, J. B.; Temple, P. A. **Influence of cleaning solvents, sunlight, humidity, and HF gas on pulsed damage and optical characteristics of 3.8-μm multilayer coatings.**

Key words: coating characterization; coating deterioration; damage thresholds; laser optical components; optical maintenance.

Samples representing state-of-the-art 3.8-μm laser optical components were sequentially exposed to potentially harmful ingredients of an airborne-operating environment and tested for degradation after each exposure. Two enhanced-reflection-coated mirror designs, Mo(substrate)/Ag/ZnS/ $(ThF_4/ZnS)^4$ and Si(substrate)/Ag/Si/$(Al_2O_3Si)^4$, were studied, along with the antireflection-coated window designs, CaF_2(substrate)/PbF_4/ ThF_4/PbF_4 and ZnSe(substrate)/ZnSe/ThF_4/ZnSe. Samples were exposed to controlled moderate doses of (1) methanol or acetone applied as cleaning solvents, (2) simulated atmospheric solar radiation at 6-km altitude, (3) 100% humidity ambient, and (4) an ambient containing 10% HF gas. Testing consisted of the following measurements at 3.8 μm: multithreshold pulsed damage profiles, absorptance, scattering, and absolute reflectance/transmission. While cleaning solvents and sunlight generally produce a reduction of thresholds for uniform damage, the influence of humidity and HF is more subtle, resulting in a significant increase in some cases. The windows respond differently than the mirrors, a result that is evidently related to an observed difference in the dominant damage characteristics. Optical characteristics do not correlate well with damage thresholds, suggesting that modification of thermal or other material properties plays a more important role.

SP638; 1983 September. 413-420. Feldman, A.; Farabaugh, E. N. **Index, thickness and birefringence of thin films by guided waves.**

Key words: birefringence; coevaporation; guided wave; MgO; prism coupler; refractive index; SiO_2; thickness; thin film.

A guided wave technique has been used to measure the refractive index and thickness of a thin film. The film, which contained approximately 90 mol % MgO and 10 mol % SiO_2 was produced by coevaporation of the two constituents onto a fused silica substrate. Measurements were performed at three visible wavelengths obtained from an argon-ion laser. From the positions of the mode coupling angles, we have calculated the refractive index and thickness of the film. The film was found to have a large birefringence which is attributed to internal stresses. A signature for the birefringence can be observed in the scattered m-line spectrum of the film, in which the order of the TE_o and TM_o modes is interchanged as compared to an isotropic film. The optical determination of the film thickness is 1.098 ± 0.003 μm as compared to 1.11 μm measured by a mechanical method. The measured values of refractive index agree well with values calculated on the basis of the Drude model.

SP638; 1983 September. 421-425. Bennett, H. E.; Burge, D. K. **Sensitive technique for measuring apparent optical figure error caused by coating nonuniformity.**

Key words: ellipsometry; film thickness nonuniformity; multilayer dielectric films; optical figure measurement; wave front distortion.

If a diffraction-limited wave front is to be produced by an optical train, the requirements on the optical figure of individual mirror components may be very stringent. Peak-to-valley values of $\lambda/8$ visible equivalent are found for some infrared systems, $\lambda/20$ for visible systems, and $\lambda/100$ visible equivalent has been suggested for some ultraviolet systems. These mirrors often have high reflectance multilayer coatings, in which case the optical figure is determined not only by the geometrical perfection of the optical surface but also by the uniformity to the multilayer coating. Although this uniformity can be determined interferometrically or by measuring the secondary structure surrounding the reflectance maxima, the most sensitive technique for determining film nonuniformities appears to be ellipsometry. It should be performed at the wavelength at which the mirror is to be used. Typically, the ellipsometric parameter Δ is found to be very sensitive to variations in film thickness but quite insensitive to absorption in the film; the converse holds for Ψ. For a representative infrared, high reflectance multilayer coating, a measurable change in Δ corresponds to film thickness nonuniformities of less than 0.01%, and a measurable change in Ψ corresponds to a change in peak reflectance of 0.001. An automated ellipsometer could be readily used to scan the surface of even a large mirror. Ellipsometry may thus provide the optimum technique for testing mirror optics for multilayer-film-induced changes in apparent optical figure. It also provides a sensitive technique for measuring the uniformity of reflectance of large, multilayer-coated mirrors.

SP638; 1983 September. 426-431. Bennett, H. E.; Burge, D. K. **Limits to the validity of evaluating a quarter-wave, high-reflectance multilayer through analysis of its secondary structure.**

Key words: absorption; high-reflectance coatings; interface absorption; laser components; multilayer film evaluation; nonuniform film thicknesses; reflectance maximum.

Information on the perfection of high-reflectance multilayer films can be obtained from a study of the secondary structure surrounding the principal reflectance maximum. The wavelengths at which the adjacent minima occur are a good indication of the correctness of the optical film thicknesses achieved in a quarter-wave multilayer stack. Calculations indicate that the depths of these minima are much more sensitive to absorption in the film layers than is the reflectance at the maximum. If the thicknesses are correct and if volume absorption in the film materials is the main source of decreased reflectance, excellent correlation is found between the measured peak reflectance and that calculated from the depth of the more easily measured secondary reflectance minima. Errors in film thickness or significant interface absorption arising from impurity segregation, surface plasmon excitation, or other sources complicate this simple picture, however, so that the peak reflectance should also be measured directly.

SP638; 1983 September. 432-437. Lowdermilk, W. H.; Mukherjee, S. P. **Graded-index antireflective coatings for high power lasers deposited by the sol-gel process.**

Key words: antireflection surface; gradient index; sol-gel process.

Gradient-index alkali borosilicate antireflection films for use in laser systems were deposited by the sol-gel process. Laser damage thresholds of these films, measured with 1.07 μm, 1-ns pulses, were four times greater than thresholds of widely-used, multilayer, antireflection coatings.

SP638; 1983 September. 439-443. Seitel, S. C.; Franck, J. B.; Marrs, C. D.; Dancy, J. H.; Faith, W. N. **Selective and uniform laser-induced failure of antireflection-coated $LiNbO_3$ surfaces.**

Key words: antireflection coatings; defect frequency; Fast Waveform Analysis Device; $LiNbO_3$; multithreshold analysis; Short Pulse Laser Damage Facility.

$LiNbO_3$ surfaces with different antireflection coatings and from different vendors were damaged with 1.06-μm, 9.5-ns full width at half maximum laser pulses. By probing with a laser spot smaller than the separation of isolated surface defects, it was possible to separate uniform damage, which was characteristic of the coating itself, from premature, defect-driven, localized failures. Uniform failure modes were identified and thresholds extracted for each by multithreshold analysis. Frequency of defect damage was determined at several fluences much lower than required for uniform failure. It is likely that defect-driven selective failures reduce the apparent damage threshold of flood-loaded samples. Tentative identification of a selective damage threshold was made and correlated with large-spot, multimode test results. Incorporation of these results into a product-improvement program has resulted in $LiNbO_3$ Q-switches with increased resistance to selective damage.

SP638; 1983 September. 446-450. Milam, D.; Rainer, F.; Lowdermilk, W. H.; Swain, J.; Carniglia, C. K.; Hart, T. T. **A review of 1064-nm damage tests of electron-beam deposited Ta_2O_5/SiO_2 antireflection coatings.**

Key words: antireflection films; film absorption; laser damage; net stress; silicon dioxide; tantalum oxide; variations in film deposition parameters.

Damage tests of Ta_2O_5/SiO_2 antireflection films deposited under a variety of conditions showed that thresholds of films deposited at 175°C were greater than threshold of films deposited at either 250°C or 325°C. Deposition at high rate and low oxygen pressure produced highly absorptive films with low thresholds. Thresholds did not correlate with film reflectivity or net stress in the films, and correlated with film absorption only when the film absorption was greater than 10^4 ppm. Baking the films for four hours at 400°C reduced film absorption, altered net film stress, and produced an increase in the average damage threshold.

SP638; 1983 September. 451-458. Farabaugh, E. N.; Sanders, D. M.; Wilke, M. E.; Hurwitz, S. A.; Haller, W. K. **Preparation of thin amorphous films by E-beam evaporation from multiple sources.**

Key words: amorphous; coevaporation; glassy; thin films.

E-beam codeposition was used to produce thin films in the system ZrO_2–SiO_2. Bk-7 glass, heated to 325°C was used as substrate material for these depositions. The films, thus produced were studied by X-ray Diffraction and Scanning Electron Microscopy Techniques. These studies yielded information on the dependence of film crystallinity on composition and substrate temperature. Particular attention was paid to the compositional range in which the structure of the film changes from polycrystalline to amorphous. The change in film structure is easily determined from the change in the XRD patterns. Different film structures were observed using SEM methods.

SP638; 1983 September. 459-470. Pawlewicz, W. T.; Martin, P. M. **Improved Si-based coating materials for high power infrared lasers.**

Key words: absorption; coatings; composition; glassy structure; mirror fabrication; reactive sputtering; refractive index; $Si_{1-x}H_x$ alloys.

Data are presented to demonstrate that alloying of Si with H during thin film coating deposition reduces coating absorption at important infrared laser wavelengths such as 1.06, 1.315 and 2.7 μm by more than an order of magnitude compared to pure Si coatings. These results contradict earlier beliefs that the presence of H in Si was undesirable because of its association with H_2O. It appears that absorption values approaching state-of-the-art for near-infrared coatings can now be obtained for a material with many attractive physical properties such as very refractive index, outstanding hardness and scratch-resistance, glassy structure, non-hygroscopicity and general environmental stability and durability. In particular, an absorption coefficient of 3 cm^{-1} has been obtained at a wavelength of 2.7 μm for a $Si_{1-x}H_x$ alloy with $x=0.12$. The $Si_{1-x}H_x$ coatings are made by reactive sputtering, and cannot be made by conventional evaporative techniques. Controlled deposition of coatings with specific compositions and optical properties is briefly described, and optical property-composition relationships are presented for the alloy mixing interval $0<x<0.4$. The same sputtering system is used to deposit the low index material SiO_2 by simple exchange of H_2 for O_2 in the sputtering gas, making possible straight-forward multilayer coating fabrication. Reflectance spectra for $Si_{1-x}H_x/SiO_2$ all-dielectric mirrors and dielectric-enhanced Au and Al mirrors are presented.

SP638; 1983 September. 472-476. Donovan, T. M.; Ashley, E. J.; Franck, J. B.; Porteus, J. O. **Hydrogenated amorphous silicon films: Preparation, characterization, absorption, and laser-damage resistance.**

Key words: amorphous silicon; electron microscopy; hydrogenated amorphous silicon; laser damage; optical absorption; optical coatings; silicon dioxide; silicon monoxide; water contamination.

Evaporated Si films in combination with oxide materials such as SiO_x form promising multilayer mirror coatings for chemical laser applications. However, high infrared absorption and relatively low damage threshold of the Si films presently limit the effectiveness of these multilayer designs.

Lower absorption values and higher damage thresholds have been obtained with sputtered Si films; this improvement apparently results from better film morphology and lower contamination levels in the sputtered films. Other work has shown that hydrogenation of as-deposited Si films can effectively passivate large numbers of bonding-type defects, and this results in further marked reductions in the infrared absorption.

In this paper, we discuss the preparation and absorption optimization of hydrogenated Si films and the formation of SiO_2, Si/SiO_2, and SiH/SiO_2 coatings by reactive sputtering. The morphology and composition of optimally prepared films will be described, and the results of absorption and chemical laser damage measurements are discussed.

SP638; 1983 September. 477-480. Bubenzer, A.; Dischler, B.; Nyaiesh, A. **Optical properties of hydrogenated amorphous carbon (a-C:H)—a hard coating for IR-optical elements.**

Key words: amorphous hydrogenated carbon; AR coating; germanium; hard coating; infrared; laser calorimetry; plasma deposition.

Hydrogenated amorphous carbon films a-C:H were deposited on glass and germanium substrates. The films are transparent in the IR and are extremely hard (Mohs's hardness of about 8). The a-C:H coatings were prepared according to the method of Holland in an RF excited discharge sustained by various hydrocarbon gases.

Thickness, density, refractive index (at 0.3 μm and 2–10 μm) and relative hydrogen content were determined. Variations in IR-refractive index and relative hydrogen content could be correlated with deposition conditions. With a refractive index of approximately 2 a-C:H is an ideal AR-coating for germanium ($n=4$). Laser calorimetric measurements of optical absorption at 10.6 μm give a loss as low as 4% for a 1.3 μm thick coating on germanium ($\lambda/4$ for $n=2$ at 10.6 μm). Preliminary damage tests with a CO_2 laser (600 W, cw) were performed.

SP638; 1983 September. 482-488. Stein, M. L.; Aisenberg, S. **Studies of diamond-like carbon coatings for protection of optical components.**

Key words: diamond-like carbon film; ion deposition; protective optical coating; thin films.

Ion-deposited diamond-like carbon is a promising candidate for thin protective coatings for optical components. Our recent studies have been directed to ascertaining several key properties of the coating, and verifying its protective nature.

Tests performed on coated discs of CaF_2 indicated improved resistance to environmental attack by acids, bases, and solvents. Hermeticity was corroberated by comparing the effects of HF-acid on coated and uncoated surfaces. The tenacity to substrates such as glass and CaF_2 was demonstrated by the difficulty to remove the coating with standard techniques, such as exposure to HF and water. Also, a marked decrease in abrasion was found (by measuring forward optical scatter) for the coated portion of a disc.

Optical measurements performed on these coated discs indicated that the coating neither signficantly decreased transmission as measured from 2 to 6 microns, nor induced visible scatter. High resolution scanning and transmission electron micrograph studies indicate that the films are partly amorphous with a partial ordering of carbon atoms; while Raman studies indicated both graphite as well as microcrystalline diamond-type behavior. ESCA studies indicated a C to CaF_2 gradient throughout the coating indicative of ion implantation. Thickness determinations were made by substrate dissolution and surface profile measurements.

SP638; 1983 September. 489-491. Moravec, T. J. **The deposition of diamondlike carbon thin films on CaF_2.**

Key words: CaF_2; carbon; diamondlike carbon; hard coating; laser calorimetry; plasma deposition; thin film.

As part of an AFML program, deposition conditions were studied to produce diamondlike carbon thin films on CaF_2. Halide materials are difficult to deposit diamondlike carbon coatings onto because of the moderate or large coefficient of thermal expansion of the halides which causes thermal induced separation of the coating. In addition, the adhesion of the carbon

films to CaF_2 is poor. Several pretreatments were attempted to improve adhesion without much success. We describe a simple thermal technique that resulted in carbon films adhering most of the time to CaF_2 mechanical test bars and optical discs. The problem of adherence, however, has not been solved for this film-substrate system.

SP638; 1983 September. 493-508. Palmer, J. R.; Bennett, H. E. **Relationship between coating defects and the limiting flux density a cooled laser mirror can withstand.**

Key words: coating defects; cooled laser mirrors; defect damage; hot-face design; limiting flux density; mirror damage; vapor-barrier-induced burnthrough.

The flux density which a cooled laser mirror can handle without catastrophic damage is predicted to be limited in typical situations by absorbing defects on the optical surface rather than by mirror reflectance. In this case, failure is predicted to occur either through coating damage in the vicinity of the defect or by burnthrough of the cooled faceplate following vapor barrier formation at the coolant-faceplate interface. Expressions are developed which predict the limiting defect size for a given flux density as a function of (1) thickness and composition of the faceplate, (2) transport properties and fluid mechanics of the liquid coolant, and (3) conditions generating a hydrodynamic crisis at the liquid coolant stagnation boundary beneath the defect. This parametric analysis can be used to optimize faceplate thickness as a function of mirror material, coolant flow, coating damage threshold, heat exchanger design, and the expected maximum size and absorption of multilayer film coating defects. According to this analysis, for thin faceplates the optimum faceplate thickness may be determined by the coating process rather than by average heat transfer considerations.

SP638; 1983 September. 510-516. Palmer, J. R.; Bennett, H. E. **A predictive tool for evaluating the effect of multiple defects on the performance of cooled laser mirrors.**

Key words: catastrophic mirror damage; cooled laser mirrors; hot-face design; laser mirror burnthrough; limiting flux density; multiple coating defects.

A technique is suggested for evaluating the distance two defects on the surface of a fluid-cooled laser mirror must be separated before they can be considered independently. The basic ingredient of the correlation is taken from a technique suggested by Max Jakob for steady-state conduction with heat generation in a circumferential fin. Using this technique with concomitant Bessel functions of zero order and first kind, a distribution of temperatures in a circumferential fin at various radii may be evaluated for cylindrical heat generators acting in concert.

SP638; 1983 September. 517-531. Stewart, A. F.; Guenther, A. H. **Preliminary experimental results of spot size scaling in laser induced damage to optical coatings.**

Key words: film thickness dependence; impurity damage; laser damage; scaling; spot size dependence; thin films.

The laser damage threshold of various thin film coatings has been assessed using 1.06 μm radiation at a pulse length of 6 ns FWHM. Samples of conventional coatings of several materials have been tested as a function of film thickness and spot size. Beam diameters employed range from approximately 9 μm and larger.

From these preliminary data, previously observed scaling has been verified, i.e., thinner films are more damage resistant, while smaller spot sizes yield higher damage thresholds, as expected. The samples employed in these tests were conventional coatings of ThF_4, ZrO_2 and HfO_2 as well as specially prepared "low defect" coatings of Cerac and RAP grown ThF_4. These "low defect" coatings are initial efforts and unfortunately showed no advantage over conventional coatings in terms of damage threshold.

SP638; 1983 September. 532-539. Epifanov, A. S.; Garnov, S. V.; Gomelauri, G. V.; Manenkov, A. A.; Prokhorov, A. M. **Recent progress in the studies of laser-induced intrinsic damage of transparent solids: Deterrent lack effect of seed electrons in avalanche ionization process.**

Key words: avalanche ionization; breakdown probability; seed electrons; spot-size dependence; temperature dependence.

Peculiarities of laser-induced damage in transparent dielectrics caused by electron avalanche in the case of deterrent lack of seed electrons are discussed. Statistical models of the avalanche process initiated by multiphoton ionization of host atoms or impurities are described. Based on the breakdown probability expressions derived, the damage threshold dependence upon the temperature and the focal spot size are discussed. The theoretical results are found to be in good qualitative agreement with the experimental data for the laser-induced damage in alkali-halide crystals.

SP638; 1983 September. 541-544. Jensen, B. **Quantum theory of multiphoton free carrier absorption at high intensities in compound semiconductors.**

Key words: compound semiconductor; free-carrier absorption; multiphoton absorption.

Multiphoton absorption and emission, accompanied by scattering of free carriers in an intense radiation field, is treated by an extension of the theory of one photon free carrier absorption in polar semiconductors. The rate equation for m photon absorption, where m is a positive integer, is obtained from the equation of motion of the quantum density matrix. It is shown to be proportional to the mth power of the radiation intensity. The effect of the field on the electron during scattering is taken into account by using the exact wavefunctions of an electron in an intense radiation field in the calculation of the transition matrix elements. An expression for the average Joule heating per electron is found. A comparison with earlier treatments is given.

SP638; 1983 September. 545-550. Vaidyanathan, A.; Guenther, A. H. **Comment on "Intense-field effects in solids".**

Key words: band structure; conduction bands; conduction electrons; electric fields; gallium phosphides; multiphoton; nonlinear optics; semiconductors.

Recent theoretical work by Jones and Reiss predict that the effective energy gap of a crystalline solid in the presence of electromagnetic radiation increases with radiation intensity. Thus, at sufficiently great intensities higher order multiphoton processes could become more probable than lower order processes. It is shown that, although this behavior contradicts the well-known perturbative results in the low intensity region, it appears to be comfirmed by the experimental data on GaP at 0.694 μm, due to Pyshkin et al. Theoretical and experimental results regarding the intensities needed for the observation of this phenomenon are compared, and its implications for nonlinear optics are discussed.

SP638; 1983 September. 551-556. Harter, D. J.; Brown, D. C. **Effects of higher order nonlinearities on second order frequency mixing.**

Key words: nonlinear optics; phase-matching; second order frequency mixing; self-focusing.

The theory which has been developed to study the effects of higher order nonlinearities in second-order frequency mixing can be applied to the case of up-conversion of high powered lasers. We have considered the effect of the intensity dependence of the refractive index upon phase-matching for second-order frequency mixing. We have also considered the effects of second-order generation on higher-order nonlinearities which have to be considered in the design of other components of high power lasers. This includes the effect of second-order frequency generation on small-scale self-focusing and on the whole beam phase profile.

SP638; 1983 September. 557-567. Soileau, M. J.; Williams, W. E.; Van Stryland, E. W.; Brown, S. F. **The use of self-focusing in the prevention of laser-induced damage.**

Key words: Kerr liquids; laser-induced breakdown; nonlinear absorption; nonlinear refraction; self-focusing.

Laser-induced breakdown in thin foils and glasses have been used to limit transmission at high laser powers in order to prevent damage to sensitive optical components in complex laser systems. In this paper we report results of using self-focusing in liquids to produce laser-induced breakdown and phase aberrations which in turn limit the transmitted power. Optical self-action in CS_2 and other liquids was used to make a power limiting device with psec response time. This device has linear response near unity transmission for input power below P_c, which is of the order of the critical power for self-focusing, and limits the transmitted power to a nearly constant value for input power greater than P_c. The onset of nonlinear transmission was adjusted by mixing various liquids to adjust n_2. Experimental results using linearly and circularly polarized, 40 psec (FWHM) pulses at 1.06 μm are presented.

SP638; 1983 September. 568-576. He, D.; Fuxi, G. **Nonlinear refractive coefficient and self-focusing damage in glasses.**

Key words: dispersion of nonlinear parameters; glass; inherent absorption wavelength; laser-induced birefringence; laser-induced damage; nonlinear refractive coefficient; self-focusing; self-induced polarization change; thermal blooming.

We have investigated some nonlinear optical effects in a series of optical glasses and laser glasses. Using different methods, we have measured the nonlinear refractive coefficient of these glasses. We have analyzed the possible mechanisms resulting in refractive index change in glass and calculated their nonlinear refractive coefficients. We have also discussed the dependence of laser-induced damage and thermo-optical blooming on nonlinear refractive coefficients.

SP638; 1983 September. 578-588. Danileiko, Y. K.; Lebedeva, T. P.; Manenkov, A. A.; Sidorin, A. V. **Nonlinear absorption and self-defocusing of intense IR-laser radiation in semiconductors due to generation of free carriers.**

Key words: Ge; high power laser interaction with semiconductors; high-power laser materials; laser-produced damage; nonequilibrium carrier generation; nonlinear absorption; photoconductivity; self-defocusing; Si.

Results of experimental studies of the interaction of high power CO_2 ($\lambda=10.6$ μm), CaF Er^{3+} ($\lambda=2.76$ μm) and YAG Er^{3+} ($\lambda=2.96$ μm) lasers with undoped Ge and Si are presented. The experiments included photoconductivity, microwave absorption and laser beam transmission measurements at various intensities up to the level of laser damage. For both the Ge and Si samples, nonequilibrium carrier generation has been observed with both CO_2 and Er-laser excitation.

It is shown that the carrier generation in Ge is due to two-photon ionization at the Er-laser wavelength, whereas none of the considered mechanisms (impact, multiphoton and thermal ionizations), explain the anomalous dependence of carrier density upon CO_2-laser excitation intensity.

Nonequilibrium carrier generation results in nonlinear absorption and self-defocusing, which in turn lead to the intensity saturation of high power laser beams. Analysis of these effects for prefocused beams is presented. It is shown, in particular, that the absence of bulk damage in Ge under CO_2 and Er-laser radiation is attributed to these effects even at very high incident intensities. It is pointed out that these effects play an important role in the application of Ge as a material for use in high power IR lasers.

SP638; 1983 September. 589-600. Van Stryland, E. W.; Woodall, M. A.; Williams, W. E.; Soileau, M. J. **Two- and three-photon absorption in semiconductors with subsequent absorption by photogenerated carriers.**

Key words: CdS; CdTe; nonlinear absorption; photoacoustic; three-photon; two-photon; ZnSe.

A careful examination of two-photon absorption in CdTe and three-photon absorption in CdS and ZnSe was made by studying the transmission of picosecond pulses at 1.06 μm and the photoacoustic signal generated in the sample by the absorption of light. We found that in order to separate the direct nonlinear absorption from the subsequent absorption by the photogenerated carriers, careful analysis of the data over a wide range of irradiance levels was necessary. The nonlinear absorption coefficients for these three materials were determined, as well as an overall excess carrier absorption cross section. In addition, for CdTe we used two different temporal pulsewidths to verify our analysis. The photoacoustic data had a 1 to 1 correspondence with the transmission data indicating that this more sensitive technique should be useful for measuring nonlinear absorption spectra in solids with a variety of less powerful lasers. In addition for samples such as BK7 glass, which showed no nonlinear transmission even when surface damage occured, the photoacoustic signal showed abrupt large increases when damage occured. No nonlinear absorption was observed in two types of CVD ZnS prior to damage.

SP638; 1983 September. 601-615. Sparks, M.; King, D. F.; Mills, D. L. **Simple theory of microwave absorption in alkali halides.**

Key words: alkali halides; microwave absorption; multiple-photon absorption.

The intrinsic microwave absorption coefficient β of alkali halides is well explained by lifetime-broadened two-photon difference processes, in contrast to energy-conserving two- and three-phonon processes as previously thought. A simple closed-form expression for β with no adjustable parameters gives excellent agreement with the magnitude, frequency dependence, and temperature dependence of β in NaCl, KBr, and KI. As ω increases from $\omega<\omega_c/3$ to $\omega=\omega_c+\gamma_{293}$, the frequency and temperature dependence of β at 293 K (or 1000 K) change from the low-frequency limit $\beta \sim T^l\omega^2$ to $\beta \sim T^h\omega^{2+}$, where $2.0\leqslant l\leqslant 2.6$ (or $2.2\leqslant l\leqslant 4.0$) and $1.1\leqslant h\leqslant 1.2$ (or $0.57\leqslant h\leqslant 1.6$) for the three materials. Here $\omega_c=20$ cm^{-1} for NaCl is the frequency difference between the transverse-acoustical and transverse-optical phonon modes at the Brillouin zone edge and γ is the combined phonon inverse lifetime at 293 K. The temperature dependence of the phonon frequencies and other parameters must be included in order to explain the temperature dependence of the experimental results. The present lifetime-broadened results agree with previous energy-conservation results (apart from smoothing) and with experimental results in the region $\omega>\omega_c+\gamma$. Previous energy-conserving results disagree with the T and ω dependence and magnitude of the experimental results in the region $\omega<\omega_c$.

SP638; 1983 September. 617-628. Volkin, H. C. **Increased breakdown thresholds in air by admixing an electronegative gas.**

Key words: attaching species; avalanche ionization; breakdown threshold; electron attachment; electronegative gas; gas breakdown; laser beam; laser-induced breakdown; laser-produced plasmas; plasma production.

The intrinsic breakdown by large area laser beams of gases containing the attaching species SF_6 mixed with clean dry air has been analyzed in detail. The results show that SF_6 is equally effective in inhibiting avalanche breakdown of these gases for near infrared pulses longer than 100 nanoseconds as for DC fields. The breakdown intensities were obtained for various pulse durations at 10.6 μm by numerically solving the Boltzmann equation for the energy distribution $n(\epsilon)$ of electrons in the generated plasma. Published electron collision cross sections considered the best available for our application were used. The calculated breakdown intensity for very long pulses of constant intensity in air at 1 atm and 300 K is $I^*=2.7\times 10^9$ w/cm^2, which agrees within experimental uncertainty with the measured value. At any given intensity, the power absorbed by the plasma and the power losses in the various electron collision processes (elastic, inelastic excitation of vibrational and electronic levels, ionization, and attachment) are evaluated in our calculations. Discrete photon effects in power absorption and photoelectric processes are expected to be small for wavelengths larger than 1 μm, so the frequency scaling (I^*/ω^2) of classical field theory should hold for our results over the near infrared region.

SP643. Shaffer, S. **National Bureau of Standards (Annual Report for Fiscal Years 1981 and 1982).** *Natl. Bur. Stand. (U.S.) Spec. Publ. 643;* 1983 February. 27 p. SN003-003-02471-6.

Key words: automated manufacturing; basic measurements and standards; building technology; calibration services; computer standards and guidelines; electronics; fire safety; materials processing; measurement techniques; standard reference materials; surface.

National Bureau of Standards explains the Bureau's role as the central U.S. reference laboratory for the physical and engineering sciences. Advances in materials science, semiconductor electronics, manufacturing automation, and dozens of other areas of NBS research are highlighted. Covering the Bureau's science and engineering measurement work during fiscal years 1981 and 1982, the report provides a broad view of some of the major projects that are underway or recently completed at NBS. Also featured are summaries of NBS services to industry, other government agencies, and the public, as well as information on cooperative research programs and a directory of the names, titles, and phone numbers of NBS research managers.

SP644. Eisenhart, C.; Ku, H. H.; Collé, R. **Expression of the uncertainties of final measurement results: Reprints.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 644;* 1983 January. 19 p. SN003-003-02466-0.

Key words: accuracy; errors; measurement uncertainty; precision; reporting of measurement data; systematic error; uncertainties.

This publication reprints and collects in one convenient source three articles, by NBS authors, that present a philosophical basis, general guidelines, and specific recommendations for expressing the uncertainties of final measurement results.

SP645. Tholen, A. D.; Barbrow, L. E.; Heffernan, A. P., eds. **Report of the 67th National Conference on Weights and Measures 1982.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 645;* 1983 January. 325 p. SN003-003-02464-3.

Key words: education programs; grain moisture; international recommendations; legal metrology; measurement assurance; metrication; model laws and regulations; packaging and labeling; pattern approval; specifications and tolerances; technology transfer; training; type evaluation; weights and measures.

These are the proceedings of the 67th National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Atlanta, GA, July 12-16, 1982, and attended by State, county, and city weights and measures officials, and representatives of the Federal Government, business, industry, and consumer organizations. Reports by the several standing and annual committees of the Conference comprise the major portion of the publication. Included also are papers presented by Conference officials and other authorities from Government and industry.

Major issues discussed at the National Conference included long-range plans for training, enforcement uniformity, national type evaluation programs and a new publication on type evaluation examinations, new design and performance requirements for commercial weighing and measuring instruments, cash and credit sales at retail motor fuel outlets, studies of model State laws and regulations, a tentative code for grain moisture meters, and adoption of several NBS Handbooks by NCWM.

SP646. Wyckoff, J. M., ed. **Federal Laboratory Directory 1982.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 646;* 1983 February. 263 p. SN003-003-02473-2.

Key words: contacts; directory; Federal laboratory; research and development; technology transfer.

This Directory provides limited information about some 388 Federal laboratories with ten or more full-time professionals engaged in research and development. Summary data arranged by Federal agency and by State provide a broad overview of the Federal laboratory system. Laboratory lists by staff size, by State and by agency provide a cross reference. For each laboratory, a contact for obtaining technical information is given by name, address, and phone number. Major mission and major scientific or testing equipment is listed for each laboratory.

SP647-1. Reed, R. P.; Smith, J. H.; Christ, B. W. **The economic effects of fracture in the United States. Part 1—A synopsis of the September 30, 1982 report to NBS by Battelle Columbus Laboratories.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 647-1;* 1983 March. 19 p. SN003-003-02470-8.

Key words: cost of fracture; economics; fracture; input-output analysis; materials.

The National Bureau of Standards and Battelle Laboratories (Columbus) have completed a study to assess the costs of material fracture to the United States for the year 1978. This exhaustive assessment used the econometric input-output model to identify contributions from the entire U.S. economy. The study included all materials and all types of structures and included both fracture occurrence and fracture prevention costs.

The costs were large: in 1982 dollars the total cost was estimated to be $119 billion per year, about 4 percent of the gross national product. The costs could be reduced by an estimated $35 billion per year if technology transfer were employed to assure the use of best practice. Costs could be further reduced by as much as $28 billion per year through fracture-related research.

The study concluded that substantial material, transportation, and capital investment costs could be saved if technology transfer, combined with research and development, succeeded in reducing the factors of uncertainty related to structural reliability. Emphasis on fracture mechanics, inspection and materials processing to achieve better structural reliability and material consistency would result in equally safe or safer structures with less material usage.

SP647-2. Duga, J. J.; Fisher, W. H.; Buxbaum, R. W.; Rosenfield, A. R.; Buhr, A. R.; Honton, E. J.; McMillan, S. C. **The economic effects of fracture in the United States. Part 2—A report to NBS by Battelle Columbus Lahoratories.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 647-2;* 1983 March. 352 p. SN003-003-02470-8.

Key words: economics; fracture; fracture costs; input-output model; resources; technological assessment.

A study was conducted to determine the cost of material fracture in the U.S. economy and to identify means of reducing the cost. An Input/Output (I/O) model of the economy was used to assess the costs of fracture. Fracture costs were determined for all materials, all sectors of the economy, and all fracture modes. The costs were associated with both the occurence of fracture and the prevention of fracture. The total cost of fracture was determined to be $99 billion (1978 dollars). Full application of presently known technology through technology transfer could reduce this amount by $29 billion. Further research in fracture-related technology could reduce the cost of fracture another $23 billion.

SP649. Breitenberg, M. A., ed. **Directory of international and regional organizations conducting standards-related activities.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 649;* 1983 April. 366 p. SN003-003-02481-3.

Key words: certification; international organizations; international standardization; international standards organizations; laboratory accreditation; metrology; organizational directory; standardization; standards.

This directory contains information on 272 international and regional organizations which conduct standardization, certification, laboratory accreditation, or other standards-related activities. This volume describes their work in these areas, as well as the scope of each organization, national affiliations of members, U.S. participants, restrictions on membership, as well as the availability of any standards in English.

This volume summarizes an effort by the National Bureau of Standards to obtain information relevant to monitoring U.S. participation in the many international organizations active in standardization. It is designed to serve the needs of Federal agencies and standards writers for information on international and regional organizations involved in standardization and related activities. It may also be useful to manufacturers, engineers, purchasing agents, and others.

SP650. Newell, K. G., Jr. **Standards committee activities of the National Bureau of Standards—1982 highlights.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 650;* 1983 March. 52 p. SN003-003-02475-9.

Key words: annual report; committee participation; standards committees; voluntary standards.

This report summarizes NBS standards committee activities and accomplishments during calendar year 1982. It describes the management of standards activities at NBS, profiles NBS staff participation on outside standards committees, and highlights significant technical and individual contributions made by NBS staff. In 1982, 457 staff members (or 29% of NBS' professional, scientific, and technical staff) participated in 1,046 outside standards committees of 97 national and international standards organizations.

SP651. Chung, R. M.; Lew, H. S.; Kovacs, W. D., eds. **Wind and seismic effects.** Proceedings of the 14th Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources. *Natl. Bur. Stand. (U.S.) Spec. Publ. 651;* 1983 April. 716 p. SN003-003-02485-6.

Key words: accelerograph; codes; design criteria; disaster; earthquake hazards; earthquakes; geotechnical engineering; ground failure; liquefaction; pipeline; seismicity; solids; standards; structural engineering; structural response; tsunami; wind loads; winds.

The 14th Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Washington, D.C., United States from May 17 through 20, 1982. This publication, which is the proceedings of the Joint Meeting, includes the program, list of members, formal resolutions, technical papers, and the task committee reports. Subjects covered in the papers presented to the panel include: (1) characteristics of strong winds, (2) wind loads on structures and design criteria, (3) earthquake ground motions and dynamic analysis of embankment dams, (4) soil liquefaction study and methods to improve liquefaction resistance, (5) seismic loads on structures and design criteria, (6) stress analyses of pipelines during earthquakes, (7) full-scale seismic experiments, (8) earthquake hazard reduction program, (9) use of microcomputer for earthquake studies, (10) quantitative evaluation of damages caused by winds and earthquakes, and (11) tsunami research projects. *These proceedings include the following papers (indented):*

SP651; 1983 April. 1-19. Okubo, T.; Narita, N.; Yamamoto, K.; Sata, H. **Effects of solidity of trusses on unsteady aerodynamic forces of stiffening trussed-girders.**

Key words: aerodynamic forces; solidity; trussed-girders.

Unsteady aerodynamic forces acting on stiffening trussed-girders are described. The models of stiffening trussed-girders which were used in the previous experiments [1] have trusses of low solidity (about 20 percent). In the present experiment, measurements were made for trusses of various solidity ratios, thus, the effects of solidity on unsteady aerodynamic forces of stiffening trussed-girders were investigated. Furthermore, measures to improve stability to torsional flutter of stiffening trussed-girders of high solidity (about 40 percent) were investigated and some effective measures have been found.

SP651; 1983 April. 20-33. Bampton, M. C. C. **Field studies on the Pasco-Kennewick Cable-Stayed Bridge.**

Key words: bridge motion; cable-stayed bridge; wind data.

This paper briefly describes a recent study to collect bridge motion and natural wind data at the site of the 763 m (2503 ft) Pasco-Kennewick Cable-Stayed Bridge using an automated data collection system. Examples of wind and acceleration spectra as well as coherence and deck frequency measurements are presented. The research was sponsored by the Federal Highway Administration and performed by Battelle Pacific Northwest Laboratories over a 3 year period.

SP651; 1983 April. 34-52. Okada, H.; Murota, T. **Wind load on solar water heaters.**

Key words: heater shape; mounting pattern; roof pitch; roof shape; solar water heaters.

Solar water heaters mounted on house roofs are becoming widely used due to the recent rise of consciousness of saving energy in Japan. This paper describes results of wind tunnel tests conducted to obtain information with regard to wind forces on solar water heaters mounted on house roofs. The effects of heater shape, mounting pattern, roof pitch, roof shape, etc., on wind forces on heaters are discussed.

The paper also describes a field observation of wind forces on a full-scale solar water heater mounted on a cottage.

SP651; 1983 April. 53-74. Joyner, W. B.; Boore, D. M. **Estimation of response-spectral values as functions of magnitude, distance, and site conditions.**

Key words: comparison; earthquakes; force coefficients; horizontal acceleration and velocity; predictive equations; response spectra.

We have developed empirical predictive equations for the horizontal pseudo-velocity response at 5 percent damping for 12 different periods from 0.1 to 4.0 s. Using a multiple linear-regression method similar to the one we used previously for peak horizontal acceleration and velocity, we analyzed response spectra period by period for 64 records of 12 shallow earthquakes in Western North America, including the recent Coyote Lake and Imperial Valley, California, earthquakes. The resulting predictive equations show amplification of the response values at soil sites for periods greater than or equal to 0.5 s, with maximum amplification exceeding a factor of 2 at 1.5 s. For periods less than 0.5 s there is no statistically significant difference between rock sites and the soil sites represented in the data set. These results are consistent with those of several earlier studies. A particularly significant aspect of the predictive equations is that the response values at different periods are different functions of magnitude (confirming earlier results by McGuire and by Trifunac and Anderson). The slope of the least-squares straight line relating log response to moment magnitude ranges from 0.21 at a period of 0.1 s to greater than 0.5 at periods of 1 s and longer. This result indicates that the conventional practice of scaling a constant spectral shape by peak acceleration will not give accurate answers. The Newmark and Hall method of spectral scaling, using both peak acceleration and peak velocity, largely avoids this error. Comparison of our spectra with the Regulatory Guide 1.60 spectrum anchored at the same value at 0.1 s shows that the Regulatory Guide 1.60 spectrum is exceeded at soil sites for a magnitude of 7.5 at all distances for periods greater than about 0.5 s. Comparison of our spectra for soil sites with the corresponding ATC-3 curve of lateral design force coefficients for the highest seismic zone indicates that the ATC-3 curve is exceeded within about 5 km of a magnitude 6.5 earthquake and within about 20 km of a magnitude 7.5 event. The amount by which it is exceeded is largest in the period range from 0.5 to 2.0 s.

SP651; 1983 April. 75-80. Ohtani, K. **Reconsideration of the input waves for dynamic analysis.**

Key words: aseismic design; aseismic safety; dynamic analysis; input waves.

The aseismic design method using dynamic analysis has been well established in Japan. Actual design cases of high rise buildings have been totaled up to about 400 in the past 20 years. In this paper, the present state of aseismic design, especially of the dynamic response analysis is reviewed.

Some problems related to the input waves for design are also discussed, and some future subjects for research and development are proposed.

SP651; 1983 April. 81-94. Brady, A. G. **Some new processing techniques for the Imperial Valley 1979 aftershocks.**

Key words: aftershocks; El Centro Array; Imperial fault; Imperial Valley.

This paper describes some of the features of the latest processing improvements that the U.S. Geological Survey (USGS) is currently applying to strong-motion accelerograms from the national network of permanent stations. At the same time it introduces the application of this processing to the set of Imperial Valley aftershocks recorded following the main shock of October 15, 1979. Earlier processing of the 22 main shock recordings provided corrected accelerations, velocity and displacement, response spectra, and Fourier spectra. The digital data has been available on two tapes from NOAA, in Colorado,

for 2 years now, and a report containing computer plots has been available, while supplies last, from the USGS in Menlo Park.

The USGS has taken the opportunity provided by the large number of triggerings at 30 permanent stations in the Imperial Valley to update the processing scheme applied particularly to short duration accelerograms with frequencies possibly as high as 50 Hz.

A total of 67 of the aftershock recordings were selected for digitization, from eight events. The number of stations involved is 20, all of which had previously recorded the main shock. A brief outline of the processing steps that have been developed is included, as they have been applied to the best recorded, M 5.0, aftershock. The selection of a long-period filter and its dependence on the need to remove a predominant 4 sec component is discussed. Displacements from those stations on the El Centro Array with radio time have been plotted so as to indicate visually the total processing package.

SP651; 1983 April. 95-123. Okubo, T.; Arakawa, T.; Kawashima, K. **Dense instrument array observation by the public works research institute and analyses of some records.**

Key words: dense instrument array; differential motion; ground motions; wave propagation.

It is important for large structures such as bridges and lifeline facilities to consider differential motions between points of the ground in estimating the design ground motions. It is well recognized that such motions are significantly dependent on local geological and topological conditions. In order to investigate such effects on earthquake ground motions, the normal type of strong motion observation performed at each individual site is not enough, and installation of a dense instrument array is indispensible.

Besides the laboratory observation array at its campus, the Public Research Institute is now on the way to deploy four local laboratory arrays around the Suruga Bay-Izu area in Shizuoka Prefecture, Japan, within 4 years, starting in the 1981 fiscal year.

This report presents one of the four local laboratory arrays in the Sagara area, at which instrumentation has been completed and observations were initiated in 1981 fiscal year, and shows some analyses of array data obtained at the PWRI campus. Analyses for finite strains induced in ground during earthquakes, effects of differential motion on structural response in terms of multisupport response spectrum, and wave propagation characteristics in vertical and horizontal directions are studied.

SP651; 1983 April. 124-149. Sasaki, Y.; Taniguchi, E. **Gravel drains as a countermeasure to liquefaction of the ground.**

Key words: gravel drains; liquefaction.

This paper presents the effectiveness of gravel drains installed to minimize damage of a "half buried type road" caused by liquefaction of the surrounding sand deposit. Large-scale shaking table tests and finite element analyses were used in the study.

SP651; 1983 April. 150-171. Chung, R. M.; Yokel, F. Y.; Anderson, E. D. **Volume change and excess pore water pressure buildup as a function of degree of saturation of sands during resonant column testing.**

Key words: degree of saturation; ground vibration; pore water pressure buildup.

Torsional resonant column tests were conducted on saturated and partially saturated hollow cylindrical Monterey No. 0 sand specimens to study the characteristics of pore water pressure buildup and volume change of the specimen as a function of degree of saturation.

Results of the tests indicated that there exists a threshold shear strain value of about 2×10^{-3} percent for fully saturated sand specimens, below which there is no buildup of excess pore water pressure. The threshold value was observed at about 5×10^{-3} percent when the volume change during testing was used as the criterion.

The degree of saturation was found to have a considerable effect on the threshold strain and the pore water pressure buildup, but it had no detectable effect on the volume change as measured by the displaced pore water.

SP651; 1983 April. 172-192. Iwasaki, T.; Arakawa, T.; Tokida, K. I.; Kimata, T. **Estimation procedures of liquefaction potential and its application to earthquake resistant design.**

Key words: liquefaction potential; pore water pressure; soil liquefaction.

Simplified methods to evaluate the effects of saturated sandy, soils are needed for the reasonable earthquake resistant design of structures considering soil liquefaction. Iwasaki et al., (1978), proposed two simplified methods which use a liquefaction resistance factor F_L and a liquefaction potential index I_L to evaluate the liquefaction potential of saturated sandy soils. Based on these proposed methods, the liquefaction potential can be estimated simply by using the fundamental properties of soils, i.e., N-values from the Standard Penetration Test, unit weights, mean particle diameters, and the maximum acceleration at the ground surface.

In this paper, the two simplified methods are first introduced, and to prove the effectiveness of the proposed methods, the values of both F_L and I_L at 64 liquefied sites and 23 non-liquefied sites during past six earthquakes are calculated according to these simplified methods. Also, shaking table tests on soil liquefaction are carried out for the saturated sandy model ground. Furthermore, several application methods using the factor F_L, the excess pore water pressure induced in the saturated sandy soils and the effects of soil liquefaction on the resistance properties of the soils surrounding structures are described. Finally, some case studies on earthquake resistant properties of civil engineering structures considering soil liquefaction are carried out according to the proposed procedures on soil liquefaction properties.

SP651; 1983 April. 193-217. Uwabe, T.; Noda, S.; Tsuchida, H. **Coupled hydrodynamic response characteristics and water pressures of large composite breakwaters.**

Key words: composite breakwater; hydrodynamic response characteristics.

In order to prevent damage by tsunami, a large composite breakwater is planned in deep sea at a depth of 60 m at the bay mouth of Kamaishi in the Tohoku district. For the purpose of examining the seismic behavior of the breakwater, an analysis of coupled hydrodynamic response characteristics and water pressures of the breakwater was carried out by means of a shaking table model test and an earthquake response calculation using the Finite Element Method.

In case the caisson of the composite type breakwater does not resonate, the model tests show that the hydrodynamic pressures acting on a caisson is calculated by the Westergaard formula using the water depth and the seismic coefficient at the top of the mound. (Mound means earth and/or rockfill).

In order to use earthquake response calculation for practical application, it is essential to investigate whether the modeling and material property values simulate the actual field condition or not. It is concluded that the method for analyzing structure-water systems using the Finite Element Method is appropriate for simulating the dynamic response and hydrodynamic pressures of the fill type breakwater.

SP651; 1983 April. 218-241. Franklin, A. G.; Hynes-Griffin, M. E. **Dynamic analysis of embankment sections, Richard B. Russell Dam.**

Key words: embankments; liquefaction; visco-elastic shear-beam analysis.

Seismic safety of the Russell Dam embankments was evaluated with a permanent displacement analysis, judged appropriate after laboratory cyclic testing verified the nonsusceptibility of embankment and foundation materials to liquefaction. The analysis included determination of critical or yield accelerations by means of conventional limit analysis, estimation of amplification of ground accelerations in the embankment through a visco-elastic shear-beam analysis, and estimation of deformations by means of a Newmark sliding block model. The results indicate that if the dam is subjected to the maximum possible earthquake for the site, superficial displacements would

not exceed 3 ft and displacements on deep-seated surfaces would not exceed 1.5 ft.

SP651; 1983 April. 242-258. Tsuchida, H.; Minami, K. I.; Kiyomiya, O.; Noda, S. **Pipe stresses during earthquakes based on a two-dimensional seismometer array observation.**

Key words: deformation method; dynamic response analysis; pipe stresses; two-dimensional seismometer array observation; wave propagation.

Pipe stresses developed during earthquakes are influenced by the relative displacement of an ambient ground. The strains caused by the relative displacement of the ground are closely related to the magnitude of the earthquakes, the epicentral distances, the subsoil conditions, and the properties of the wave propagation in surface layers. Analyses of records obtained by a two-dimensional seismometer array observation at the Tokyo International Airport were carried out to evaluate the behavior of the pipelines during earthquakes. Pipe stresses are calculated from the ground deformation by the observation. The stresses calculated by the deformation method, which has been used for earthquake resistant design in Japan, and by the dynamic response analysis are compared with those from the observation.

SP651; 1983 April. 259-271. Ariman, T. **Buckling and rupture failure in pipelines due to large ground deformations.**

Key words: ground deformations; lifeline earthquake engineering; rupture failure.

A concise and up-to-date review of buckling and rupture failure in pipelines due to ground deformations is presented. It is shown that, in comparison to surface structures, pipeline systems are particularly vulnerable to local differential movements of ground. It is noted that permanent differential movements may be caused by any earthquake and that the movements can assume a variety of patterns depending on local soil conditions and the presence of faults. Therefore, the response of buried pipelines to permanent ground movement is an important part of lifeline earthquake engineering.

SP651; 1983 April. 272-324. Kuribayashi, E.; Iwasaki, T.; Hagiwara, R. **Experimental studies on seismic behavior of structural members using a dynamic structural testing facility at PWRI.**

Key words: dynamic structural testing facilities; earthquakes; seismic behavior.

Dynamic structural testing facilities of an earthquake engineering laboratory were recently completed in March 1980 at Tsukuba by the Public Works Research Institute, Ministry of Construction. Four experiments as shown in table 1 were conducted so far using the facilities. Outlines of the facilities and two experiments conducted in the fiscal year of 1980 using the facilities are described.

SP651; 1983 April. 325-342. Yasue, T.; Iwasaki, T.; Sasaki, Y.; Asanuma, H.; Nakajima, T. **Report of the Urakawa-oki earthquake of March 21, 1982.**

Key words: civil engineering structures; damage; earthquake, Urakawa-oki.

On Sunday morning, March 21, 1982, a severe earthquake of magnitude 7.3 on the Richter Scale hit Urakawa-oki, off Urakawa, the southern part of Hokkaido Island in Japan. This report briefly describes an outline of the earthquake and damage to civil engineering structures due to the Urakawa-oki Earthquake of March 21, 1982.

SP651; 1983 April. 343-360. Fleming, J. F. **Linear versus nonlinear behavior of cable stayed bridges.**

Key words: cable stayed bridges; nonlinear behavior; static and dynamic response.

The first modern cable stayed bridge was constructed in Sweden in 1955. Since that time over 100 major bridges of this type have been built throughout the world. One of the major difficulties which many designers must face, when confronted with the task of designing a structure of this type, is a lack of knowledge of how they behave under static and dynamic design loads. It is well known that cables exhibit a nonlinear force-elongation relationship due to the change in sag with axial load. The purpose of this paper is to describe the results to date of an ongoing investigation into the effect of nonlinear behavior upon the overall static and dynamic response of cable stayed bridges. Mathematical models representing several actual or proposed bridges, under a variety of static and dynamic loads, were considered in the study.

SP651; 1983 April. 361-401. Narita, N.; Saeki, S.; Kanai, M.; Ohshio, T. **Behavior of concrete-filled steel tubes.**

Key words: bridge piers; concrete-filled steel tubes; earthquake.

In our country, bridge piers are subjected to strong motions due to earthquake. Furthermore, size of bridge piers are strictly limited in metropolitan highways and in monorails. High ductility and high resistance is, therefore, required for bridge piers in Japan. In this regard, use of concrete-filled steel tubes is examined.

Steel tubes have very high resistance; however, steel tubes are liable to yield by local buckling and to lose ductility after yielding. Concrete piers with adequate reinforcing have good ductility; however, they are large-sized. Concrete-filled steel tubes are thin steel tubes with concrete and shear connectors in the tubes. When they are subjected to a strong motion, the concrete prevents the local buckling of thin steel tubes and the steel tubes give adequate reinforcing to the concrete. Therefore, even small-sized concrete-filled steel tubes have excellent ductility and resistance.

Sometimes, concrete-filled steel tubes have been used for bridge piers or building members. However, they were used just to increase the rigidity of the members or to stiffen the steel tubes, and were not designed as composite structures. In our report, the concrete-filled steel tubes are regarded as composite structures to expect higher resistance and ductibility. At present, many problems are not resolved to design concrete-filled steel tubes as composite structures, such as provisions for shear connectors, plate thickness and so on. These problems are examined in detail in this paper. Based on the results of full-size tests, design recommendations are presented.

The following reports are coming in series. Part I—Compression Members; Part II—Long Columns; Part III—Bending Members; Part IV—Beam Columns.

SP651; 1983 April. 402-415. Takahashi, S. K.; Tyrrell, J. V. **Microcomputer for earthquake studies.**

Key words: BASIC; COBOL; earthquake; FORTRAN; microcomputer.

The use of microcomputers is now a practical reality for the small engineering office. The reasons for the immediate popularity are the low initial cost of the system ($4K to $8K), the large number of software programs available and its versatility.

The cost of a typical microcomputer (MC) system, one that is operational at the Naval Civil Engineering Laboratory, with a 64K RAM (Random Access Memory), dual 8 in. disk drives, and letter quality printer, is about $8K. Presently it has an 8-bit processor, but it can be upgraded to a 16-bit processor at any time. Similarly, the memory can be upgraded from 64K to 128K as the need arises. One standard parallel port and two RS-232C serial ports allows the addition of printers, plotters, digiti zers, and communications with data bases and other computers. Two drives provide 932,000 characters of storage; adding two more drives will bring the capacity to about two million characters. If a hard disk drive system is utilized, it can access 8.4 million characters. The Daisy Wheel letter quality printer (figure 4) was slected so that drafts and final manuscripts could be written and stored on the diskette for instant retrieval and modifications of the text. Additional information and specifications of the MC can be found in reference 1.

This MC adapts easily to the choice of languages such as BASIC, COBOL, FORTRAN, etc., because the system has no primary language stored in Read Only Memory (ROM). Transfer of information, from one installation that uses a microcomputer

which utilizes the CP/M system to another Navy agency also utilizing a microcomputer that uses 8 in. single-sided, single-density diskette, can be made easily on the 8 in. diskette with 128 byte record size because this is the standard international interchange format.

SP651; 1983 April. 416-425. Bernard, E. **A tsunami research plan for the United States.**

Key words: coastal hazards; tsunamigenic earthquake; identification; tsunami research.

In response to the identification of deficiencies in tsunami research, a group of scientists and government representatives developed a coherent research plan to address these problems. The plan is designed to foster a course of action that will focus research on forecasting tsunami dangers and evaluating coastal hazards. A brief review of the status of tsunami research is presented and needs for priority research are identified. The three highest need areas are: 1) tsunami observational program, 2) modeling and design related to terminal effects, and 3) tsunamigenic earthquake identification. Two moderate need areas include the creation of a tsunami data set and the development of emergency preparedness programs.

SP651; 1983 April. 426-432. Lander, J. F. **Digital data services for tsunamis and engineering seismology.**

Key words: engineering seismology; NEDRES; seismographic data; tsunamigenic earthquakes; tsunamis.

The consolidation of NOAA's environmental data banks in one system, the development of dgital data directories, dictionaries, and inventories, the use of data base management systems and mass store, and accessibility of the whole system remotely offer new opportunities for users to directly get data shaped to their needs from multiple discipline files. A National Environmental Data Referral Service can help users find data in the system and elsewhere worldwide. Possibilities of networking with bibliographic and other data bases are also promising.

SP651; 1983 April. 433-439. Wright, J. K. **Construction of the full-scale reinforced concrete test specimen.**

Key words: concrete test specimen; construction practices; reinforcement details.

A short summary of the construction of the full-scale seven-story reinforced concrete building is presented. Differences between Japanese and U.S. construction practices are discussed. Cross section dimensions and reinforcement details for important portions of the structure are also presented.

SP651; 1983 April. 440-456. Okamoto, S.; Nakata, S.; Kitagawa, Y.; Yoshimura, M.; Kaminosono, T. **Progress report on the full-scale seismic experiment of a seven-story reinforced concrete building—Part 1. Pseudo-dynamic test before repair.**

Key words: dynamic loading; earthquake ground motions; pseudo-dynamic test; reinforced concrete building; seismic design; static loading tests.

The appropriate evaluation of strength and deflection characteristics of building structures is a fundamental requirement for the proper estimation of structural safety in the event of major earthquake disturbances. Various unsolved problems yet remain for this evaluation due to complexity of the combination of randomness in earthquake ground motions with nonlinear behavior of structural systems. Effects of scale and construction quality make the precise evaluation more complicated and difficult.

In order to predict the behavior of structures subjected to seven earthquake ground motions, many analytical models of materials, members, and systems were developed, and numerical analyses have been made. Nevertheless, it is uncertain whether or not the results of these studies represent the true behavior of the structures because of various approximations, assumptions, and simplifications in the course of modeling and analysis. Static loading tests of full-scale models provide useful information on strength and deformation characteristics of structures, but the true margin of safety of those structures cannot be estimated.

To simulate the earthquake response of a structural model, the pseudo-dynamic test procedure is considered to be one of the most effective testing techniques if the model is beyond the capacity of a shaking table. In the Building Research Institute (BRI), Ministry of Construction, a computer-actuator on-line system was developed in 1980, and subsequently a series of pseudo-dynamic tests of a full-scale model of a seven-story reinforced concrete building with the cooperation of the Joint Technical Coordination Committee members have been performed. The primary objectives of the test were: (1) to calibrate the accuracy of techniques developed for analyzing structures under static or dynamic loading, and (2) to estimate the true margin of safety of the structure. The test was also expected to provide fundamental data for current seismic design.

SP651; 1983 April. 457-475. Okamoto, S.; Nakata, S.; Kitagawa, Y.; Yoshimura, M.; Kaminosono, T. **A progress report on the full-scale seismic experiment of a seven-story reinforced concrete building—Part 2. Pseudo-dynamic test after repair.**

Key words: pseudo-dynamic test; reinforced concrete building.

After the pseudo-dynamic test of the full-scale reinforced concrete structure, repair works and the installation of nonstructural elements to the damaged structure were carried out. The hinge zone of the beams and the shear wall of the structure were repaired by using epoxy resin. The repair works proved to be economically effective for the reuse of the damaged structure after earthquake damage from the viewpoint of recovering the stiffness and the strength of the structure. The aseismic arrangements of nonstructural elements such as partition walls, spandrel walls, window glasses, etc., were verified through a series of pseudo-dynamic tests.

SP651; 1983 April. 476-488. Morgan, B. J.; Hiraishi, H.; Corley, W. G. **Tests of planar wall assemblies under in-plane static reversing loads.**

Key words: concrete structures; in-plane static reversing loads; planar wall assemblies.

During the 1968 Tokachi-Oki Earthquake in Japan, numerous reinforced concrete school buildings of modern design suffered heavy damage. Following that earthquake, a joint seminar under the sponsorship of the U.S.-Japan Cooperative Science Program was held in Sendai, Japan in 1970. One purpose of the seminar was to identify and define programs of research that could be conducted effectively on a cooperative basis between the United States and Japan.

Prompted by discussions held at Sendai, a U.S.-Japan Cooperative Research Program on Earthquake Engineering was established under the U.S.-Japan Cooperative Science Program. The period of this program was initially 1973 to 1975. A program review meeting was held in Hawaii in 1975. Several formal recommendations grew out of the presentations and discussions at this meeting. One of these recommendations was that a cooperative research program should be established with emphasis on large-scale testing of structural systems. During the period of 1974 to 1978, government delegates on a separate U.S.-Japan Panel on Wind and Seismic Effects arrived at the same conclusions.

Based on conclusions and recommendations of both university and government groups, a planning group was established to define specific details of research to be carried out. After four meetings during 1977 to 1979, the planning group recommended that research should focus on "studies to determine the relationship among full-scale tests, small-scale tests, component tests, and analytical studies."

SP651; 1983 April. 489-506. Watabe, M.; Yamanouchi, H.; Midorikawa, M.; Fukuta, T.; Kaminosono, T. **Research program on the full-scale seismic experiments of steel buildings.**

Key words: pseudo-dynamic tests; seismic experiments; static tests; steel buildings.

This research program is conducted in accordance with recommendations prepared by the U.S.-Japan planning group established in 1977 under the auspices of the U.S.-Japan Panel on Wind and Seismic Effects, United States-Japan Natural Resources

(UJNR) Program. Research activities from these recommendations have been conducted under the Joint Technical Coordinating Committee (JTCC), which consists of researchers from both countries.

In its first year, the Structural Steel Phase was begun by experiments on structural members and subassemblages. These results would support analyses on a full-scale test building. The support tests consist of four experimental programs. They are: (1) static tests on three-story steel planar frames, (2) dynamic and pseudo-dynamic tests on steel frames (designated as a Correlation test), (3) static tests on composite girders, and (4) static tests on column-to-footing connections. The second year's main program is to conduct tests on the full-scale six-story steel building using the pseudo-dynamic testing method. The test building consists of two unbraced moment-resisting frames and a braced frame with K-braces. This structure would represent a portion of an overall building. Two types of K-bracing systems, the concentric K and the eccentric K, should be used in different stages of testing. It should be tested in several stages using a loading procedure simulating realistic seismic conditions. At the final stage of testing, nonstructural elements such as curtain walls and partitions should be added to the structural system and the entire structure should be loaded to failure. In the third year, analyses and estimation on the full-scale test will be done, associated with supplementary tests on subassemblages. Comprehensive consideration will be directed to seismic safety of steel buildings.

SP651; 1983 April. 507-521. Hebenstreit, G. T.; Krumpe, P. F. **United States foreign assistance program on tsunami hazard.**

Key words: computer modeling; earthquake sources; tsunami; tsunami behavior; tsunamigenic earthquake.

The Office of Foreign Disaster Assistance, U.S. AID, and Science Applications, Inc., are developing a program to make the results of current tsunami research techniques available to disaster control officials in developing nations which are subject to potentially severe tsunami hazards. This program uses a combination of historical study of past tsunamis and computer modeling of possible future tsunamis to assess the threat to specific areas. The first application of the program has been to the potential threat arising from tsunamis generated in the Peru-Chile Trench.

This paper outlines the techniques used in the computer modeling, the choice of specific earthquake sources, and the results of early studies. Research is currently underway to examine in more detail tsunami behavior in areas which appear strongly threatened. We discuss briefly our approach to this phase of the problem and our plans for transferring the results of the program to officials in developing nations.

SP651; 1983 April. 522-531. Kamimura, K.; Watabe, M.; Ishiyama, Y.; Yamazaki, Y. **Technical cooperation in developing countries on earthquake engineering.**

Key words: aseismatic building techniques; earthquake disasters; earthquake engineering.

In order to improve earthquake engineering techniques in developing countries, it is necessary, apart from direct technical cooperation, to raise the standards of research and techniques in the country concerned from a long-term point of view. The International Institute of Seismology and Earthquake Engineering, the Building Research Institute, has been conducting training programs in seismology and earthquake engineering since 1962 for the purpose of training researchers and engineers from developing countries. These training programs have played an immeasurable role in raising the standards of research and techniques in developing countries.

This report is intended to outline the surveys on earthquake disasters conducted overseas in connection with the Institute and to introduce the training programs. In addition, the report will also briefly touch upon the cooperation programs for Indonesia and Peru under the Bilateral Earthquake Engineering Cooperation Program with which the Institute is closely associated.

SP651; 1983 April. 532-537. Simiu, E. **Incremental expansion and aseismic design of low-cost housing in sites and services projects.**

Key words: aseismic design; design problems; incremental expansion; shelter core.

In recent years, sites and services projects have evolved into one of the more effective components of urban strategies dealing with the enormous shelter problems faced by developing countries. In sites and services projects the responsibility for building the shelter itself rests to a large extent with the beneficiary.

For reasons of hygiene and fire safety and to facilitate immediate occupancy, sites and services plots are in many instances provided initially with sanitary cores, fire walls, and a rudimentary partial shelter. Depending upon his evolving needs and ability to pay for the requisite materials and labor, the beneficiary then completes the dwelling in incremental stages. His direct involvement in the building effort—usually referred to as self-help—can be expected to yield a product more suitable to his needs and, to the extent that financing costs and overhead are reduced, more economical than would be the case for conventional construction.

The advantages of incremental expansion by self-help should not obscure some potential technical pitfalls, particularly with regard to construction in earthquake and typhoon (cyclone) prone regions. This is true even where the level of conventional technical skills available to the sites and services beneficiaries can be assumed to be reasonably adequate.

It will be shown in this paper that incremental expansion schemes pose special and delicate structural design problems that arise from the evolutionary nature of the building process in sites and services projects. A first type of problems arises if an initial but incomplete shelter core is provided on the site. In that case efficient ways must be found to ensure the structural integrity of the initial construction. A second type of problems is due to the difficulty of tying successive incremental portions of the dwelling both to the initial construction and among themselves in such a manner as to create systems that are structurally sound at all times. Without due attention to such problems the resulting construction can be unnecessarily uneconomical as well as constituting a serious hazard to life and property in case of earthquake or tropical cyclone. These two types of problems will be illustrated by using examples of shelter construction in actual sites and services projects.

SP651; 1983 April. 538-540. Barrientos, C. S. **Storm surge forecasting.**

Key words: forecasting; hurricane; storm surge.

The National Weather Service of the National Oceanic and Atmospheric Administration (NOAA) has the responsibility to provide forecasting and warning of impending storm surges. This presentation will summarize the storm surge forecast models now in use by NOAA and briefly discuss certain other storm surge models.

SP651; 1983 April. 541-555. Sasaki, Y.; Koga, Y. **Vibratory cone penetrometer to assess the liquefaction potential of the ground.**

Key words: artificial vibration; impact loadings; liquefaction; standard penetration tests; vibratory cone penetrometer.

This paper describes a vibratory cone penetrometer that aims to investigate the liquefaction potential of sand deposit in a direct and simple manner in the field, and also the test results in the laboratory using the vibratory cone penetrometer. This cone penetrometer was developed on the basis that the point resistance of the static penetration with vibration or the difference of the point resistance between the above penetration and the static penetration reflects the liquefaction potential of the ground. Such a presumed characteristic was found in the laboratory tests, which were performed on model sand deposits of various relative density and overburden pressure. As a result, the applicability of this new vibratory cone penetrometer was validated.

SP651; 1983 April. 556-564. Watabe, M. **Direct evaluation method for floor response spectra.**

Key words: floor response spectra; random vibration theory; response analyses; seismic design.

Floor response spectra are generally obtained by response analyses when the results by response analyses in time history of structures are employed as input excitations. It is possible to apply the random vibration theory to evaluate the maximum responses of structures and their floor response spectra without response analyses in time history.

In this paper, the calculation procedure of maximum responses of structures and their floor response spectra subjected to nonstationary random earthquake ground motions are proposed. The method herein proposed is verified to be valid and very useful when its results are compared with the results obtained by the general method.

SP651; 1983 April. 565-586. Kuribayashi, E.; Iwasaki, T.; Nakajima, T. **A proçedure for estimating indirect effects of earthquakes on economy.**

Key words: earthquakes; economic damage; indirect effects; value-added.

This paper discusses the economic damage caused by the Miyagi-ken-oki Earthquake of 1978. The earthquake has brought about extensive structural damage and the amount of direct losses has reached 269 billion yen. In consequence of the physical damage, the aftermath of the earthquake lasted about four months and one of the severest effects came out in the reduction of value-added in the local economy. This paper studies the reduction of value-added in Miyagi Prefecture after the Miyagi-ken-oki Earthquake of 1978.

SP651; 1983 April. 587-599. Matsumoto, N.; Totoda, M.; Shiga, M. **Dynamic tests of rockfill dam models.**

Key words: dynamic tests; frequency response functions; rockfill dam models.

Dynamic tests of two-dimensional rockfill dam models with a central impervious core were conducted using a shaking table. Heights of the models were 74 cm and 84 cm respectively. Models were excited with horizontal sinusoidal motion and the frequency response functions of the models were obtained.

The response characteristics of the models were compared between full and empty reservoir conditions. The models were also subjected to scaled earthquake motions and the nature of the failure during earthquake motions were compared with the case of the sinusoidal motion input.

SP651; 1983 April. 600-616. Narita, N.; Asanuma, H.; Fukui, J.; Yamamoto, Y. **The connecting method for pile head and footing of pile foundations subjected to a horizontal load.**

Key words: connecting method; load-deformation characteristics; pile foundation; pile heat.

It is necessary for the foundation of a bridge structure to efficiently transmit the load from the superstructure to the ground. In the case of a pile foundation, in particular, it is necessary to give sufficient consideration to the safety of the connection of pile heat and footing because of sudden changes in cross section and rigidity. Various connecting methods have been developed. However, there remain many points which need to be clarified with regard to the ultimate strength, load-deformation characteristics, etc., of the connection.

SP651; 1983 April. 617-654. Rojahn, C.; Borcherdt, R. D. **On the status of in situ strong ground motion and structural response investigations.**

Key words: earthquakes; strong-motion arrays; structural response investigations.

Strong-motion data from large earthquakes provide the basis for the design of buildings, bridges, dams, and other critical structures as well as the basis for research on fundamental problems related to earthquake hazard evaluation, earthquake processes, and internal structure of the earth. Review of existing strong-motion data acquisition programs in the United States shows significant progress in instrument deployment since 1933, but that significant improvements in data acquisition capabilities are needed for scientific and engineering research studies. The need for installation of several additional well-designed strong-motion arrays (free field, structures) in areas of high seismic potential worldwide is readily apparent as well as the need to develop instrumentation to reduce maintenance costs. Review of existing analog and digital strong-motion recording systems indicates that proven reliability and level of technical maintenance expertise still recommend analog systems for applications involving small amounts of data and long-term deployment. Those applications involving highly trained technicians, improved quality data, and large amount of data are facilitated by using digital instrumentation. Recent applications of digital technology in other fields suggests that numerous improvements in digital recorders are feasible and warranted.

Review of recently collected strong-motion data sets shows a significant increase in the strong-motion data base for moderate-sized earthquakes with that from the earthquake in Imperial Valley, California (October 15, 1979) being most complete. Compilations of these data show a critical scarcity of in situ information on near field ground motions and damaging structural response levels for earthquakes larger than magnitude 7.

SP651; 1983 April. 655-668. Goda, Y.; Hashimoto, H. **Storm surge defense works and related researches in Japan.**

Key words: coastal dikes; defense works; storm surge.

Five typhoons on the average land every year because Japan is located in a typhoon attacking zone of the Western Pacific Ocean. They bring storm surges and high waves along a coast. Once the storm surge causes a flood, damage is enormous. Coastal dikes and gates have been constructed to prevent damage. Storm surge defense works have been carried out on the principle established after the Ise-wan Typhoon which caused heavy damage in 1959. In this regard, research related to the numerical estimation of storm surges and waves were made. Experimental investigations were carried out by universities and governmental institutions to determine the wave run-up and overtopping on a dike. The research stopped after the defense works were almost completed.

SP652. Shives, T. R., ed. **Damage prevention in the transportation environment.** Proceedings of the 34th Meeting of the Mechanical Failures Prevention Group held at the National Bureau of Standards; 1981 October 21-23; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 652;* 1983 April. 349 p. SN003-003-02488-1.

Key words: airline environment packaging; hazardous materials transportation; highway design; marine environment packaging; packaging techniques; railroad environment packaging; shipping; transportation; transportation damage prevention; trucking environment packaging.

These proceedings consist of 27 submitted entries (25 papers and 2 abstracts) from the 34th Meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards, Gaithersburg, Maryland, October 21-23, 1981. The subject of the symposium was damage prevention in the transportation environment. Areas of special emphasis included packaging for the transportation environment, research in the railroad industry, damage prevention in the railroad industry, designing for the transportation of hazardous materials, and highways. *These proceedings include the following papers (indented):*

SP652; 1983 April. 3-7. Wong, R. J. **Allocating loss and damage to the railroad transport cycle.**

Key words: freight damage; lading damage; loss and damage.

This paper presents the results of allocating loss and damage cost to various elements of the railroad transport cycle. Estimates of loss and damage attributed to linehaul shock and vibration and flat and hump yard coupling impacts are provided. In addition, loss and damage estimates are provided for various levels of overspeed impacts in hump yards.

SP652; 1983 April. 8-37. Colletti, J. P. **Export packing in the marine environment.**

Key words: containerization; packaging; packing; preservation.

This paper is intended to offer the shipper a ready reference on how to prepare his product for export shipment. The paper addresses, in general, the basics of preservation, packaging and packing including the selection of materials, methods of construction of skids, crates and boxes and a brief look at containerization.

SP652; 1983 April. 38-45. Winn, B. D.; Downing, W. D.; Crumrine, S. B. **Packaging software for shipment and storage.**

Key words: error correction; error detection; magnetic media; memory; semiconductor memory; storage media.

The proliferation in the use of computers in all types of equipment has led to a dramatic increase in demand for computer software. Software is distributed on many different media including paper, magnetic materials and semiconductor memories. Each medium has its own handling requirements. This paper will discuss packaging, preservation methods and special considerations involved in preparing computer software for shipment and storage. Emphasis will be given to techniques designed to prevent damage to the software due to temperature, humidity, static discharge, electromagnetic emissions and other transportation environments.

SP652; 1983 April. 46. Godshall, W. D. **Packaging for the transportation environment.**

Key words: hazards of transportation; packaging; packaging protection.

SP652; 1983 April. 49-65. RamaChandran, P. V.; ElMadany, M. M. **Improved suspension designs and their influence on freight car dynamics.**

Key words: freight car dynamics; lateral stability; performance regimes; premium trucks; ride quality; suspension; trackability; truck design features; type I trucks; type II trucks; vibration.

An evaluation of freight car truck performance was accomplished through the use of extensive field testing under revenue operating conditions. The field test data were reduced and analyzed through the use of digital computers. Results from the analysis were studied, and the performance characteristics of premium design trucks were compared to those of conventional trucks. Incremental performance improvements, relating to freight car dynamics, were studied with the objective of relating them as a cause-and-effect relationship to specific design features in the truck suspensions. This paper discusses the relationship of advanced features in truck suspension design to mitigating effects on the mechanisms influencing wear and failure of vehicle system components.

SP652; 1983 April. 67-78. Yang, J. C. S.; Hirt, M. A. **A method to detect and monitor crack in bridge structures.**

Key words: crack propagation; fatigue tests; random decrement analysis.

The problem of detecting crack in bridge structures is studied with the use of Random Decrement analysis. Fatigue tests were performed on several 3300 mm steel beams using the program controlled load simulator at the Institute of Metal Construction, EPFL, Switzerland. Inputs to the simulator were obtained from actual measurements from various traffic patterns throughout Switzerland. A special technique utilizing pre-stressed thin wires mounted on the specimen was used to detect the initiation of crack in the specimen. The breakage of the wire automatically stops the simulator. Crack propagation resistance gages were then mounted on the specimen to monitor the growth in the size of the crack as the test is continued.

Accelerometers were attached to the specimen and responses were recorded periodically before and after the initiation of crack. These time history responses were used as inputs in the Random Decrement method to obtain the Random Decrement signatures. The change in shape of the signatures was correlated and compared to the experimentally determined crack initiation and growth to test the ability of the Random Decrement method to detect and monitor an unknown crack from the random data.

SP652; 1983 April. 79-92. Gross, A. **Railroad long-term maintenance-of-way planning technique development program.**

Key words: maintenance-of-way; track deterioration; track geometry; track maintenance planning; track quality indices; track safety research.

This paper describes the cooperative Federal Railroad Administration (FRA)-Conrail research program to develop techniques for long-term track maintenance planning that will better utilize the limited maintenance-of-way (MOW) resources and improve the quality of rail service and overall track safety. This research program makes use of FRA's track geometry cars and other related data (traffic, physical, maintenance) to determine track degradation and develop analytical techniques for planning expenditures for track maintenance.

SP652; 1983 April. 93-131. Manos, W. P.; Shang, J. C.; Raidt, J. B. **Analytical investigation of lading responses from various pulse shapes.**

Key words: end-wall forces; impulse input wave forms; lading dynamics; lading flexibility and looseness with floor friction.

The dynamic response of lading and the maximum end-wall forces from variously shaped input pulses in a struck railroad freight car were analyzed. Five different pulse shapes: rectangular, three triangular, and a half sine wave were investigated for cases where the coulomb friction between the lading and the car floor, and the lading looseness, i.e., backlash, were considered. Equal impulses, of magnitude: $I = \int_o t_l F_b(t)dt$, were chosen as the comparison criteria.

The maximum lading response and the maximum end-wall forces from the lading to various pulse shapes were compared using both compressive force and period ratios. The investigation did not intend to find any optimum car cushioning characteristics, but attempted to show the effects of floor friction and lading looseness on the maximum end-wall forces for each input pulse shape, when plotted as a function of lading stiffness. The results showed that rectangular pulse shapes do not always produce the lowest maximum end-wall forces for all conditions of lading stiffness, lading looseness and floor friction.

The results for the nondimensional, maximum lading forces from rectangular input pulses, as a function of period ratio were shown to compare very well with those obtained using the phase plane delta method. For the other input pulses, the computer solutions were compared with the analytical solutions for zero floor friction and lading looseness.

SP652; 1983 April. 132-145. Richardson, J. J. **System for train accident reduction—DOT STAR.**

Key words: bearing thermal sensor; DOT STAR; journal and roller bearing temperature transients; local derailment sensor; NITINOL; railroad safety system.

The Department of Transportation-System for Train Accident Reduction (DOT STAR) study at the Naval Surface Weapons Center (NSWC) is developing a prototype system to help reduce the number of train accidents. NSWC has taken military technology and applied it to develop an on-train anti-derailment system. This system can sense a local derailment or a hot bearing. Upon sensing these conditions, the system automatically applies emergency braking.

Exploratory development hardware of the journal bearing thermal sensor successfully completed over 100,000 miles of travel. A roller bearing thermal sensor has also been designed. NITINOL is the key component used to sense over-heated bearings. The derailment detector uses the impact of a sensor foot with the rail head to sense a local derailment. Upon generation of a hot box or a local derailment, the sensors initiate a thermal pulse battery. The electrical pulse activates the air-valve which applies the train's brakes. To foster the success of the DOT STAR concept highly reliable, rugged and maintenance free military-developed components are being used. This document

provides an overview of the DOT STAR program followed by a more detailed presentation of technical aspects of the sensors.

SP652; 1983 April. 149-157. Orth, C. L.; Kachadourian, G. **Freight car response analysis and test evaluation model (FRATE).**

Key words: dynamic loads; freight car dynamic response; freight car model; hunting simulation.

This paper gives an overview of the computer model, FRATE, which simulates the dynamic responses of a 70-ton boxcar to various track conditions. The FRATE model can, using over-the-road input motions, define the response displacements, accelerations, and loads of the freight car. A recent test utilized an actual 70-ton boxcar on the Vibration Test Unit at the Transportation Test Center, Pueblo, Colorado, to collect data for validating this model. The preliminary results will be presented here.

SP652; 1983 April. 158-164. Meeker, W. G. **The accident performance of tank car safeguards.**

Key words: coupler design; heat punctures; tank car safeguards.

SP652; 1983 April. 165-171. Dancer, D. M. **Rail tank car impacts.**

Key words: metallurgy; nondestructive testing; puncture prevention; structural integrity.

This paper describes the Federal Railroad Administration's research efforts to mitigate the consequences of impacts to rail tank cars.

SP652; 1983 April. 172-178. Mirabella, J. V. **A locomotive evaluator—New research capability through simulation.**

Key words: locomotive engineer; railroad safety; simulation; train handling; training.

The Locomotive Evaluator, presently being developed by the Federal Railroad Administration, is reviewed in terms of the basic difference in approach between a "research evaluator" and a "training simulator." The new research capabilities which will be possible with an advanced, real-time train action model combined with human input in a realistic environment are discussed along with the potential for improvements in both safety and efficiency.

SP652; 1983 April. 181-212. Phillips, E. A. **Designing for damage prevention in the railroad tank car industry.**

Key words: damage prevention; hazardous materials transportation; railroad tank cars; safety research.

This paper describes a cooperative industry project between the railroads and the major tank car companies that has had the objective of improving the safety of tank cars in accidents. The project was established in 1970 following a sudden rash of castastrophic accidents. Organized to study all aspects of tank car design, the project sought to find cost effective changes that would reduce the probability of tank car punctures and fire induced ruptures in the accident environment. Work was divided into 18 technical phases, a major one of which was the collection of accident data to develop a solid base upon which to evaluate potential "solutions." In many areas, work was carried out cooperatively with the Federal Railroad Administration which also had ongoing research with the same objectives.

This paper describes the various phase activities and the major results of the research. One has been the retrofitting of 22,000 liquified compressed gas tank cars with special (shelf) couplers to reduce the severity of jackknifing and the potential for head punctures. Another has been the application of head puncture protection (head shields) on the same cars and the application of fire retardant insulation to 19,000 of the cars. Means also were developed for protecting bottom fittings from being torn off when cars slide along the ground after being detrucked. The project still continues with major effort comprising accident data collection and evaluation of the need to improve the safety of other type cars.

SP652; 1983 April. 213-218. Vickerman, W. A.; Godshall, W. D. **Performance testing to reduce loss and damage.**

Key words: bracing; impact tests; loading; packaging; performance testing; shipping containers; unitizing.

Performance testing of shipping containers can help reduce loss and damage by increasing the efficiency of package development. The cumulative effect of successive handlings can be predicted in the laboratory. This insures a higher probability of success during test shipments in the field.

SP652; 1983 April. 219. Sneed, W.; Zarembski, A. M. **Field measurement of the fatigue loading environment for railroad freight equipment.**

Key words: fatigue loading environment; loading input; railroad freight equipment.

Railroad freight equipment in North America operates in a broad range of conditions for up to four decades. Consequently, the equipment must be capable of surviving long term, fatigue inducing loading in addition to short term structural loads.

In order to adequately design for fatigue life, a thorough knowledge of the loading environment that revenue freight traffic experiences during its lifetime is necessary. To obtain this information, a test program was developed to measure loading input into the freight car structure during over-the-road revenue service for extended periods of time.

The program used a stratified random sampling technique to develop statistically valid representation of the loading and utilized a self contained portable data acquisition system to record and store the measured load levels. It is the purpose of this paper to describe both the data sampling techniques developed to define representative load environments, and the actual measurement system and hardware used to obtain the specific load data.

SP652; 1983 April. 223-237. Lamoreaux, G. H.; Trujillo, A. A.; Magnuson, C. F. **Truck and rail shock and vibration environments during normal transport.**

Key words: cargo tie-down design guide; over-the-road/rail dynamic measurements; rail car coupling tests; shock and vibration data; transportation environments for radioactive material shipping containers.

The Sandia National Laboratories Transportation Technology Center (SNL/TTC) provides technical management and support for programs which span a broad range of technical problems related to the transport of nuclear materials.

As part of this program, SNL has obtained data on the shock and vibration experienced by large shipping casks during normal transport. These data were initially generated under contract to the U.S. Nuclear Regulatory Commission (NRC) by: 1) Extracting, reviewing, and reducing the shock and vibration environment definitions on fire in the DOE/DOD and DOE Transportation Data Banks; 2) Determining the best estimates of the environments for large shipping containers on trucks and railroad cars; 3) Defining and conducting tests to obtain any additional data required; 4) Conducting dynamic analyses of the shock environment experienced by cargo during rail switching and coupling to identify the dependence of the shock environment on heavy cargo weights and on shock attenuation couplers; and, 5) Using the results to refine the estimates of the shock load description.

As part of the follow-on activity at the TTC, sponsored by the U.S. Department of Energy, two approaches for using the data to estimate the shock and vibration environments were investigated. The first is a shock spectra approach which assumes that there is a single-degree-of-freedom dynamic interaction between the cask, tie-downs, and vehicle bed. The second, or direct measurement approach, assumes that the cask is rigidly attached to the vehicle bed and consequently, for low frequency excitations, no such interaction takes place. Based upon the results of these activities, the need for additional data was identified and tests were planned to obtain the required data. Details and results of the overall program are presented.

SP652; 1983 April. 238-246. Emerson, E. L.; McClure, J. D. **The nature of transportation accidents involving radioactive material packagings.**

Key words: accident; data base; failure; handling accidents; hazardous materials; HMIR's; packaging; radioactive material; radioactive material transportation; radioactive material transportation accidents; radioactive material transportation analysis; radioactive material transportation incidents; transportation; vehicle.

This paper analyzes the transportation accidents and incidents which have occurred in the United States in the period 1971–1980 based upon the information in the Radioactive Material Transportation Accident/Incident Data Base developed by the Transportation Technology Center (TTC) at Sandia National Laboratories. Principal sources of this information are the Hazardous Material Incident Reporting system of the U.S. Department of Transportation and information from the files of the U.S. Nuclear Regulatory Commission (NRC). Detailed statistics are provided for transportation accidents, handling accidents, package types involved and material transported.

SP652; 1983 April. 247-260. Reese, R. T.; Shepherd, E. W. **Perceived safety of transporting hazardous materials.**

Key words: hazardous materials; risk assessment; transportation.

SP652; 1983 April. 261-278. Yoshimura, H. R.; Huerta, M. **Analysis, scale modeling, and full-scale testing of shipping containers for radioactive materials.**

Key words: computer analysis; finite element analysis and full scale testing; impact tests; lumped parameter analysis; physical scale modeling; radioactive materials transportation; spent fuel; spent fuel cask.

This paper will discuss techniques for predicting the structural response under accident conditions of shipping containers designed for the transportation of radioactive materials. The techniques include numerical analysis methods as well as physical scale modeling. These methods will be discussed with some examples, and comparisons will be made between analysis results and those of full-scale tests conducted subsequent to the analyses.

SP652; 1983 April. 279-287. May, R. A.; Lamoreaux, G. H.; Romesberg, L. E.; Yoshimura, H. R. **Response of radioactive material waste drums to accident environments.**

Key words: accident environments; accident response; computer analysis; contact-handled transuranic waste; scale model testing; Type A containers; 55 gallon drums.

Using computer analyses, subscale model tests, and selected full scale tests, it is possible to predict the structural behavior of 208 liter (55 gal) drums resulting from accident environments. This was verified by analyzing and testing DOT-17C drum arrays containing simulated contact-handled transuranic waste (CH-TRU) in simulated accident environments.

This paper briefly describes the results of the static and dynamic tests using full scale 17C drums and compares them to the results obtained from subscale tests and computer analyses. Methods of eliminating or minimizing the damage to the drums are mentioned. More detailed information can be found in Ref. [1].

SP652; 1983 April. 288-302. Romesberg, L. E.; Sutherland, S. H.; Lamoreaux, G. H.; Eakes, R. G. **Design of packaging for transporting transuranic contaminated wastes.**

Key words: contaminated wastes; transuranic; waste packagings.

Contact-handled transuranic (CH-TRU) waste continues to be generated and temporarily stored at a number of locations in the United States as a by-product of national defense programs. The Transportation Technology Center at Sandia National Laboratories has assumed the lead lab responsibility for development of safe, efficient, licensable, and cost-effective transportation systems to be used in the management of this waste. The *TR*ans*U*ranic *PAC*kage *T*ransporter (TRUPACT), a Type B packaging, will be transported by rail or truck and will be compatible with Type A packagings used by waste generators, interim storage sites, and repositories. Developing an efficient interface with each facility is being given a high priority.

SP652; 1983 April. 305-307. Cantilli, E. J.; Rossini, D. **Planning to prevent failure in the transportation of hazardous materials.**

Key words: hazardous materials; transportation of hazardous materials; transportation system safety.

The prevention and mitigation of consequences in the transportation of hazardous materials are discussed. Efforts in the mitigation, or "emergency response" aspects, are over-emphasized at the expense of preventive efforts.

Planning for the prevention of incidents requires two areas of effort: knowledge of past failures, and a preventive outlook in design, construction, operation, and maintenance. There is a general lack of data base for preventive efforts. Incident information is usually used solely for training emergency response personnel.

An example is discussed, that of the George Washington Bridge incident of August 7, 1980. Why a valve failed. Why it took . purest chance and coincidence—to solve such a potentially catastrophic situation. An example of how little questioning there was of valves or other components of vehicles or guideways, in all the transport modes. The problems of moving hazardous materials in bulk form, a major problem on the railroads. Derailment, turnover, puncture as a common sequence. The application of limited solutions: shields as crutches. Ignoring the systems approach. The need for a system-wide approach ("Transportation System Safety") in planning, based on feedback from construction, testing, operations (incidents) and maintenance. The need for original, specific designs for each special purpose.

SP652; 1983 April. 308-324. Forton, C. R. **Cargo ride evaluation on a road simulator.**

Key words: effective road; frequency domain; frequency response function (FRF); power spectral density (PSD); spatial PSD; system resonances; temporal PSD; time domain.

A combination vehicle such as a tractor-semi-trailer is a dynamic system which responds to road surface irregularities. When the natural frequencies of the system coincide with the road frequencies, near resonant conditions exist which might result in cargo damage or driver fatigue or both. A technique is presented in this paper where a road simulator is used to compare the effects of road surface, speed, and suspension on ride and trailer floor accelerations.

Fruehauf Road Simulator is a tire actuated electrohydraulic system where real roads can be simulated under controlled conditions. The spindle accelerations are measured on the road. The transfer function between the tires and spindles are measured on the road simulator. Then, by a compensation technique, the effective road profile can be calculated. When the trailer is excited with this effective road profile, the response of it will be similar to that on the road.

Once the effective road profile of a representative road surface is obtained, it could be used to study the effects of speed, loading conditions, suspension design and wheel base on ride and cargo accelerations.

At present, there is no universal specification for maximum acceleration on cargo. The reason for this may be because there are infinite variations in loading locations, speed, road surface and cargo mounts. As an indication of the dynamic environment to which the cargo will be subjected, the PSD of the vertical accelerations of the floor at various locations are calculated from acceleration response. Again, the effects of modification, including load location, can be easily studied.

Thus, the road simulator could be effectively used to compare various design changes in terms of cargo accelerations under controlled conditions in the laboratory.

SP652; 1983 April. 325-329. McCarthy, B. M. **Highway design and maintenance for tomorrow's traffic.**

Key words: asphalt concrete; California Bearing Ration (CBR); DAMA; design period; Equivalent Axle Load (EAL); highway system; pothole; rehabilitation; resilient modulus (M_r).

The condition of the roadway surface plays a significant role in preventing damage to cargo and to increasing safety in the shipment of goods by ground transportation. Increasing traffic volumes and loads have led to changes in pavement design concepts to adequately handle the increased stresses occurring in the roadway. Additionally, because of these increased stresses, proper preventive maintenance has become a major concern of highway engineers. This problem is complicated by the rapid rise of inflation and declining revenues available for pavement maintenance which has resulted in the highway system deteriorating at an alarming rate in recent years. It will be shown that programmed maintenance that includes timely resurfacing before rapid deterioration begins will extend the pavement life more economically than in the case where pavement resurfacing is delayed. The consequences of deferred action are increased fuel costs, increased operator costs, increased damage to cargo, increased safety problems, rerouting of commercial traffic and general user dissatisfaction. A pavement management system is essential if we are to obtain the most efficient use of the highway dollar and establish those roads in immediate need of repair.

SP652; 1983 April. 330-341. Ervin, R. D. **The failure of manhole covers on tank trailers during rollover.**

Key words: fire; fuel spillage; manhole cover; rollover; tank trucks.

Accidents involving the rollover of bulk petroleum transport tankers in Michigan have frequently involved the wholesale failure of the manhole cover assemblies mounted at the top of the tank. Such failures result in the rapid spillage of large quantities of liquid and, often, are the occasion of large fires. This paper describes a research effort by which the pertinent accident experience was defined and full-scale rollover experiments conducted to establish the mechanisms by which manhole cover failures occur. Results show that the internal fluid pressures prevailing inside the tank vessel at the moment of ground impact are three to five times higher than the pressure level currently specified in Federal regulations which mandate the proof testing of manhole cover assemblies. Recommendations are made for a type of proof test which would assure the level of manhole cover strength needed to prevent failure.

SP653. Phillips, W. D., ed. **Laser-cooled and trapped atoms.** Proceedings of the Workshop on Spectroscopic Applications of Slow Atomic Beams held at the National Bureau of Standards; 1983 April 14-15; Gaithersburg, MD. *Natl. Bur. Stand. (U.S.) Spec. Publ. 653;* 1983 June. 172 p. SN003-003-02494-5.

Key words: atom traps; clocks; cooled atoms; frequency standards; high resolution spectroscopy; ion traps; laser cooling; laser deceleration; laser traps; optical frequency standards; slow atomic beams.

The proceedings of the Workshop on Spectroscopic Applications of Slow Atomic Beams contain papers on laser cooling of atomic beams, gases, and trapped particles and papers on trapping of neutral atoms in laser, electric, and magnetic fields. These and other papers discuss possible applications of cooled atoms to spectroscopy and to time and frequency standards. The present status and directions of research in time and frequency standards is also discussed. *These proceedings include the following papers (indented):*

SP653; 1983 June. 1-8. Phillips, W. D.; Prodan, J. V.; Metcalf, H. J. **Neutral atomic beam cooling experiments at NBS.**

Key words: frequency standards; high resolution spectroscopy; laser cooling; laser trapping; slow atomic beam.

We have decelerated and cooled a neutral atomic sodium beam using a near resonant, counterpropagating laser beam. A spatially varying magnetic field compensates for the changing Doppler shift as the atoms decelerate, keeping the atoms in resonance with the laser. We have observed final velocities as low as 40 m/s, or about 25 times slower than the initial thermal velocity. By compressing the atomic velocity distribution we have increased the atomic density per unit velocity by as much as a factor of 30 over that of the thermal distribution.

SP653; 1983 June. 9-18. Stein, S. R. **The design of atomic frequency standards and their performance in specific applications.**

Key words: atomic clocks; frequency standards; navigation; secure communications.

The reduction of timing errors in atomic clocks is shown to be important for secure communications and navigation. An approach based upon control of all systematic frequency shifts and a reduction in both the first order Doppler shift and confinement effects is recommended. Ion storage is a promising technique because of its ability to achieve extremely long observation times, negligible confinement perturbations, and laser cooling. The applicability of atom cooling should be evaluated.

SP653; 1983 June. 19-26. Wineland, D. J.; Itano, W. M.; Bergquist, J. C.; Bollinger, J. J.; Hemmati, H. **Frequency standard research using stored ions.**

Key words: atomic clocks; atomic spectroscopy; frequency standards; high resolution spectroscopy; laser spectroscopy.

We summarize research undertaken to develop time and frequency standards based on stored ions. The ion storage method for high resolution spectroscopy is also briefly compared to the methods for stored neutrals and slow atomic beams.

SP653; 1983 June. 27-37. Evenson, K. M.; Jennings, D. A.; Petersen, F. R.; Wells, J. S.; Drullinger, R. E. **Optical frequency synthesis spectroscopy.**

Key words: iodine; optical frequency synthesis (OFS); optical spectroscopy.

In order to measure the super narrow spectral features of cooled atoms and ions, in the optical region, optical frequency synthesis (OFS) techniques rather than wavelength techniques must be used. It is anticipated that many of these resonances will be in the optical region of the spectrum, and this paper will address the state-of-the-art of the measurements of frequencies in that region. Two recent optical frequency measurements of iodine transitions in the visible will be described as well as recent improvements in fabricating the point-contact diode used in these measurements.

SP653; 1983 June. 38-46. Lewis, L. **Limitations of atomic beam frequency standards.**

Key words: atomic beams; atomic frequency standard; cooled atoms; optical pumping.

Atomic beam frequency standards may be placed into two categories: field standards and laboratory standards. While this distinction is somewhat artificial, because the two types of standards are interdependent, each category does have different requirements of accuracy, size, and cost. Despite this separation, generally the developments which produce the best laboratory standards eventually give rise to improved field standards. Existing field standards are limited in long term fractional frequency stability to $\sigma_y(\tau) \sim 3 \times 10^{-13}$, for $\tau \sim 6$ months. A laboratory standard such as NBS-6, the U.S. primary cesium standard, is limited in inaccuracy to $\Delta y \sim 8 \times 10^{-14}$. Proposed new cesium field standards are expected to yield long term stabilities of $\sigma_y(\tau) \sim 1 \times 10^{-14}$ ($\tau = 6$ months). Stored ion standards, prime candidates for new laboratory frequency standards, are expected to have better than $\Delta y = 1 \times 10^{-15}$ inaccuracy. As other approaches to atomic beam frequency standards are considered, they should attempt to compete favorably with these emerging technologies.

SP653; 1983 June. 47-52. Hemmer, P. R.; Ezekiel, S.; Leiby, C. C., Jr. **Stabilization of a microwave oscillator using a resonance Raman transition in a sodium beam.**

Key words: microwave oscillator; resonance Raman transition; sodium beam.

Preliminary results of stabilization of a 1772 MHz oscillator to a resonance Raman transition in an atomic beam of sodium are presented. Short term stability of 5.6×10^{-11} ($\tau=100$s) for a 15 cm interaction region separation has been achieved. Sources of frequency drift are briefly discussed.

SP653; 1983 June. 53-58. Mittleman, M. H. **The force on an atom in a laser and D.C. field.**

Key words: D.C. field; deflection of atoms.

The deflection of an atom depends upon the coupling of the field to the internal motion of the atom. This internal motion can be profoundly altered by a laser field so the deflection can depend upon the laser intensity and frequency. The force that an atom experiences in a combined D.C. and laser field is reviewed. The fluorescence of the atom is shown to play an important role.

SP653; 1983 June. 59-67. Metcalf, H. J. **Magnetic trapping of decelerated neutral atoms.**

Key words: cooling; precision spectroscopy; trapping.

A scheme is proposed for trapping atoms having finite magnetic moments using inhomogeneous magnetostatic fields. Fields of ~0.1 T can be used to contain atoms decelerated to v~few m/s. Application to the NBS decelerated atom project is discussed.

SP653; 1983 June. 68-73. Gordon, J. P. **The motion of neutral atoms in a radiative trap.**

Key words: neutral atoms; radiative trap.

A number of proposals have been made in recent years for the cooling and/or trapping of neutral atoms in a near-resonance optical radiation field. As we have heard in this workshop, substantial slowing and cooling of an atomic beam has already been achieved. Making a trap is a more difficult problem; so far the only neutral atom traps are on paper. The possibility of success of such a trap depends on two factors; first, the creation of the necessary force field, and second, the ability to cool the atoms sufficiently that they stay contained. Our overall conclusions are that a harmonic oscillator model atom can be trapped successfully, whereas a two-level atom cannot. In the case of a real atom such as sodium, a successful trap must involve at least three levels and three radiation fields of different frequencies.

SP653; 1983 June. 74-93. Wing, W. H. **Some problems and possibilities for quasistatic neutral particle trapping.**

Key words: atomic hydrogen; cooling; electric and magnetic fields; high-resolution spectroscopy; neutral atoms; polar molecules; positronium; Rydberg atoms; trapping.

Some basic considerations regarding the confinement of bound neutral systems of particles in limited regions of space by slowly varying electromagnetic fields are reviewed. Electrostatic traps are described, spectroscopic linewidth is discussed, and several specific cases are described briefly. Use of a light field to lengthen the trapping time of decaying states is proposed. A universal refrigeration system utilizing trapped ions is presented, and its utility for cooling neutrals as well as other charged particles is discussed.

SP653; 1983 June. 94. Wing, W. H. **Gravitational effects in particle traps.**

SP653; 1983 June. 95-102. Stwalley, W. C. **A hybrid laser-magnet trap for spin-polarized atoms.**

Key words: atom trap; laser; low temperature; magnetic field; neutral atom; spin-polarized atom; trapping.

This paper presents a brief survey of theoretical issues related to a hybrid laser-magnet trap for neutral spin-polarized atoms. At low densities, such a trap might be used to address a number of fundamental questions, e.g., the interaction of an individual atom with an electromagnetic field, while at high densities it might be used for "containerless" preparation of bulk amounts of a new metastable form of matter, spin-polarized atoms. In particular, a discussion is presented of the feasibility and limitations of a trap based on a near-resonant CW TEM ("doughnut mode") laser beam, which provides trapping in two dimensions, and on a strong homogeneous solenoidal magnetic field (the axis of which is also the laser axis), which provides trapping in the third dimension.

SP653; 1983 June. 103-111. Pritchard, D. E. **Good and bad aspects of traps for neutral particles.**

Key words: magnetic fields; neutral particles.

SP653; 1983 June. 112-118. Giacobino, E.; Berman, P. R. **Cooling of vapors using collisionally aided radiative excitation.**

Key words: collisions; cooling; laser assisted collisions; resonant broadening.

Collisionally aided radiative excitation (CARE) is proposed as a mechanism for cooling an atomic vapor. With a CW laser power of 1.0 W/cm^2 and the resonant dipole-dipole interaction providing the collision mechanism, we estimate that temperature gradients of tens of degrees per cm can be achieved at vapor densities of order 10^{16} atoms/cm^3.

SP653; 1983 June. 119-124. Rubin, K.; Lubell, M. S. **A proposed study of photon statistics in fluorescence through high resolution measurements of the transverse deflection of an atomic beam.**

Key words: fluorescence; photon statistics; transverse deflection; transverse laser beam.

Information about the photon statistics in fluorescence can be obtained from the study of the variance in the angular deflection of a beam of atoms interacting with a transverse laser beam. The quantity of interest, $Q=(\Delta n^2-n)/n$, is a measure of the departure of the photon statistics from a Poisson distribution, where n is the mean and Δn^2 is the variance of the number of photons emitted by a "two-level" atom. We demonstrate in this paper that our existing apparatus has sufficient resolution to make a statistically significant measurement of Q.

SP653; 1983 June. 125-136. Lubell, M. S.; Rubin, K. **Velocity compression and cooling of a sodium atomic beam using a frequency modulated ring laser.**

Key words: atomic beams; dipole radiation force; laser-cooling.

A thorough understanding of the effects associated with velocity compression and cooling of atomic beams through laser-atom interactions requires a detailed study of the dipole radiation force. Such a study can be carried out with the use of a high-resolution atomic beam apparatus and a frequency-swept ring laser employed in a counter-propagating colinear laser-atom beam geometry. The principles of the proposed experimental program are discussed as well as directions for future research.

SP653; 1983 June. 137-141. Prodan, J. V.; Phillips, W. D. **Chirping the light—Fantastic? Recent NBS atom cooling experiments.**

Key words: atomic beam velocity modification; frequency scanning; high resolution spectroscopy; laser cooling.

We have successfully decelerated and cooled a neutral atomic sodium beam using a counter-propagating laser beam tuned nearly resonant with the D_2 transition. In order to compensate for the changing Doppler shift as the atoms slow down, the laser frequency was rapidly scanned or "chirped." We have observed final velocities of 6×10^2 m/s, or about 0.5 of the initial velocity. As of yet we have not been able to cool a significant number of atoms to lower velocities.

SP653; 1983 June. 142-153. Blatt, R.; Ertmer, W.; Hall, J. L. **Cooling of an atomic beam with frequency-sweep techniques.**

Key words: atomic beam velocity distributions; laser spectroscopy; radiative cooling.

We review the ideas of velocity-modifying an atomic beam by resonant scattering of intense light from a frequency-swept laser source. Some of the realistic parasitic effects, particularly fluctuations and residual transverse heating are considered. A computer Monte-Carlo simulation program is described which provides encouragement and insights useful in the design of a real atomic beam apparatus. We describe a new rf/optical modulation method to generate the desired laser optical frequency and intensity profiles versus time. This digital method provides the necessary sweep accuracy and program flexibility in a convenient and powerful way.

SP653; 1983 June. 154-161. Ertmer, W.; Blatt, R.; Hall, J. L. **Some candidate atoms and ions for frequency standards research using laser radiative cooling techniques.**

Key words: laser stabilization; optical frequency standards; radiative cooling.

The rapid progress in laser atomic cooling ideas and also in laser spectral coverage and frequency stabilization make it appropriate to reexamine the periodic table for atoms and ions that may be of special interest for radiatively-cooled frequency standards research. We discuss Hg^+, Pb^+, Ba^+, neutral alkalis, Mg, Ca, and Ag. Optical two-photon and weak single-photon transitions are represented, along with microwave hfs and fs transitions.

SP653; 1983 June. 162-165. Greene, G. L. **Trapping of low energy neutrons.**

Key words: hexapole; trapping; ultra cold neutrons.

A brief review of recent work concerning the trapping of low energy neutrons is given. Particular emphasis is placed on magnetic confinement schemes which might also be applicable to neutral atoms. Important differences between the neutron and neutral atom cases are mentioned.

SP654. Hall, W. **NVLAP sixth annual report and directory of accredited laboratories.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 654;* 1983 September. 63 p. SN003-003-02517-8.

Key words: accredited laboratories; laboratory accreditation process; laboratory accreditation programs.

This annual report of the National Voluntary Laboratory Accreditation Program (NVLAP) is prepared in accordance with NVLAP Procedures (Title 15 CFR Parts 7a, 7b, and 7c). Part I summarizes significant activities, including program changes, accreditation actions and ongoing discussions concerning laboratory accreditation on the national and international levels. Part II is a directory of laboratories currently accredited on behalf of the Secretary of Commerce.

SP655. Westley, F. **Ozone reactions in aqueous solutions—A bibliography.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 655;* 1983 August. 22 p. SN003-003-02518-6.

Key words: aqueous solution; bibliography; chemical kinetics; decomposition; mechanism; oxidation; ozone; rate constant; reaction.

A reaction oriented list of references is provided for published papers and reports containing rate data or information on mechanism for reactions of ozone with various substrates in aqueous solutions. Catalyzed, as well as uncatalyzed, reactions are included. One hundred and sixty-four papers are listed. The period covered extends from 1913 to 1981.

SP656. Zeisler, R.; Harrison, S. H.; Wise, S. A., eds. **The Pilot National Environmental Specimen Bank—Analysis of human liver specimens.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 656;* 1983 August. 135 p. SN003-003-02508-9.

Key words: atomic absorption spectrometry; cryogenic homogenization; gas chromatography; human liver; inorganic analysis; isotope dilution mass spectrometry; neutron activation analysis; organic analysis; organochlorine pesticides; specimen banking; trace elements; voltammetry.

This work was performed under a joint EPA/NBS research program to develop state-of-the-art protocols for the sampling, storage, and analysis of biological and environmental-type matrices as part of a Pilot National Environmental Specimen Bank program. The purpose of this report is to summarize the experience and results obtained for the first sample type, human liver. The sample collection protocol was evaluated with respect to costs and suitability of donor selection criteria. An analytical protocol was implemented for the determination of trace elements in the liver samples using the techniques of atomic absorption spectrometry, isotope dilution mass spectrometry, neutron activation analysis, and voltammetry. Individual sections of this report describe in detail the procedures used and the results obtained for each of these analytical techniques. The analytical results for the determination of 31 trace elements in 36 liver specimens are presented and discussed. Analytical methodology for the measurement of organochlorine compounds is also described.

SP657. Chapman, R. E.; Berman, E. B. **The resource recovery planning model: A new tool for solid waste management.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 657;* 1983 July. 198 p. SN003-003-02495-3.

Key words: economic analysis; facility location; fixed-charge problem; mathematical programming; optimization; resource recovery; solid waste management.

The Resource Recovery Planning (RRPLAN) model is designed with three purposes in mind. First and foremost, is the ability to generate a preferred plan for resource recovery. Second is the capability to evaluate a scenario specified by the decision maker for technical and economic feasibility. Third is its use as a tool to facilitate the decision making process by providing answers to many what-if questions through an in-depth sensitivity analysis. This report presents a nontechnical discussion of the RRPLAN model. The basic philosophy behind the model is one of optimization. This approach was taken because it permits the economic and engineering data associated with the problem (e.g., waste generation rates and the location of processing facilities) to be organized in an objective manner. Although the model can focus on energy as its main objective, the minimization of the costs of processing a region's solid waste stream is believed to be the objective most often emphasized by decision makers. An example based on this objective is critically analyzed and used to illustrate how the model would be applied in practice.

SP658. Lew, H. S., ed. **Wind and seismic effects.** Proceedings of the 11th Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources; 1979 September 4-7; Tsukuba, Japan. *Natl. Bur. Stand. (U.S.) Spec. Publ. 658;* 1983 July. 755 p. SN003-003-02506-2.

Key words: accelerograph; codes; design criteria; disaster; earthquakes; ground failures; hazards; seismicity; solids; standards; structural engineering; structural responses; tsunamis; wind loads; winds.

The Eleventh Joint Meeting of the U.S.-Japan Panel on Wind Seismic Effects was held in Tsukuba, Japan on September 4-7, 1979. The proceedings of the Joint Meeting include the program, the formal resolution and the technical papers. The subjects covered in the paper include (1) the engineering characteristics of wind, (2) the characteristics of earthquake ground motions, (3) the earthquake response of structures, (4) the wind response of structures, (5) recent design criteria against wind and earthquake disturbances, (6) the design and analysis of special structures, (7) the evaluation, repairing, and retrofitting for wind and earthquake disaster, (8) earthquake disaster prevention planning, (9) storm surge and tsunamis, and (10) technical cooperation with developing countries. *These proceedings include the following papers (indented):*

SP658; 1983 July. 1-14. Thiel, C. C. **New initiatives in earthquake hazards mitigation.**

Key words: earthquake mitigation; post-earthquake recovery activities; seismic design; seismic safety;

Under the National Earthquake Hazards Reduction Program a number of significant steps have been taken to improve national earthquake mitigation policies and practices. The recently established Earthquake Hazards Reduction Coordination Group within the Executive Office of the President, is coordinating a

number of efforts to improve building practices, land use, insurance, preparedness, emergency response and post-earthquake recovery activities. An "Interagency Committee on Seismic Safety in Construction" has been established to: develop seismic design and construction standards for Federal projects; develop guidelines to ensure serviceability following an earthquake of vital facilities constructed or financed by the Federal government; and develop guidelines that provide independent and State and local review of seismic considerations in the construction of critical facilities constructed and financed by the Federal government, where appropriate.

In a collateral activity a "Building Seismic Safety Council" has been formed within the private sector to enhance the public safety by providing a national forum to foster improved seismic safety provisions for use by the building community. The scope of the Council's activities encompasses seismic safety of building-type structures with explicit consideration and assessment of the social, technical, administrative, political, legislative, and economic implications of its deliberations and recommendations.

SP658; 1983 July. 15-21. Leyendecker, E. V.; Harris, J. R.; Wright, R. N.; Pfrang, E. O. **Earthquake hazard reduction research at the National Bureau of Standards.**

Key words: earthquake hazard reduction; earthquake-resistant construction; National Bureau of Standards; seismic design.

Current and planned Earthquake Hazard Reduction programs at the National Bureau of Standards in Research and Standards Development are being conducted in order to achieve the responsibilities assigned to NBS under the President's National Earthquake Hazards Reduction Program. These responsibilities, to: 1) provide technical support to the building community in the development of seismic design and construction provisions for building codes and national standards; 2) provide technical support to the Federal agencies in development of seismic design and construction provisions for Federal programs; and 3) perform research on performanc criteria and supporting measurement technology for earthquake-resistant construction; are being carried out in cooperation with the Federal and private sectors. This research is complementary to that of the National Science Foundation (NSF) and U.S. Geological Survey (USGS).

SP658; 1983 July. 23-45. Okubo, T. **On the U.S.-Japan cooperative program of large-scale testing.**

Key words: large-scale testing; U.S.-Japan Joint Earthquake Research Program; wind and seismic effects.

The Implementing Arrangement between the Science and Technology Agency (STA) and the Ministry of Construction (MOC) of Japan and the National Science Foundation (NSF) of the U.S.A. for cooperation in the U.S.-Japan Joint Earthquake Research Program involving Large-Scale Testing, under the auspices of the Panel on Wind and Seismic Effects of the UJNR was signed by Mr. Nobuo Kozu (STA), Mr. Hidenobu Takahide (MOC) and Dr. Jack T. Sanderson (NSF) on August 10, 1979.

The U.S.-Japan Cooperative Program on Large-Scale Testing was initiated in 1974 by this Panel and has begun implementation. In this presentation, the author outlines the Program.

SP658; 1983 July. I-1–I-15. Uchida, E.; Fujiwhara, S.; Tatehira, R.; Tabe, I.; Ohtsuka, K. **Modeling the 1978 Tokyo Tornado that overturned the Tozai subway train.**

Key words: meteorological elements; tornadic cyclone; tornado elements; 1978 Tokyo tornado.

A high wind developed in the evening of February 28, 1978, over areas from Kawasaki City (Kanagawa Prefecture) to Kamagaya City (Chiba Prefecture). The wind caused extensive damage (for example, overturning the Tozai subway train, houses, cars, vessels etc.)

Judging from weather conditions which were detailed by data from weather maps, automatic records of wind direction and speed, of air pressure, radar echo patterns, AMeDAS data, and disaster distributions, we envisage that this high wind was associated with a tornado formed within a tornadic cyclone having $5 \sim 6 \times 10$ km diameter.

We estimate that this tornado was generated within a converging and unstable area near a squall line preceding a cold front, the diameter of the tornado core is estimated as $100 \sim 200$ m (radius $50 \sim 100$ m), the maximum wind velocity $60 \sim 80$ m/s and the propagation speed 25 m/s.

A numerical simulation experiment was carried out in relation to meteorological elements of the tornado (core radius, the maximum-wind velocity, propagation speed) under an assumption of a single tornado having a straight path and a uniform velocity. The most adaptable values of tornado elements, in regard to the kinematical analysis of the overturned train were located within $75 \sim 100$ m in core radius, $70 \sim 80$ m/s in maximum-wind velocity and $25 \sim 35$ m/s in propagation speed.

These results from the engineering aspect nearly coincide with those of the estimated values and the reliability of this model was thereby roughly verified.

SP658; 1983 July. I-16–I-30. Changery, M. J.; Simiu, E.; Filliben, J. J. **Extreme wind speeds at 129 stations in the contiguous United States.**

Key words: building (codes); probability distribution functions; statistical analysis; storms; structural engineering; wind pressure; wind speeds.

The purpose of this report is to present information on recorded and predicted wind speeds at 129 airport stations in the contiguous United States at which reliable records are available over a number of consecutive years. This information is provided to serve as basic documentation from which appropriate decisions can be made on values of design wind speeds to be specified in building codes and standards, and on special projects. Included in the report are: recorded wind speeds and anemometer elevations; predicted wind speeds based on probability distributions of the largest values; estimates of the sampling errors inherent in the predicted wind speeds; a description of the statistical procedure used in the analysis of the data; and a discussion of the results of the analysis.

SP658; 1983 July. I-31–I-45. Naito, K.; Tabata, I.; Banno, N.; Takahashi, K. **Analysis of high wind observations from very tall towers.**

Key words: gust winds; high wind analysis; tall towers; wind turbulence spectrum.

This paper describes the analyzed results of high winds, such as typhoons, observed in Japan and its vicinity from tall towers which vary in height from 200 to 400 meters. The results show that the vertical profile of the average wind velocity is well simulated by the power law: the obtained values of power are 0.12, 0.23, 0.46 and so on, and depend upon the local topography upwind. When the upwind roughness of the ground surface, or the unobstructed "clearness" which represents the reciprocal character of upwind roughness, are introduced to model the characteristics of the strong wind, the power decreases with larger degree of clearness, and vice versa. The power is expected to be around 0.12 or 0.15 in extreme clearness. This seems to agree with what is called the seventh-root formula obtained in wind tunnel experimentation. The power is considered usually to be less than 1.0, but will be over 1.0 in severely obstructed situations. The turbulent intensity decreases generally with the increase of height. It shows the following height dependency: for example it is $0.52\ Z^{-0.31}$ for good clearness, and $1.02\ Z^{-0.42}$ and $2.14\ Z^{-0.54}$ for intermediate, or worse clearness, respectively, where Z represents the height in meters. These results show that the profile of turbulent intensity depends upon the effect of the local terrain. The gust factor shows characteristics somewhat similar to those of turbulent intensity. The energy spectrum of turbulence is simulated quite well by the $-5/3$ power law, but the local topography affects height variation in the distribution of small spectral peaks.

SP658; 1983 July. II-1–II-12. Otsuka, M. **A proposal for a new parameter in assessing seismic disaster.**

Key words: earthquake prediction; fault dynamics; seismic disaster parameters.

Out of the recent progress in modern seismology, especially in the rapidly increasing body of knowledge about the nature of what the fault generating process looks like, a prospect of practical earthquake prediction in the near future seems reasonable.

Although a general methodology is not at hand for complete forecasting, long-term estimating of earthquake occurrences in limited areas based on past seismicity studies has already been put to practical use in many reported instances. Though this technique is still insufficient for prediction, since it lacks temporal accuracy about the occurrence of the earthquake, it should prove invaluable and be reflected in disaster reduction strategy. What is needed still is the methodology to associate the expected fault geometry to the plausible disasters.

The purpose of this paper is, then, to search for a technique to evaluate the influence of the impending earthquake based only on a geometrical estimate of a 'should be' fault and without any dynamic information.

Through repeated trials, the author has arrived at the conclusion that the intensity of the seismic vibration is closely related to the solid angle extended from the observation site toward the periphery of the fault.

SP658; 1983 July. II-13–II-23. Kubo, T.; Watabe, M. **Simulation of earthquake ground motion and its application to dynamic response analysis.**

Key words: dynamic response analysis; ground motion; modeling; synthetic earthquake motion; waveforms.

Through the relation of Fourier transformation, two types of stochastic modeling of earthquake ground motion are introduced. Twenty samples of synthetic motion, in each case, are generated by use of these two modelings simulating a certain recorded motion. Using these motions, characteristics of synthetic motions such as the cumulative energy distribution (the integration of square acceleration), the maximum elastic response and the maximum elasto-plastic response are evaluated. From a statistical viewpoint, the results are compared with those obtained from the recorded earthquake motion in an attempt to make use of synthetic motions for an engineering application.

SP658; 1983 July. II-24–II-44. Uwabe, T. **Comparison of vertical components of strong-motion accelerograms for Western United States and Japan.**

Key words: earthquake engineering; earthquake resistant structures; earthquakes; ground motion.

Characteristics of the vertical component of 187 strong-motion accelerograms recorded in the Western United States were studied. According to the analysis of the ratio of maximum vertical acceleration to maximum horizontal acceleration, the average ratio of vertical peaks to horizontal peaks is 0.48. Significant correlations between maximum horizontal acceleration, epicentral distance, and earthquake magnitude could not be found. The vertical maximum acceleration occurs near the occurrence time of the horizontal maximum acceleration. But, the coincidence of vertical and horizontal peaks is very rare. At the time when the safety factor against sliding and overturning for gravity-type structures is smallest, the ratio of the vertical acceleration to the resultant horizontal acceleration is less than one-third. A comparison was made of the ratios of vertical peaks to horizontal peaks for Western United States and for 574 strong-motion accelerograms from Japan. The result of this comparison is as follows: The ratio of vertical peaks to horizontal peaks in the Western United States is larger than that in the Japanese recordings. The difference between the accelerograms of the two countries is believed to be caused by dissimilar instruments, dissimilar installation conditions, and differences in focal depth and site conditions. This difference should be kept in mind when the digitized accelerograms of both countries are used together.

SP658; 1983 July. II-45–II-64. Nakano, K.; Kitagawa, Y. **Earthquake observation systems in and around structures in Japan.**

Key words: earthquake observation systems; simulation models; spectral analysis; transfer function; underground amplitudes.

Ever since the observation system for underground earthquake motions are undertaken in 1934, efforts have been made to obtain exact knowledge of the characteristics of ground motions, the dynamic interaction behavior between building and subsoil, and the earthquake motions input to structures.

The number of observation sites has increased year by year. There are now more than 200 in number, and much valuable data has been accumulated. In this paper the state-of-the-art of underground earthquake observation in Japan is reviewed.

SP658; 1983 July. III-1–III-22. Fuller, G. R. **Single-story residential masonry construction in Uniform Building Code Seismic Zone 2.**

Key words: minimum property standards; partially reinforced masonry; residential; roof diaphragms; seismic resistance; shaking table tests; single-story.

The U.S. Department of Housing and Urban Development's (HUD) Minimum Property Standards (MPS) require that all masonry construction in Seismic Zone 2 have partial reinforcement in accordance with the Uniform Building Code (UBC). Since there is a lack of behavioral data on the resistance of single-story masonry houses to earthquake forces, the housing industry has objected to the added cost of providing this reinforcement. HUD therefore contracted with the University of California at Berkeley to determine the behavior of masonry structures under seismic loads, by testing full scale specimens on the shaking table. This paper is a report of the related results of material, timber roof connections and shaking table tests. HUD also engaged the Applied Technology Council (ATC) of Palo Alto to develop design and construction criteria for adoption in the HUD-MPS. Upon completion of that contract in early 1980, a separate report will be presented to the UJNR Panel.

SP658; 1983 July. III-23–III-28. Gergely, P.; Fagundo, F.; White, R. N. **The performance of lapped splices in reinforced concrete under high-level repeated loading.**

Key words: beams; bond; concrete; design; lapped splices; reinforced concrete; seismic design; splices; testing.

The results of two series of experiments on lapped splices in reinforced concrete is reported; one on half-scale beams and the other on full-scale beams. The effects of repeated loading and transverse reinforcement on splices in constant moment regions have been studied to date.

SP658; 1983 July. III-29–III-40. Ohtani, K.; Minowa, C. **Dynamic behavior of reinforced concrete frame structures.**

Key words: earthquake acceleration-displacement analysis; reinforced concrete structures; shaking table simulation; structural testing.

This study presents earthquake simulator test of reinforced concrete structures conducted at the Earthquake Engineering Laboratory of the National Research Center for Disaster Prevention at the Tsukuba New Science City.

Two types of one-story, single-bay reinforced concrete frames in actual size were built on the shaking table. The two reinforced concrete frames had different slab weights; about 60 tons for the first tested frame and about 130 tons for the second one. Using this large-scale shaking table, both reinforced concrete frames were subjected to simulated and modified earthquake ground motions with intensities large enough to cause inelastic behavior and dynamic property changes to the frames.

Test results of both frames are described, as is the yielding of reinforcing steel bars, the varying properties of the overall frame responses, natural frequencies, and damping ratios.

Finally, computer simulations to evaluate inelastic responses and the correlation with measured performance are described using bi-linear or tri-linear analytical models.

SP658; 1983 July. III-41–III-64. Becker, J. M.; Llorente, C.; Mueller, P. **Seismic response of precast concrete walls.**

Key words: dynamic analysis; friction; post-tensioning; precast concrete; seismic response; shear walls.

Large panel precast concrete structures have been widely utilized in major seismic regions throughout the world. The seismic behavior of such structures is strongly dependent upon the characteristics of both the horizontal and vertical connections. The limiting behavior of precast systems, however, is basically dependent upon the horizontal connection. The influence of horizontal connections can be studied in term of the behavior of a simple wall—a vertical stack of panels having only horizontal connections.

This paper reports on research into the seismic behavior of simple precast concrete walls. The research was carried out through the development of computer-based modeling techniques capable of including the typical behavioral characteristics associated with horizontal joints. The model assumes that all nonlinear, inelastic behavior is concentrated in the connection regions and that the precast panels remain linear elastic. This assumption allows the precast panels to be modeled as statically condensed 'super-elements' and the connection regions as interface elements. The above modeling technique allows for nonlinear-inelastic seismic analysis that is capable of handling both rocking type motions throughout the height of the structure and slippage due to shear in the plane of the connection.

A series of parametric studies are presented to illustrate the potential influence of rocking and slip on precast walls using both regular reinforcement and post-tensioning. These studies demonstrate the period elongation associated with the non-linear elastic rocking phenomenon. Shear slip is found to occur only when friction coefficients are extremely low or when the normal forces across the connections are low. This latter case occurs only in low buildings or in the upper floors of tall buildings.

The paper concludes with a brief discussion of the design implications of these results. Particular attention is paid to the problems stemming from the force concentrations associated with rocking and shear slip.

SP658; 1983 July. III-65–III-86. Ohashi, M.; Iwasaki, T.; Kawashima, K. **Seismic response analysis of the Itajima Bridge through use of strong motion acceleration records.**

Key words: bridge-pier foundations; bridge seismology; earthquake frequency characteristics; foundation structure response; ground surface accelerations.

In analyzing the seismic behavior of highway bridges constructed on soft soil deposits, it is important to take into account soil-structure interaction effects. In this paper, the seismic response of a bridge pier-foundation is analyzed from earthquake acceleration records taken simultaneously from the pier crest and the ground surface near the bridge. Four motions were used in the analysis, i.e., two were induced by two earthquakes with magnitudes of 7.5 and 6.6, and two by their aftershocks. In the former two earthquakes, the maximum accelerations were 186 and 441 gals on the ground surface, and 306 and 213 gals on the pier top. Analyses of frequency characteristics of the motions showed that the predominant frequencies of the pier-foundation were always almost identical to the fundamental natural frequency of the subsoil. Analytical models were formulated to calculate the seismic response of the pier-foundation assuming the subsoil and pier-foundation to be a shear column model with an equivalent linear shear modulus and an elastically supported beam on the subsoil, respectively. Bedrock motions were computed from the measured ground surface motions and then applied to the bedrock of the analytical model. The seismic responses of the pier-foundation were thus calculated and compared with the measured records and produced a good agreement.

SP658; 1983 July. III-87–III-118. Marcuson III, W. F.; Curro, J. R., Jr. **Field and laboratory determination of soil moduli.**

Key words: damping; dynamic properties; field testing; geophysical; laboratory testing; resonant column test; shear modulus; wave velocities.

A field geophysical investigation was performed to determine the shear and Young's moduli as a function of depth for a site in southern Ohio. This investigation included crosshole, downhole, and surface refraction investigation techniques. A supplementary set of laboratory resonant column tests were performed with the Drnevich resonant column device. Laboratory undisturbed specimens were excited in both the longitudinal and torsional modes to obtain both Young's and shear moduli as a function of strain. Both laboratory and field data are presented, compared, and discussed.

An idealized soil profile for boring 821-UD is presented. This soil profile includes recommended design values of moduli and damping. At this boring location, bedrock lies approximately 36 ft (11 m) below the ground surface. The 36 ft (11 m) thick soil deposit has been subdivided into four layers whose shear moduli range from 3.4×10^3 to 86×10^3 psi (23.4×10^3 to 592×10^3 kPa). The moduli increase as a function of depth. The Young's moduli for this soil profile range from 10×10^3 to 225×10^3 psi (59×10^3 to 1551×10^3 kPa) and also increase with depth. The internal damping of the soil deposit was found to range from 3 to 5 percent for low dynamic strain amplitudes and is constant with depth. The bedrock has a shear modulus of 125×10^3 (861×10^3 kPa) and a Young's modulus of 370×10^3 psi (2551×10^3 kPa).

SP658; 1983 July. III-119–III-132. Asama, T.; Shioi, Y. **An experimental study on the liquefaction of sandy soils in a cohesive soil layer.**

Key words: cohesion in soil; liquefaction; sandy soils; strain levels; stress levels.

Experimental and theoretical researches on liquefaction have been made by many researchers. There is a general understanding that liquefaction occurs when the shear stress reaches a critical value which is determined by the type of soil, its density, its normal stress, and the like. The previous research shows that an essential factor should be stress levels in the soils. But the authors observe that liquefaction chiefly depends upon strain levels of soils. Especially where a sand layer lies on a soft cohesive soil layer, the strain can be amplified by the response of the cohesive soils.

SP658; 1983 July. III-133–III-162. Oh-oka, H.; Itoh, K.; Sugimura, Y.; Hirosawa, M. **Stress-strain behavior of dry sand and normally consolidated clay by inter-laboratory cooperative cyclic shear tests.**

Key words: damping ratios; dynamic soil properties; shear modulus; shear-strain testing of sand and clay; stress-strain soil behaviors; test procedures.

Inter-laboratory cooperative cyclic shear tests were conducted to obtain fundamental information about stress-strain behavior of dry sand and normally consolidated clay by using various kinds of dynamic shear apparatus which have been developed in Japan.

The tests were carried out in order to examine the characteristics of test apparatus and test procedures under as nearly identical conditions as possible. The results obtained by these tests are compared and discussed.

SP658; 1983 July. IV-1–IV-19. Bampton, M. C. C.; Bosch, H.; Cheng, D. H.; Scheffey, C. F. **Wind and structure motion study for Pasco-Kennewick Bridge.**

Key words: aerodynamic response; bridges; cable-stayed bridges.

A program to study the responses to the natural wind of the 2507 ft (763 m) Pasco-Kennewick Bridge is described using an automatic data collection system. The study consists of three phases: preliminary investigation, data collection and data analysis. The study is sponsored by the Federal Highway Administration and will last two years.

SP658; 1983 July. V-1–V-5. Cooper, J. D.; Scheffey, C. F.; Sharpe, R. L.; Mayes, R. L. **Draft seismic design guidelines for highway bridges.**

Key words: bridges; design guidelines; seismic design.

Seismic design guidelines for highway bridges in the United States have been under development since 1977. The draft guidelines represent the collective thinking of a distinguished group of academicians, consultants and highway bridge engineers. The guidelines were formulated and based on both the observed performance of bridges during past earthquakes and on

recent research conducted in the United States and abroad. They are currently undergoing evaluation by bridge designers and based on their comments are subject to change. The final version of the guidelines will be available in 1981.

SP658; 1983 July. VI-1–VI-8. Gergely, P.; White, R. N. **Analysis and design of cracked reinforced concrete nuclear containment shells for earthquakes.**

Key words: concrete; containment vessels; cracking; dynamic analysis; hysteresis; nuclear structures; reinforced concrete; seismic effects; shear; stiffness; testing.

Cracking reduces the shear stiffness of reinforced concrete cylindrical containment shells. An extensive experimental program on specimens carrying biaxial tension and cyclic shear produced highly nonlinear shear-slip curves, relatively high sliding shear strength, and low shear stiffness. The effects of this behavior on seismic response and design are discussed.

SP658; 1983 July. VI-9–VI-43. Iida, R.; Matsumoto, N.; Kondo, S. **Comparison of the measured and computed responses of the Yuda Dam during the July 6, 1976 and June 12, 1978 earthquakes.**

Key words: arched gravity dam; dynamic analysis; earthquake accelerogram; frequency response functions; hydrodynamic pressure.

Two accelerograms were recorded at the foundation and dam crest of the Yuda Dam, an arched gravity dam, during the July 8, 1976 and June 12, 1978 earthquakes. The frequency response functions for dam crest to foundation were calculated from these accelerograms. The ground acceleration was used as an input, and the dynamic response was calculated using two-dimensional FEM analysis to compare with the measured response.

The essential conclusions may be enumerated as follows: 1) The displacements at the crest of Yuda Dam were calculated from recorded accelerograms using a digital filtering procedure in which the cutoff frequency of the weighting function was slightly lower than the fundamental frequency of the dam. 2) According to the frequency response functions obtained from two accelerograms, the performance of the dam body may be considered to be linear elastic. The water level of the reservoir influences the frequency response function. 3) The computed response of the dam crest using the foundation accelerogram as an input from the two-dimensional FEM analysis coincides with the measured one. Comparing Westergaard's method and Chopra's method in the evaluation of hydrodynamic pressure, Chopra's method gives the response which contains more low frequency components than Westergaard's method. However, there is not much difference between them. Westergaard's added mass when computed by neglecting the compressibility of water provides a satisfactory approximation of the hydrodynamic pressure.

SP658; 1983 July. VII-1–VII-21. Watabe, M.; Matsushima, Y.; Ishiyama, Y.; Kubo, T.; Ohashi, Y. **Report on the 1978 Miyagi-Ken-Oki Earthquake.**

Key words: ground motions; Miyagi-Ken-Oki Earthquake; subducting plate actions.

The damage features and the causes of damage due to the Miyagi-Ken-Oki Earthquake June 1978 are summarized as follows: (1) Earthquake Ground Motions, (2) Damage of Structural Members, (3) Damage of Non-Structural Members, and (4) Overall Views.

SP658; 1983 July. VII-22–VII-35. Haruyama, H.; Kobayashi, M. **Disastrous ground failures in a residential area over a large-scale cut-and-fill in the Sendai region caused by the earthquake of 1978.**

Key words: artificial fill; disaster prevention; earthquake disaster; ground failure; slope steepness.

This paper examines the relationship between the disastrous ground failures in a hilly residential area and the land properties, due to the Miyagi-Ken-Oki earthquake of 1978.

We measured the change of landforms by comparisons of two maps based on aerial photographs taken before and after major area earthworks. As the first step, we prepared a landform map at a scale of 1/2,500 with a 2 meter contour interval, from a time just before the earthworks for residential development (1957) and after the earthworks (1978).

Then we constructed a thickness isopleth map of the artificial fill with a 2 meter interval and many profiles across the earthworks.

Then we examined the interrelationships between the distribution of ground cracks, the damage to destroyed houses, the retaining walls, the maps described above, and the original landforms.

SP658; 1983 July. VII-36–VII-61. Okubo, T.; Ohashi, M.; Iwasaki, T.; Kawashima, K.; Tokida, K. **Damage features of civil engineering structures due to the Miyagi-Ken-Oki Earthquake of 1978.**

Key words: earthquake history; ground motions; Miyagi-Ken-Oki Earthquake; subsoil conditions.

At 17h 14m (JST), June 12, 1978, a destructive earthquake took place offshore Miyagi-ken and caused extensive damage to buildings, highway facilities, river dykes, water supply, sewage systems, electrical and gas supply systems, and others.

Major observed damage characteristics shows: (i) the influence of subsoil conditions was great, and (ii) losses in commercial and industrial sectors and residential housings comprise a high percentage of the total damage amount.

This paper describes the outline of the earthquake, the earthquake history in the affected area, the geological and subsoil conditions, the recorded ground motions and damage features to civil engineering structures which were caused by the earthquake, especially bridge damage.

SP658; 1983 July. VII-62–VII-78. Yamamura, K.; Sasaki, Y.; Koga, Y.; Taniguchi, E. **Damage to river dykes caused by the Miyagi-Ken-Oki Earthquake of June, 1978.**

Key words: earthquake-resistant dykes; river dyke damage; soil liquefaction; soil relationships.

A large number of engineering structures were severely damaged by the Miyagi-Ken-Oki Earthquake of June, 1978. This paper describes the damage to the river dykes in the Kitakami, Naruse, Eai, and Yoshida Rivers by this earthquake.

Field surveys and laboratory investigations were performed on subsoils underlying the dykes and following conclusions drawn: i) River dykes in the Miyagi prefecture were extensively damaged by this earthquake. ii) The seismic resistance of river dykes is affected by the stability of supporting subsoils during an earthquake: either by a tendency toward liquefaction, or by the bearing capacity of the subsoils. iii) The damage of river dykes has a close relationship to the micro-topographical features. Dykes on a "former river bed" have a high potential to be damaged by earthquakes. It is suggested by the analyses on Eai River that the Land Form Classification Map for Flood Control Planning is useful in predicting river dyke damage. iv) Re-liquefaction may or may not occur at the same place. It was observed not to occur at a layer which had been compacted by previous earthquakes.

SP658; 1983 July. VII-79–VII-109. Tsuchida, H.; Noda, S. **Damage to port structures by the 1978 Miyagi-Ken-Oki Earthquake.**

Key words: earthquake damage; seaport damage characteristics; site liquefaction; stability analysis; strong motion accelerograms.

The 1978 Miyagi-Ken-Oki Earthquake (M=7.4) caused damage to port facilities. From field investigations and analyses, the following lessons concerning earthquake engineering were learned: 1) Strong-motion accelerograms were recorded by an observation network of the Port and Harbour Research Institute. The largest peak ground acceleration of 280 gals was recorded at Shiogama Port. 2) Port facilities were damaged seriously when a backfill liquefied. Otherwise, they suffered only lightly. 3) Current procedures for estimating liquefaction potential can lead to an appropriate judgement for actual sites. 4) A relationship between the seismic coefficient and the maximum ground acceleration for gravity quaywalls: $e = 1/3(\alpha)^{1/3}$ agrees with the

investigations of this earthquake. 5) The above-mentioned relationship may be equally applicable to a stability calculation for sheetpile quaywalls with anchor plates.

SP658; 1983 July. VII-110–VII-129. Agbabian, M. S. **Wood diaphragms in masonry buildings.**

Key words: analytical model; dynamic response; seismic hazard; unreinforced masonry; wood diaphragms.

Reports of damage from past earthquakes indicate that wood diaphragms supported on masonry walls have suffered little or no damage during excitation. However, the supporting masonry walls have suffered degrees of damage varying from minor tension cracks to separation from the diaphragms and complete collapse.

The interaction of a diaphragm with the masonry walls has a critical effect on the dynamic behavior of the structure. Numerical analyses of plywood, diagonal- and straight-sheathed floor and roof diaphragms indicate that highly nonlinear and hysteretic load-deflection relationships are needed to describe the response of wood diaphragms. Experiments are planned to improve the analytical model by obtaining performance characteristics of wall anchorages to diaphragms as well as deformations of diaphragms under cyclic excitations. Finally, candidate retrofit/strengthening techniques will be incorporated into typical wood diaphragms, and the tests will be repeated in order to develop structural systems that will survive disastrous earthquakes.

SP658; 1983 July. VII-130–VII-142. Agbabian, M. S. **Mitigation of seismic hazards in existing unreinforced masonry buildings.**

Key words: earthquake hazard mitigation; masonry buildings; mitigation; seismic hazards.

Analytical and experimental investigations to determine resistance of structures in various seismic zones of the United States are combined in an ongoing study. The study is being carried out by a joint venture of three consulting engineering firms in Los Angeles under the sponsorship of the National Science Foundation.

A survey was initially made of unreinforced masonry (URM) buildings in seven geographic areas in the United States. The selection of types of structures for investigation considered construction materials, size, distribution of walls around the perimeter and within the building, connection details, and the application or absence of seismic design criteria.

The structures selected for study consist of: a) Rectangular, six-story industrial buiding; b) Rectangular, four-story public school; c) Irregular, four-story plus basement public building; d) U-shaped, four-story apartment building; e) Rectangular, six-story and three-story office buildings; f) Rectangular, one-story and three-story industrial buildings. A methodology for earthquake hazard mitigation is being developed that will be applicable to the broad range of buildings surveyed. Concurrent with these analyses, tests are planned for masonry walls in the out-of-plane and in-plane directions, anchorage of walls to diaphragms, and wood and steel diaphragm characteristics. Tests of repaired and/or retrofitted elements will also be carried out.

The effect of the following rehabilitation techniques is being investigated: Strengthening of masonry walls; Adding or improving anchorages; Repair and strengthening of diaphragms; Amelioration of foundation settlement.

SP658; 1983 July. VII-143–VII-156. Murota, T.; Ishiyama, Y. **Development of a universal fastener for wooden building roof frames.**

Key words: joint fasteners; roofing damage; structural performance; tension tests; universal fasteners; wooden roofs.

A new type of joint fastener to be used in reinforcing wood building roof frames was developed at the Building Research Institute. This fastener, its behavior and strength developed in tension tests are described and shown in this paper. The structural performance of this fastener is also compared to those of conventional joint fasteners such as cramp irons.

SP658; 1983 July. VIII-1–VIII-22. Scalzi, J. B.; McDonough, G. F., Jr.; Costes, N. C. **The NASA/MSFC experimental facilities at Huntsville, Alabama.**

Key words: foundation tests; large scale testing; structures soils; test facilities.

An evaluation of National Aeronautics and Space Administration (NASA) facilities and supporting capabilities for earthquake engineering research was made during a site visit and workshop held at George C. Marshall Space Flight Center (MSFC), Alabama, on February 22, 23, and 24, 1979. Workshop participants included twenty-six earthquake engineering specialists from the academic community, industry, and government. The workshop was sponsored by the National Science Foundation and NASA, and it was hosted by MSFC. The chairmanship and overall direction of the workshop was assumed by the Earthquake Engineering Research Institute.

The results of the workshop indicate that the NASA/MSFC facilities and supporting capabilities offer unique opportunities for conducting earthquake engineering research. Specific features that are particularly attractive for large-scale static and dynamic testing of natural and man-made structures include the following: large physical dimensions of buidings and test bays; high loading capacity, wide range and large number of test equipment and instrumentation devices; multichannel data acquisition and processing systems; technical expertise for conducting large-scale static and dynamic testing; sophisticated techniques for systems dynamics analysis, simulation and control; and capability for managing large-size and technologically complex programs.

This paper will describe the pertinent facilities at MSFC including their capabilities, original purpose and utilization and potential uses, both in their current state and with modification, to support seismic testing of structures.

SP658; 1983 July. VIII-23–VIII-27. Thiel, C. C.; Anderson, W. A.; Gaus, M. P.; Hakala, W.; Krimgold, F.; Liu, S. C.; Scalzi, J. B. **Earthquake hazards reduction research supported in 1978.**

Key words: earthquake design; earthquake hazards research; geotechnical engineering; seismic design standards.

Research activities supported by the National Science Foundation in 1978 are reviewed. Abstracts of 153 awards are presented to describe the diversity of research activities underway as part of the National Earthquake Hazards Reduction Program.

SP658; 1983 July. VIII-28–VIII-112. Nakazawa, K.; Kuribayashi, E.; Tazaki, T.; Hadate, T.; Hagiwara, R. **Functional damage and rehabilitation of lifelines in the Miyagi-Ken-Oki Earthquake of 1978.**

Key words: functional damage; lifeline systems; Miyagi-Ken-Oki Earthquake.

The Miyagi-Ken-Oki Earthquake of June 12th, 1978 with a magnitude of 7.4 brought many disasters to Sendai City, population six hundred thousand, and the adjacent area. The disaster is deemed one of the biggest earthquake disasters since the Kanto Earthquake of 1923. Since then earthquake disasters in modernized prefectural cities have been experienced in the Fukui Earthquake of 1948 and the Niigata Earthquake of 1964. However, Sendai City was more greatly urbanized than Fukui City and Niigata City was in those days.

In this survey, the facts connected with earthquake disaster prevention measures were investigated cooperatively with the organizations listed later. This paper aims primarily at a successful analysis of the functional losses and the rehabilitation of lifeline systems.

SP658; 1983 July. VIII-113–VIII-120. Anderson, W. A. **Social aspects of earthquake mitigation and planning in the United States.**

Key words: hazard awareness; mitigation and preparedness measures; socioeconomic factors.

A number of social scientists in the United States have recently turned their attention to the pre-disaster responses of individuals and social units and are investigating the socioeconomic factors

related to mitigation and preparedness. This research is important because it promises to result in the identification of the principal factors which influence the utilization of known and developing social and technological adjustments to earthquakes, including building codes, land use regulations, public education and earthquake prediction. As a result of on-going and recently completed social science studies, increased knowledge is developing on a number of important topics. The emerging findings on the following questions are discussed in this paper: How is the earthquake hazard perceived by officials and the public? What types of mitigation and preparedness measures are citizens and officials willing to accept? What is the impact of some existing hazard mitigation programs? What are some of the social factors to consider in trying to enhance the benefits of future earthquake predictions?

SP658; 1983 July. IX-1–IX-7. Takahashi, H.; Fujinawa, Y. **Orientation of tsunami research in Japan.**

Key words: disaster warning; earthquake detection; flood warning; tsunami prediction; tsunami research.

We have been struck by large tsunamis which were induced by earthquakes occurring near the Tonankai area of Japan on an average of every thirteen years in a 350 year period. It is conjectured by some seismologists that a large earthquake may occur in the area of Tonankai. We have experienced nine earthquakes which are considered to be grouped in the Tonankai earthquake zone. All of these earthquakes were accompanied by tsunamis. Victims rose to 31,000 in 1498 (Meio), 3,906 in 1605 (Keicho), 4,924 in 1707 (Hoei, and 3,427 in 1854 (Ansei), respectively. We urgently need to plan countermeasures against tsunamis, especially to develop a warning system for tsunamis which take less than about ten minutes to reach our coasts. Tsunami research in Japan is briefly reviewed from the standpoint of developing an effective warning system.

SP658; 1983 July. IX-8–IX-18. Hashimoto, H.; Uda, T. **Wave setup caused by typhoon 7010.**

Key words: storm surge; typhoon damage; wave setup.

Typhoon 7010 caused heavy damage to Kochi city brought on by flooding from the storm surge. Numerical computations were carried out but they do not explain fully the abnormally high rise of the sea level. As one explanation, it is suggested that wave setup contributes to an abnormally high rise since a typhoon is usually accompanied by high waves.

Experimental investigation and numerical calculations were carried out to make clear the magnitude of wave setup at the mouth of Kochi harbor. Generally, on a straight coast, the normal component of radiation stress caused by breaking waves generates wave setup and the tangential component generates along-shore current. Investigations, however, show that the along-shore current is obstructed by a breakwater at Kochi harbor and wave setup is generated by the tangential component together with the normal one. The wave setup contributes to the anomaly, and its height is estimated to range from 0.5 m to 1.0 m. Numerical calculations confirm the experimental results though they need further improvement.

SP658; 1983 July. IX-19–IX-24. Barrientos, C. S.; Hess, K. W. **Specification and prediction of surface wind forcing for ocean current and storm surge models.**

Key words: hurricane; ocean current; oil spill trajectory; storm surge; wind forcing; wind models.

Forecast methods to predict movements of oil spills in the ocean are being developed in the Techniques Development Laboratory of the National Weather Service (NWS). An operational model for oil movement forecast is being implemented in NWS. The model will be available for routine use in the event of oil spills and for assessment studies of probable impacts of oil spills.

The most important component in the movement of an oil spill is due to the surface wind forcing. Surface wind stress acts on the spilled oil in two ways: (1) to generate ocean surface currents, and (2) to drag directly the oil on the surface. We examined different boundary layer wind formulations and assessed the resulting surface currents response.

A dynamical storm surge model has been developed in NWS and is being used in real time forecasting of surges when a hurricane is approaching land. The model has proved useful in routine use during the last 10 years. Recently, a model has been developed that forecast surges in bays and estuaries.

Storm surge is generated by the action of the wind and low atmospheric pressure in the storm (inverted barometer effect). The wind forcing is the dominant factor in surge generation. The spatial distribution of the wind in a storm or typhoon determines the resulting characteristics of the surge, such as, maximum surge and location on the coast, extent of the coastline affected by the surge and the height variation of the surge along the coast. We tested different storm wind models and determined the response of the storm surge model.

SP658; 1983 July. IX-25–IX-28. Jelesnianski, C. P.; Barrientos, C. S.; Chen, J. **A dynamic model to predict storm surges and overland flooding in bays and estuaries.**

Key words: forecast and warning; hurricane; overland flooding; storm surge.

In the United States, most of the damages caused by hurricanes are attributed to storm surges. NOAA provides forecast and warning services to prevent loss of lives and property. A dynamical model was developed to forecast storm surges in bays and estuaries. The development of the model and the operational application for forecasting will be described.

SP658; 1983 July. IX-29–IX-37. Goda, Y. **Topics on tsunami protection along the port areas in Japan.**

Key words: disaster planning; seawall protection; tsunami breakwaters; tsunami prediction.

The major Japanese tsunamis since the 15th century and a general description of counter-measures against them are briefly introduced. Particular reference is made on tsunami break-waters used to protect port areas. The performance of the Ofunato tsunami breakwater in the instance of the Tokachi-oki Earthquake Tsunami in 1968 is discussed, and a new plan for a Kamaishi tsunami breakwater is introduced. Also mentioned are several tsunami prediction plans in progress.

SP658; 1983 July. X-1–X-16. Hattori, S. **Seismic risk maps (maximum acceleration and maximum particle velocity) in the Southeast Asian countries of the Philippines, Indonesia, and Indo-China.**

Key words: disaster prediction; earthquake motions; hypocenters; seismic risk maps; seismic zoning.

Seismic risk maps in the Southeast Asian Countries of the Philippines, Indonesia, and Indo-China were made using existing seismic data, attenuation models, and the method of extreme value fitting. The maps consist of the following two kinds: (i) The maximum particle velocity (kine) on the base rock, and (ii) The maximum acceleration (gal) on the ground. The return periods of these maps are 50, 100 and 200 years, respectively.

This paper is a modification of the report which the author is going to present at the International Conference on Engineering for Protection from Natural Hazard, which was held in the Conference Center of the Asian Institute of Technology in Thailand January 7-10, 1980.

SP658; 1983 July. X-17–X-38. Meehan, J. F. **California school and hospital ceilings.**

Key words: anchorage; applied ceilings; plaster ceilings; seismic forces; T-bar ceilings.

A description of the methods of anchoring plaster, panel applied and T-bar ceilings against seismic forces is presented which is acceptable to the Structural Safety Section of the Office of the State Architect for public school and hospital buildings in California.

SP659. Cullen, W. C.; Rossiter, W. J., Jr.; Mathey, R. G.; Clifton, J.

R. **Low sloped roofing research plan.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 659;* 1983 July. 40 p. SN003-003-02507-1.

Key words: low-sloped roofing; mathematical modeling; membranes; repair; research plan; roofs; standards; thermal insulations.

This report presents a long-range plan for roofing research. The plan was developed in response to a need for roofing research addressing major materials problems and changes in low-sloped roofing materials technology. The intent of the plan is to establish the technical basis for developing standards and minimum levels of performance to assist in the selection of cost-effective and durable roofing materials. Four major areas of needed research are identified: (1) low-sloped roofing systems, (2) roofing membranes including single-ply and built-up, (3) thermal insulation for roofing systems, and (4) condition assessment and repair of roofs. Within each research area, a goal is given as well as a number of objectives to achieve the goal. A recommended approach to accomplish each objective is also given.

SP660. Link, A. N. **Measurement & analysis of productivity growth: A synthesis of thought.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 660;* 1983 September. 36 p. SN003-003-02532-1.

Key words: determinants of productivity; literature review; measurement of productivity; productivity; research and development; technological change.

Productivity is one of the most important factors influencing our economic well-being. Productivity growth is essential to a higher standard of living and is vital to a sound economic and political environment. However, there has been a slowdown in the growth of productivity in the United States since the mid-1960s. This slowdown has caused concern among policy makers and researchers. Accordingly, several questions persist both in policy and academic circles. Why has productivity been slowing? and What can be done to reverse this trend?

The purpose of this report is to address broadly the first of these two questions by surveying and synthesizing the vast literature on the measurement and determinants of productivity. This review is intended to be a source document for those interested in the measurement and analysis of productivity growth.

The report is divided into five sections. In the first section, the importance of productivity growth on economic activity is discussed. In the second section, the so-called "facts" about patterns of measured productivity growth in the United States are presented. In the third section, the methods currently used for calculating productivity indices are summarized. In the fourth section, the literature related to the determinants of the productivity growth are reviewed. Finally, in the last section, some suggestions are made for future work in this area.

SP661. Weeks, S. J.; Becker, D. A.; Hsu, S. M. **ASTM/NBS basestock consistency study data.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 661;* 1983 October. 482 p. SN003-003-02540-2.

Key words: additive response physical & chemical properties basestock; consistency; data; lubricants; oil; petroleum; rerefining.

ASTM and NBS co-sponsored a Basestock Consistency Study (BCS) to assess the quality consistency of lubricating base oils. This study, which is the first of its kind, will impact on developing basestock characterization methodology and on efficient utilization of energy resources as well as their conservation through recycling.

The purpose of this publication is to present the ASTM/NBS BCS data for data analysis.

Monthly production samples from six re-refiners and four refiners were analyzed by 14 laboratories for a 13 month period. The results of over 55 tests are divided according to six major categories: rheology, physical properties, chemical properties, hydrocarbon type analysis, general performance tests, and oxidation and wear bench tests. The data are presented in tabular and graphical form, which is quite amenable to further data analysis.

SP662. Yakowitz, H., ed. **The National Bureau of Standards Office of Recycled Materials 1976–1982.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 662;* 1983 September. 634 p. SN003-003-02531-3.

Key words: characterization of materials; econometric modelling; hazard assessment; hazardous waste management; incineration; ocean incineration; recycled materials; refuse derived fuels; solid waste management; state measurement needs; used oil characterization; waste-to-energy conversion.

This report is meant to serve two purposes: (1) Summarize the activities and accomplishments of the Office of Recycled Materials of the National Bureau of Standards (NBS/ORM) undertaken in response to legislative directives from 1976 through 1982; (2) Provide a compilation of FY 1982 activities of NBS/ORM.

During its six and one-half year lifetime, NBS/ORM fulfilled virtually all of the legislative directives with which NBS was charged. Waste oil and other materials destined for waste were the subject of requirements for test method development, evaluation and subsequent production of standards and guidelines for specifications. More than 125 publications and reports remain as a tangible legacy of NBS/ORM. In addition, the methods and standards developed under the guidance of NBS/ORM have been adopted throughout the recycling community. This report places major NBS/ORM activities in perspective and provides a point of embarkation for anyone wishing to utilize or adapt NBS/ORM results. In addition, the Report indicates that NBS fulfilled the legislative requirements in a timely, accurate, and efficient manner.

SP663. Tholen, A. D.; Barbrow, L. E.; Heffernan, A. P., eds. **Report of the 68th National Conference on Weights and Measures 1983.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 663;* 1983 September. 356 p. SN003-003-02530-5.

Key words: legal metrology; specifications and tolerances; training; type evaluation; uniform laws and regulations; weights and measures.

These are the proceedings of the 68th National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Sacramento, CA., July 17-22, 1983, and attended by State, county, and city weights and measures officials, and representatives of the Federal Government, business, industry, and consumer organizations. Reports by the several standing and annual committees of the Conference comprize the major portion of the publication. Included also are papers presented by Conference officials and others.

Major issues discussed at the Conference included labeling of gasoline containing alcohol, national type evaluation, and development of training materials.

SP664. Suzuki, S.; Yakowitz, H. **Gasification of refuse derived fuel in a paired fluidized bed pyrolysis unit.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 664;* 1983 September. 45 p. SN003-003-02519-4.

Key words: Baltimore County (MD) Resource Recovery Facility; Cooperative Research (Japan-U.S.); pilot plant scale-up for resource recovery from waste destined for disposal; pyrolysis of refuse derived fuel; refuse derived fuel gasification; solid waste management.

As part of the scientific interchange program initiated by the United States Government and the Government of Japan, the Department of Commerce was selected by the White House to be the pilot agency for a project concerned with resource recovery from discards orginally destined for waste. Such discards include municipal waste and industrial waste. Under terms of the agreement signed by the President and the Prime Minister on May 2, 1980, the United States and Japan will exchange small teams of government scientists in order to examine resource recovery in the respective countries and to formulate possible joint research ventures.

The Office of Recycled Materials of the National Bureau of Standards (NBS/ORM) which was charged with fulfilling the duties assigned to the Secretary of Commerce by Subtitle E of the Resource Conservation and Recovery Act as amended (P.L. 94-580; PL 96-482) was designated as the U.S. contact point for this project. The Japanese team visited the U.S. in December, 1981; NBS/ORM arranged the itinerary and provided technical briefings and an overview of resource recovery activities. At that time, NBS/ORM and Japanese representatives concluded an agreement for joint research to be performed as part of the project. The results described in this report were developed in partial fulfillment of this agreement.

SP668. Chung, R. M., ed. **Nuclear waste management program—Summary report.** Workshop on Research and Development Needs in Backfill for Long Term Storage of Nuclear Waste in Deep Geologic Repositories, held at the National Bureau of Standards; 1981 April 13-14; Washington, DC. *Natl. Bur. Stand. (U.S.) Spec. Publ. 668;* 1983 December. 228 p. SN003-003-02545-3.

Key words: backfill; compressibility; geology; nuclear waste; permeability (hydraulic conductivity); research and development; shear strength; sorption; swelling; thermal conductivity.

An international workshop on the backfill component of a multi-barrier underground isolation system for nuclear waste disposal/storage was conducted on April 13 and 14, 1981, at the National Bureau of Standards, Washington, DC. This report includes the papers presented and/or submitted to the workshop for publication. It also contains the surveyed results of a questionnaire distributed to the participants at the workshop. The workshop held a one-day informal indepth discussion on the subject and a summary of these discussions are included in this report, which states areas where further research and development needs are required to better understand the fundamental mechanisms of the backfill in the waste repository.

SP670. Gass, S. I.; Murphy, F. H.; Shaw, S. H., eds. **Intermediate Future Forecasting System.** Proceedings of a Symposium held at the Department of Energy; 1982 August 19; Washington, DC. *Natl. Bur. Stand. (U.S.) Spec. Publ. 670;* 1983 December. 147 p. SN003-003-02547-0.

Key words: coal; electric utilities; energy economy; energy markets; energy models; forecasting; natural gas; oil; policy analysis.

The Symposium on the Department of Energy's Intermediate Future Forecasting System IFFS was held in Washington, DC, on August 19, 1982. It was funded by the Energy Information Administration of the Department of Energy (DOE) and organized by the Operations Research Division of the National Bureau of Standards. The purposes of the Symposium were (1) to present to the energy community details of DOE's new energy market model IFFS and (2) to have an open forum in which IFFS and its major elements could be reviewed and critiqued by external experts. DOE speakers discussed the total system, its software design, and the modeling aspects of oil and gas supply, refineries, electric utilities, coal, and the energy economy. Invited experts critiqued each of these topics and offered suggestions for modifications and improvement. This volume documents the Proceedings (papers and discussion) of the Symposium. *These proceedings include the following papers (indented):*

SP670; 1983 December. 4-17. Murphy, F. H. **An introduction to the Intermediate Future Forecasting.**

SP670; 1983 December. 18-26. Hogan, W. W. **System overview: A comment.**

SP670; 1983 December. 27-29. Shaw, S. H. **System implementation and software design.**

SP670; 1983 December. 30-33. O'Neill, R. P. **Introduction to the oil and gas supply subsystem.**

SP670; 1983 December. 34-43. Finger, W. R.; Nissen, D. **Oil and natural gas supply subsystem: A critique.**

SP670; 1983 December. 44-51. Conti, J. **Introduction to the oil subsystem.**

SP670; 1983 December. 52-59. Cleary, N. J. **Refineries Subsystem: A critique.**

SP670; 1983 December. 60. Todd, J. E. **Introduction to the afternoon session.**

SP670; 1983 December. 61-70. Sanders, R. **Introduction to the electric utilities.**

SP670; 1983 December. 71-81. Rubin, L. J. **Electric utilities subsystem: A critique.**

SP670; 1983 December. 82-92. Hutzler, M. J. **Introduction to the coal subsystem.**

SP670; 1983 December. 93-95. Gordon, R. L. **IFFS coal supply model.**

SP670; 1983 December. 96-99. Elliot-Jones, M. **Coal subsystem: A critique.**

SP670; 1983 December. 100-105. Jorgenson, D. W. **Introduction to the energy-economy interactions.**

SP670; 1983 December. 106-114. Hall, R. E. **Energy-economy interactions: A critique.**

SP670; 1983 December. 115-135. Hausman, J. A. **IFFS: An overview.**

5.6 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.

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 10. Moore, C. E. **Selected tables of atomic spectra. A: Atomic energy levels—Second edition. B: Multiplet table. O IV.** *Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 3, Sec. 10;* 1983 March. 21 p. SN003-003-02469-4.

Key words: atomic energy levels, O IV; atomic spectra, O IV; multiplet table, O IV; oxygen spectra, O IV; spectrum, O IV; wavelengths, O IV.

The present publication is the tenth 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 analyses of optical spectra. As in the previous Sections, Part A contains the atomic energy levels and Part B the multiplet tables. Section 10 includes these data for O IV. The form of the presentation is described in detail in the text to Section 1.

NSRDS-NBS63, Supplement 2 and 1983 cumulative indexes. Heller, S. R.; Milne, G. W. A.; Gevantman, L. H. **EPA/NIH mass spectral data base. Supplement 2 and 1983 cumulative indexes.** *Natl. Stand. Ref. Data Ser., Natl. Bur. Stand. (U.S.) 63, Suppl. 2 and 1983 cumulative indexes;* 1983 December. 2107 p. SN003-003-02514-3.

Key words: analytical data; mass spectra; organic substances; verified spectra.

This second Supplement to the EPA/NIH Mass Spectral Data Base (NSRDS-NBS 63) presents an additional collection of 6557 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 mass spectra.

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.

BSS146. Fattal, S. G. **Evaluation of construction loads in multistory concrete buildings.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 146;* 1983 February. 139 p. SN003-003-02465-1.

Key words: concrete buildings; concrete casting; construction loads; construction standards; falsework; field measurements; flat plate; floor slab; formwork; instrumented shores; load measurement; multistory construction; shored construction.

Construction loads in a multistory flat plate concrete building were measured using strain-gaged metal shores and an analog recorder. The instrumented shores were placed within an interior bay of the third story under the formwork for the fourth story floor slab, and loads on the shores were measured continuously over a 24-hour period during the casting and partial curing cycle of that slab. The loads on some of these shores, when subsequently used as reshores in the same bay, were measured during an 8-hour period which included the casting of the fifth story floor slab. A time-lapse camera, operating synchronously with the load data acquisition system, gathered simultaneous photographic evidence of the construction activities during load monitoring periods. This report presents a complete documentation of the field data in compact form for subsequent use in related studies. The load data is interpreted and compared with construction load and design provisions of current standards.

BSS150. Kao, J. Y.; Sushinsky, G.; Didion, D. A.; Mastascusa, E. J.; Chi, J. **Low-voltage room thermostat performance.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 150;* 1983 April. 46 p. SN003-003-02478-3.

Key words: room temperature control; temperature controller; thermostat evaluation; thermostat modeling; thermostat test; two-position control.

To predict performance of low voltage electric thermostats in a dynamic building system, a computer model representing two types of thermal feedback was developed. Unlike the information obtained from existing test standards, this model allows thermostat performance to be determined under any load conditions. As input to the model, the basic parameters of thermostat performance were first identified and then determined experimentally in a controlled laboratory facility. The experimental results from the tests were used as input parameters for the simulation model. Based upon the results from the simulation model and test results on four commercially-available thermostats, a switch-feedback model computer simulation is recommended for studying low-voltage room thermostat performance.

BSS151. Simiu, E.; Leigh, S. D. **Turbulent wind effects on tension leg platform surge.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 151;* 1983 March. 46 p. SN003-003-02479-1.

Key words: compliant platforms; ocean engineering; offshore platforms; structural engineering; tension leg platforms; turbulence; waves; wind loads.

A procedure is presented for estimating surge response to turbulent wind in the presence of current and waves. The procedure accounts for the nonlinearity of the hydrodynamic forces with respect to surge and for the coupling of aerodynamic and hydrodynamic effects. It is shown that current wind spectra do not model correctly the wind speed fluctuations at very low frequencies and an alternative model of the wind spectrum, consistent with fundamental principles, is presented. The equation of surge motion under turbulent wind in the presence of current and waves is solved for typical tension leg platforms, and it is shown that under extreme wave conditions the damping provided by the hydrodynamic forces precludes the occurrence of significant wind-induced resonant amplification effects even if the drag coefficient in the Morison equation is very small (e.g., $C_d = 0.1$). It is verified that for the platforms being investigated the use of a one-minute wind speed to represent the effect of the mean wind and of the turbulent wind fluctuations is acceptable for the purpose of estimating peak surge response.

BSS152. Gillette, G. **A daylighting model for building energy simulation.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 152;* 1983 March. 135 p. SN003-003-02487-2.

Key words: building computer simulation; building energy performance; clerestory performance; daylighting; skylight performance; window performance.

A computer model is outlined for estimating the annual energy performance of a daylighted building. The daylighting model is a system of FORTRAN subroutines designed for inclusion into larger building energy simulation programs such as DOE-2, BLAST, and NBSLD. Once incorporated into the main energy program, these subroutines will allow the existing program to account for the energy tradeoffs associated with natural illumination.

The daylighting model, DALITE, comprises three separate routines to do three separate functions. The first routine generates hourly sky luminances and sky illuminances as well as direct sun illuminance, taking solar radiation and sun position data as input. The second predicts interior daylight illumination at various points within a room due to any number of windows, skylights or clerestories. The last routine adjusts the electric lighting load (via photoelectric controls) in response to the available daylight. Unlike other daylighting estimation techniques, this model is a dynamic model designed to study how conditions change with time. It has a further advantage in that it can be easily installed into most existing models written in FORTRAN 77.

BSS154. Reed, D. A.; Simiu, E. **Wind loading and strength of cladding glass.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 154;* 1983 May. 49 p. SN003-003-02480-5.

Key words: aerodynamics; buildings; deformation; engineering mechanics; failure; glass; loads (forces); probability theory.

A procedure for investigating glass cladding behavior under arbitrary loads, including fluctuating wind loads, is presented. The procedure accounts for the fact that internal stresses are nonlinear functions of the external loads, that initial glass strengths are random functions of position and direction, and that glass strength undergoes degradation under the action of external loads in accordance with basic fracture mechanics laws. Numerical examples are presented, and corresponding probability distribution curves are calculated, indicating the probability of failure of a specified panel subjected to fluctuating wind loads and to 1-minute constant loads. These curves are used to illustrate a method for assessing current glass cladding design procedures. For the case considered in the paper, it was found that transformation of the peak wind load averaged over 1–2 seconds into an equivalent 1-minute load appears to underestimate the probability of failure of glass cladding. The work reported in the paper is part of an ongoing window cladding research program being conducted at the National Bureau of Standards.

BSS155. Domanski, P.; Didion, D. **Computer modeling of the vapor compression cycle with constant flow area expansion device.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 155;* 1983 May. 162 p. SN003-003-02500-3.

Key words: air conditioner; capillary tube; coil; compressor; condenser; evaporator; expansion device; heat pump; modeling; vapor compression cycle.

An analysis of the vapor compression cycle and the main components of an air source heat pump during steady-state operation has been performed with emphasis on fundamental phenomena taking place between key locations in the refrigerant system. The basis of the general heat pump model formulation is the logic which links the analytical models of heat pump components together in a format requiring an iterative solution of refrigerant pressure, enthalpy and mass balances.

The modeling effort emphasis was on the local thermodynamic phenomena which were described by fundamental heat transfer equations and equation of state relationships among material

performance of each coil tube is computed separately by considering the cross-flow heat transfer with the external air stream and the appropriate heat and mass transfer relationships. A capillary tube model was formulated with the aid of Fanno flow theory.

The developed heat pump model has been validated by checking computer results against laboratory test data for full and part load operation for the cooling/dehumidifying mode as well as the heating mode under frosting conditions.

BSS156. Kusuda, T.; Piet, O.; Bean, J. W. **Annual variation of temperature field and heat transfer under heated ground surfaces (slab-on-grade floor heat loss calculation).** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 156;* 1983 June. 67 p. SN003-003-02511-9.

Key words: ASHRAE design values; building heat transfer; Delsante method; earth temperature; slab-on-grade heat transfer; soil temperature.

Seasonal sub-surface ground temperature profiles and surface heat transfer were determined for the condition whereby one and more than one region of the earth's surface temperature were disturbed. The analysis was conducted by numerical integration using a closed form solution based on the Green's function. Monthly profiles of earth temperature isotherms under a house of 20′×20′ (6.1m×6.1m) floor area and under a ground of six houses near a wooded area are presented. The heat losses calculated from this approach for square slabs of various sizes were compared with those derived from the recent analytical solution of Delsante et al. resulting in good agreement.

The Delsante solution, which is based upon a Fourier Transform technique, is then extended to generate the frequency domain thermal response factors suitable for the periodic heat transfer calculation for multi-layer slab floors on grade.

In the appendix, this thermal response factor method was used to generate annual cycles of monthly heat loss from several slab floor constructions shown in the 1981 ASHRAE Handbook of Fundamentals. The maximum values of these monthly slab floor heat losses agree relatively well with the ASHRAE design values.

BSS157. Hyland, R. W.; Hurley, C. W. **General guidelines for the on-site calibration of humidity and moisture control systems in buildings.** *Natl. Bur. Stand. (U.S.) Bldg. Sci. Ser. 157;* 1983 September. 56 p. SN003-003-02529-1.

Key words: chilled mirror hygrometer; dew point temperature; humidity generator; humidity sensors; lithium chloride humidity sensors; moisture content of building air; relative humidity; saturated salt solutions; sensor calibration; sensor precision; specific humidity; wet-bulb temperature.

The control of the moisture content in the air in buildings directly affects the comfort of the building occupants and is one of the more important tasks of an energy management and control system (EMCS). Unfortunately, a lack of understanding of the principles of operation and calibration of the various instrumentation used in monitoring the moisture content of air often makes this one of the most difficult and most neglected tasks for those assigned the responsibility of maintaining and operating building heating, ventilating and air-conditioning (HVAC) control systems.

This report was written for the purpose of assisting the managers and operators of EMCS in buildings in the understanding and use of various techniques for on-site measurement of the moisture content in the air. In addition, various methods of on-site calibration of typical types of moisture monitoring instruments are also discussed.

The ideal gas law is reviewed because of its direct application in converting the various humidity units. Relative humidity and dew point temperature are defined and their relationship described. Typical types of moisture monitoring instruments are described together with their method of operation. Several calibration techniques are discussed together with their typical advantages and disadvantages. The last section of this report is devoted to the assessing and reporting of the errors or uncertainties associated with the calibration and functioning of various moisture monitoring instruments. This very important area is often neglected and can result in excessive operating and maintenance costs.

5.9 FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

Publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315), dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations). This series is available only from the National Technical Information Service, Springfield, VA 22161.

FIPS PUB 11-2. Walkowicz, J., Standards Coordinator. **Guideline: American National Dictionary for Information Processing Systems.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 11-2;* 1983 May 9. 157 p.

Key words: computers; data processing; definitions; dictionary; Federal Information Processing Standards Publication; information processing; terms; vocabulary.

This publication adopts X3TR-1-82, American National Dictionary for Information Processing Systems, as a FIPS Guideline. It provides a common reference within the Federal Government for terms and definitions used in such information processing activities as the representation, communication, interpretation and processing of data by human or automatic means.

The Dictionary consists of a single alphabetic listing of over 4000 terms and their definitions. The label (ISO) is used in the Dictionary to indicate terms and definitions that have been approved by the International Organization for Standardization.

FIPS PUB 60-2. Burr, W. E.; Recicar, S. A., Standards Coordinators. **I/O channel interface.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 60-2;* 1983 July 29. 104 p.

Key words: automatic data processing (ADP); channel level power control interface; computer peripherals; computers; Federal Information Processing Standard; input/output; interfaces.

This standard defines the functional, electrical, and mechanical interface specifications for 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 63-1. Burr, W.; Recicar, S., Standards Coordinators. **Operational specifications for variable block rotating mass storage subsystems.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 63-1;* 1983 April 14. 50 p.

Key words: command codes; disk drives; Federal Information Processing Standard; format track; operational specification; rotating mass storage subsystems; sense information; status byte.

This standard provides operational specifications for command codes, data formats, sense and status information, etc., for variable block rotating mass storage subsystems which attach to the I/O Channel Interface, FIPS 60. This standard will facilitate the connection of variable block rotating mass storage subsystems to general purpose computer systems; however, additional optional specifications of track format and sense information are provided for the most common device types.

FIPS PUB 90. Bagg, T. C., Standards Coordinator. **Guidelines for optical character recognition (OCR) print quality.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 90;* 1983 September 29. 4 p.

Key words: computer systems; data entry (automatic); Federal Information Processing Standards Publication (FIPS PUB); information processing systems; optical character recognition; print quality.

This Guideline provides basic information on methods for evaluating the readability of printed characters and symbols that are to be optically recognized by electronic means. In addition, it gives tolerance ranges which permit the system designers to make the most beneficial cost tradeoffs between the various parts of a complete optical character recognition system.

The specifications are contained in "Guidelines for Optical Character Recognition (OCR) Print Quality" ANS X3.99-1983 published by the American National Standards Institute.

This Guideline is related to FIPS PUBS 32-1, 40, 85, and 89.

FIPS PUB 92. Saltman, R.; Walkowicz, J., Standards Coordinators. **Guideline for Standard Occupational Classification (SOC) Codes.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 92;* 1983 February 24. 30 p.

Key words: data element; Federal Information Processing Standards Publication; occupational classification; occupational codes; representations and codes; statistical standard.

This Guideline adopts the set of codes used to identify the occupational classifications published in the *Standard Occupational Classification Manual 1980*, and promulgated as Directive 10 by the Office of Federal Statistical Policy and Standards (now the Regulatory and Statistical Analysis Division, Office of Information and Regulatory Affairs, Office of Management and Budget). The Standard Occupational Classification provides a mechanism for cross-referencing and aggregating occupation-related data collected by social and economic statistical reporting programs. The system is designed to maximize the analytical utility of statistics on the labor force, income, and other occupational data collected for a variety of purposes by various agencies of the U.S. Government, State agencies, professional associations, labor unions, and private research organizations.

FIPS PUB 94. Recicar, S., Standards Coordinator. **Guideline on electrical power for ADP installations.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 94;* 1983 September 21. 98 p.

Key words: computer; electrical power; Federal Information Processing Standards Publication; grounding; isolating transformers; life-safety; lightning protection; motor-generator sets; power conditioning; shielding; signal reference grids; surge arrestors; uninterruptible power source.

This recommended Guideline for Federal agencies identifies and describes the electrical environment for safe, reliable operation of automatic data processing (ADP) systems. The electrical environment in and immediately outside the computer room is considered. The Guideline describes the fundamentals which underlie the power, grounding, and life-safety requirements, and provides a guide and checklist for specifying and preparing ADP sites, and evaluating their suitability.

An annotated bibliography is provided.

FIPS PUB 95. Saltman, R. G., Standards Coordinator. **Codes for the identification of Federal and Federally-assisted organizations.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 95;* 1982 December 23. 75 p.

Key words: administration; codes; computers; data; element; Federal Information Processing Standard; information interchange; organization.

This Standard provides a four-character identifier for each organization listed. The two leftmost characters form a component data element, called the Treasury Agency Symbol (TAS), which is identical to the two-digit numerical code used in the budgetary process to identify major Federal agencies. Organizations that are related by a common budgetary appropriation usually have the same TAS code. Organizations identified in this Standard include legislative, judicial, and executive branch agencies, as well as those Federal-State, interstate, and international organizations that receive budgetary support. Government-sponsored enterprises and certain Federally-aided organizations are included also. Provision is made for the inclusion of additional categories of organizations.

FIPS PUB 96. Moore, K., Standards Coordinator. **Guideline for developing and implementing a charging system for data processing services.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 96;* 1982 December 6. 84 p.

Key words: ADP services; chargeback; charging system; computer service; cost recovery; DP service; Federal Information Processing Standards Publication; performance evaluation; performance management.

This Guideline describes a step-by-step methodology for developing and implementing a charging system for use in Data Processing (DP) facilities. Charging for DP services refers to distributing the costs of providing DP services to the users who receive the services. The distribution of costs requires definition of the basic DP services, the resources used to provide the services, and the costs incurred to obtain and make use of the resources. A charging system is comprised of two subsystems: the rate-setting subsystem and the billing subsystem. The rate-setting subsystem incorporates procedures for forecasting the use of each service, forecasting the costs of the resources used to provide each service, and establishing the rate to be charged for each unit of service. The billing subsystem includes procedures for monitoring the use of services, applying the billing rates to compute the total charge for the services each user receives, and reporting the charges to the user and to appropriate accounting groups.

The Federal Government has established policies through the Office of Management and Budget Circular A-121 that calls for distributing the "full cost of operating DP facilities to users according to the services they receive." This Guideline describes a charging system. Four phases and 14 steps are identified in the procedure. Major decisions are identified, recommendations are presented, and "best" practices are described.

FIPS PUB 97. Burr, W.; Recicar, S., Standards Coordinators. **Operational specifications for Fixed Block Rotating Mass Storage Subsystems.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 97;* 1983 February 4. 88 p.

Key words: computers; FBRMS; Federal Information Processing Standard; fixed block; I/O channel interface; magnetic disk controller; magnetic disks; mass storage subsystems; sense information.

This specification is intended for use in the acquisition of Fixed Block Rotating Mass Storage (FBRMS) Subsystems (e.g., magnetic disk devices with fixed sized blocks and their controllers), and is a companion to the I/O Channel Interface Standard, FIPS 60. This standard defines the command repertory for FBRMS subsystems, sense information supplied by FBRMS subsystems for error recovery purposes and error recovery procedures for both FBRMS subsystems and attached computers. This standard does not specify recording technology or the internal implementation of subsystems; consequently, storage geometries, recording formats, physical addressing, and hardware diagnostic sense information are not specified.

FIPS PUB 98. Watkins, S.; Mulvenna, G., Standards Coordinators. **Message format for computer-based message systems.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 98;* 1983 March 1. 63 p.

Key words: computer-based message system; Federal Information Processing Standard; interchange codes; interconnection; media and data files; message format; software standard.

A computer-based message system (CBMS) allows communication between "entities" (usually people) using computers. Computers serve both to mediate the actual communications between systems and to provide users with facilities for creating and reading the message.

The message format specification addresses the problem of exchanging messages between different CBMSs. The specification addresses only the issues of form and meaning of messages at the points in time when they are sent from one CBMS and received by another. Messages are composed of *fields*, containing different classes of information. These fields contain information about the message originator, message recipient, subject matter, precedence and security, and references to previous messages, as well as the text of the message. Standard formats (*syntax*) for messages provide a basis for the contents of messages generated by one CBMS to be processed by another CBMS. Standard meanings (*semantics*) for the components of a message facilitate standard interpretation of a message, so that everyone receiving a message gets the meaning intended by its sender.

FIPS PUB 99. Houghton, R. C., Jr., Standards Coordinator. **Guideline: A framework for the evaluation and comparison of software development tools.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 99;* 1983 March 31. 26 p.

Key words: dynamic analysis; Federal Information Processing Standards Publication; programming aids; software development; software engineering; software tools; static analysis; taxonomy.

A framework for the evaluation and comparison of software development tools is introduced and presented. The framework is a hierarchical structure of tool features that provides the level of detail necessary to analyze and classify the capabilities of tools. Through a careful analysis of tool features, one can obtain a better understanding of the characteristics of a tool and can compare these characteristics with those of other tools.

FIPS PUB 100. Wong, M., Standards Coordinator. **Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for operation with packet-switched data communications networks.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB 100);* 1983 July 6. 13 p.

Key words: automated data processing; computer networking; data circuit-terminating equipment; data communications; data terminal equipment; Federal Information Processing Standard; packet switching; public data network; Recommendation X.25; telecommunications.

This joint Federal Information Processing Standard (FIPS) and Federal (Telecommunication) Standard (FED-STD) specifies the means of interfacing automated data processing (ADP) equipment and services, as well as telecommunication system terminal equipment, with packet-switched data communication networks. It is based on Recommendation X.25 which was developed and approved by the International Telegraph and Telephone Consultative Committee (CCITT) of the International Telecommunications Union (ITU). Recommendation X.25 contains a large number of options and implementation alternatives, which if exercised in different ways would impede the interoperability of equipment and services. This joint standard limits these options and alternatives in order to satisfy the vast majority of Federal user requirements for interconnections with packet-switched data communications networks.

FIPS PUB 104. Saltman, R.; Walkowicz, J., Standards Coordinators. **Guideline for implementation of ANSI Codes for the Representation of Names of Countries, Dependencies, and Areas of Special Sovereignty.** *Natl. Bur. Stand. (U.S.) Fed. Info. Process. Stand. Publ. (FIPS PUB) 104;* 1983 September 19. 27 p.

Key words: code; country; data; Federal Information Processing Standard; geographic code; information resources management; ISO; standard.

This Guideline implements ANSI Z39.27, Structure for the Representation of Names of Countries of the World for Information Interchange, of the American National Standards Institute (ANSI). ANSI Z39.27 adopts, with qualifications, the entities, names, and codes prescribed by ISO 3166, Codes for the Representation of Names of Countries, a standard of the International Organization for Standardization (ISO). The qualifications provide for complete coverage of the land areas of the world without overlap or

duplication, and for entity names that, to the maximum extent possible, are approved or accepted by the United States Board on Geographic Names.

Both two and three-character alphabetic codes are provided for each entity adopted from ISO 3166. The two-character codes are provided for general use and are recommended by ISO for international interchange. The three-character codes are available for special applications when their use would provide a particular advantage.

5.10 VOLUNTARY PRODUCT STANDARDS

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

No publications issued in this period.

Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other Government agencies.

TN910-6. Nicodemus, F. E., ed. **Self-study manual on optical radiation measurements: Part I—Concepts, Chapter 10. Introduction to coherence in radiometry.** *Natl. Bur. Stand. (U.S.) Tech. Note 910-6;* 1983 March. 69 p. SN003-003-02468-6.

Key words: coherence; cross-spectral density; incoherence; interference; partial coherence; radiometry; spectroradiometry; wave optics.

This is the sixth in a series of Technical Notes (910-6) entitled "Self-Study Manual on Optical Radiation Measurements." It contains Chapter 10 of Part I of this Manual. Additional chapters will continue to be published, similarly, as they are completed. The Manual is a comprehensive tutorial treatment of the measurement of optical radiation that is complete enough for self instruction. Detailed chapter summaries make it also a convenient authoritative reference source.

In this chapter we introduce the reader to the basic field quantity of the theory of partial coherence, the cross-spectral density function, and show how it is used to describe radiation fields. We discuss the propagation of cross-spectral density along a beam and illustrate this propagation with calculations of diffraction effects in a number of simple aperturing and imaging examples. For instance, we treat in considerable detail one of the most common radiometric situations in which coherence effects can manifest themselves, the measurement of the slit-scattering function of a monochromator. Among other things, this treatment shows that laser illumination of a monochromator entrance slit must be nearly on-axis to avoid serious slit-scattering function distortions. Finally, we present the relationships between the cross-spectral density function and the classical radiometric quantities, such as spectral radiance.

TN1056. Glaze, D. J.; Stein, S. R. **Picosecond time difference measurements utilizing CAMAC-based ANSI/IEEE-488 data acquisition hardware Operating Manual IE3 version 1.0.** *Natl. Bur. Stand. (U.S.) Tech. Note 1056;* 1983 August. 36 p. SN003-003-02509-1.

Key words: ANSI/IEEE-488; ANSI/IEEE-583; automated data acquisition system; dual-mixer measurements; picosecond time-difference measurements.

Automated time-difference measurements at the picosecond level have been achieved. The system described combines the best properties of three common methods: the single heterodyne measurement technique, the frequency divider, and the dual-mixer time-difference measurement system. This particular system combines two instrumentation standards, ANSI/IEEE-583 and ANSI/IEEE-488 with new, modular dual-mixer time-difference measurement hardware. The modular, standardized hardware together with the new measurement techniques permit the data acquisition modules to be contained in a standard CAMAC crate. This system, along with an external controller, is capable of measuring eight clocks, at the present time, and is expandable to twenty-four clocks with modified software and additional measurement modules. The system noise performance is described by $\sigma_y(\tau)=3\times10^{-12}\tau^{-1}$ for time difference measurements.

TN1060. Gallawa, R. L.; Chamberlain, G. E.; Day, G. W.; Franzen, D. L.; Young, M. **Measurement of multimode optical fiber attenuation.** *Natl. Bur. Stand. (U.S.) Tech. Note 1060;* 1983 June. 52 p. SN003-003-02496-1.

Key words: attenuation; attenuation measurement; fiber measurement; optical fibers; optical waveguides.

This document is one of a series which describes optical fiber measurement capabilities at the National Bureau of Standards. We concentrate here on the measurement of attenuation of multimode, telecommunication-grade fibers for the wavelength range of 850 nm to 1300 nm. The document begins by discussing the need for restricted launch conditions, the most fundamental and crucial aspect of precise attenuation measurements. The limited phase space launch (also called the beam optics launch) and the mode filter launch are discussed. Attention then turns to the practical matter of ensuring that the conditions of the restricted launch are met. Discussions of system noise and system linearity are also included. The document describes measurement procedure and results obtained in the laboratory using three typical fibers. Results are presented for the two wavelengths of current interest: 850 nm and 1300 nm. The procedures are applicable to any wavelength, however. The document touches briefly on the matter of monomode fibers. Finally, a summary of the results from an interlaboratory comparison are presented to give perspective to the stability of a fiber subjected to handling and shipping.

TN1061. Eaton, B. E.; Ely, J. F.; Hanley, H. J. M.; McCarty, R. D.; Rainwater, J. C. **Phase equilibria: An informal symposium.** *Natl. Bur. Stand. (U.S.) Tech. Note 1061;* 1983 January. 156 p. SN003-003-02459-7.

Key words: critical line; extended corresponding states; fluids; hydrocarbons; mixtures; phase equilibria; prediction.

This Technical Note reports an informal conference on phase equilibria held at the National Bureau of Standards, Boulder, CO in October 1980. Talks were given on extended corresponding states, critical behavior, mixing rules and, in general, the prediction of the phase behavior of simple mixtures. A survey of methods used in industry was also presented. Suggested work for the future is given.

TN1062. Kanda, M. **An electric and magnetic field sensor for simultaneous electromagnetic near-field measurements—Theory.** *Natl. Bur. Stand. (U.S.) Tech. Note 1062;* 1983 April. 36 p. SN003-003-02476-7.

Key words: electric field; electromagnetic interference; electromagnetic radiation; loop; magnetic field; near fields.

This paper describes the theory of a single sensor to perform simultaneous electric and magnetic near-field measurements. The theory indicates that it is possible to obtain the magnetic-loop and electric-dipole currents using a loop terminated with identical loads at diametrically opposite points. The theory also indicates that it is possible to obtain an ideal load impedance for achieving equal electric and magnetic field responses of the loop. Preliminary experiments have been performed using plane waves to verify these results.

TN1063. Greenlee, D. H.; Kanda, M.; Chang, D. C. **The characteristics of iris-fed millimeterwave rectangular microstrip patch antennas.** *Natl. Bur. Stand. (U.S.) Tech. Note 1063;* 1983 October. 50 p. SN003-003-02524-1.

Key words: antenna gain; aperture coupling; cavity; half-power beamwidth; iris; microstrip; millimeterwave; patch antenna; power pattern.

The fabrication of various iris-fed millimeterwave rectangular microstrip patch antennas is described. A model is proposed to describe the iris-fed antenna. Irises ranging in size from 15 percent of the area of the patch to the fully open waveguide are used to couple energy into the antenna. Resonance of the antenna is observed to be insensitive to the size of the iris for irises up to 115 percent of the size of the patch. A study is also made of the relationship of coupling to the antenna as a function of the position of the iris with respect to the transverse plane of the waveguide, the iris always being centered with respect to the patch. In general, the antenna has a VSWR in the waveguide feed on the order of 5:1 at resonance, except for the fully open waveguide which gives rise to a VSWR of 2.9:1 at resonance. Far-field antenna power patterns are observed to be quite broad with H-plane beamwidths on the order of 130°. Maximum antenna gain is seen to be 4.5 dBi with 3 dBi typical. An initial study is made of the microstrip patch antenna fed from a longitudinal waveguide wall. Results indicate that this feed structure is likely to prove valuable for microstrip patch antennas with coupling at least as good as for the transverse-fed patch added to the possibility of feeding of multiple patches from a single waveguide.

TN1064. Ma, M. T.; Koepke, G. H. **Uncertainties in extracting radiation parameters for an unknown interference source based on power and phase measurements.** *Natl. Bur. Stand. (U.S.) Tech. Note 1064;* 1983 June. 48 p. SN003-003-02497-0.

Key words: dipole moments; electrically small source; error analysis; interference sources; phase measurements; power measurements; radiation pattern; TEM cell; total radiated power; uncertainties.

A method for determining the radiation characteristics of a leaking interference source has been reported in a previous publication, in which the unintentional electrically small leakage source was modeled by two vectors representing a combination of equivalent electric and magnetic dipole moments. An experimental setup, measurement procedures, and the necessary theoretical basis were all described therein to explain how the relevant source parameters can be extracted from the measurement data of output powers and phases taken when the interference source is placed inside a transverse electromagnetic (TEM) cell. Simulated examples were also given to show that the equivalent source parameters of unknown vector dipole moments and thus the detailed radiation pattern and the total power radiated by the source in free space could be uniquely determined by the method if the measurement data were not contaminated by noise. This report presents the mathematical analysis of the uncertainties in the final, extracted results when the experimental data are degraded by the background noise and measurement inaccuracies.

TN1065. Danielson, B. L. **Optical time-domain reflectometer performance and calibration studies.** *Natl. Bur. Stand. (U.S.) Tech. Note 1065;* 1983 June. 32 p. SN003-003-02498-8.

Key words: APD; avalanche photodiodes; backscattering; backscatter signatures; optical fiber scattering; optical time-domain reflectometer; OTDR.

The measurement accuracy of the optical time-domain reflectometer (OTDR) is restricted in some applications by a limited operational dynamic range and by a lack of standardized test procedures. In an effort to better understand these restrictions, we have measured the range of linearity of some avalanche photodiodes used as backscatter detectors. Also, the effect of input launch conditions is examined and a possible standardized OTDR test procedure is proposed. Using these suggestions, we have made comparisons between attenuation values determined by cutback and backscatter methods and found that good agreement is possible. Finally, some methods are described for checking the response linearity of OTDR systems.

TN1066. Liu, B. H.; Chang, D. C.; Ma, M. T. **Eigenmodes and the composite quality factor of a reverberating chamber.** *Natl. Bur. Stand. (U.S.) Tech. Note 1066;* 1983 August. 54 p. SN003-003-02510-1.

Key words: cavity; composite quality factor; eigenfrequency; eigenmode; electromagnetic field; mode density; mode number; reverberating chamber.

The total number N of electromagnetic eigenmodes, with eigenfrequencies not greater than some given value, which can exist inside a rectangular mode-stirred or mode-tuned reverberating chamber is important in that it reveals how many modes can be available at an operating frequency for the "stirring" or tuning purpose. This is calculated analytically via a lattice-point counting technique in the k-space (k=wave number), leading to an exact expression for N, which can be split into a smooth component and a fluctuating part. The former contains, in addition to Weyl's volume term, an edge term as a second-order correction. The latter is sensitive to the dimensions of the chamber. Simple design criteria are then derived in view of the number of available modes and the uniformity of their distribution. To take into account the ohmic loss in metal walls of the chamber, a composite Q-factor is also proposed for design purposes. This is achieved by taking a suitable average of 1/Q-values of all possible modes within a small frequency interval. Comparison with numerical Q-values for individual modes shows that the composite Q can be used as a practical design parameter.

TN1067. Andrews, J. R.; Bell, B. A.; Baldwin, E. E. **Reference flat pulse generator.** *Natl. Bur. Stand. (U.S.) Tech. Note 1067;* 1983 October. 72 p. SN003-003-02527-5.

Key words: available waveform; baseline; circuit analysis; flat pulse generator; modeling; step response; topline; transfer standard; transition duration.

A reference step-like pulse generator is described which has been developed for NBS. This generator can be used for accurately characterizing the step response of various kinds of transient recording equipment (oscilloscopes, waveform recorders, transient digitizers, etc.). Basic design principles are given as well as complete circuit diagrams and descriptions. An analysis of the output stage of the generator is presented together with the circuit models for developing a time-domain computer simulation program using extended-SCEPTRE. Preliminary specifications indicate that the NBS Reference Flat Pulse Generator provides a negative-going reference transition duration (90 to 10 percent) of 600 ps, ±2 percent after 5 ns.

TN1068-1. Donaldson, J. R.; Tryon, P. V. **Introduction to STARPAC, The standards time series and regression package.** *Natl. Bur. Stand. (U.S.) Tech. Note 1068-1;* 1983 October. 24 p. SN003-003-02525-9.

Key words: data analysis; STARPAC; STARPAC overview; statistical computing; statistical subroutine library; STATLIB.

STARPAC, the Standards Time Series and Regression Package, is a library of Fortran subroutines for statistical data analysis developed by the Statistical Engineering Division (SED) of the National Bureau of Standards (NBS), Boulder, Colorado. Earlier versions of this library were distributed by the SED under the name STATLIB [Tryon and Donaldson, 1978]. STARPAC incorporates many changes to STATLIB, including additional statistical techniques, improved algorithms and enhanced portability. STARPAC emphasizes the statistical interpretation of results, and, for this reason, comprehensive printed reports of auxiliary statistical information, often in graphical form, are automatically provided to augment the basic statistical computations performed by each user-callable STARPAC subroutine. STARPAC thus provides the best features of many stand-alone statistical software programs within the flexible environment of a subroutine library. STARPAC documentation is being published as a series of Technical Notes. This Note is the first in the series. It gives an overview of the STARPAC library, defines conventions used in the documentation, provides an example using STARPAC subroutines, and presents general background material. This Note includes information which is essential for using the STARPAC library, and users should be familiar with its contents before attempting to use any STARPAC subroutine.

TN1068-2. Donaldson, J. R.; Tryon, P. V. **Nonlinear least squares regression using STARPAC, The standards times series and regression package.** *Natl. Bur. Stand. (U.S.) Tech. Note 1068-2;* 1983 October. 64 p. SN003-003-02526-7.

Key words: derivative checking; derivative step size selection; NL2SOL; nonlinear least squares; nonlinear regression; quasi-Newton methods; STARPAC; statistical computing; statistical subroutine library; statistics; weighted nonlinear least squares.

STARPAC, the Standards Time Series and Regression Package, is a library of Fortran subroutines for statistical data analysis developed by the Statistical Engineering Division (SED) of the National Bureau of Standards (NBS), Boulder, Colorado. Earlier versions of this library were distributed by the SED under the name STATLIB [Tryon and Donaldson, 1978]. STARPAC incorporates many changes to STATLIB, including additional statistical techniques, improved algorithms and enhanced portability. STARPAC emphasizes the statistical interpretation of results, and, for this reason, comprehensive printed reports of auxiliary statistical information, often in graphical form, are automatically provided to augment the basic statistical computations performed by each user-callable STARPAC subroutine. STARPAC thus provides the best features of many stand-alone statistical software programs within the flexible environment of a subroutine library. This Note documents 16 subroutines for nonlinear least squares regression. Twelve of these compute the least squares estimates, performing either weighted or unweighted analysis with either numerically approximated or user-supplied (analytic) derivatives. The other four are user-callable subroutines for two procedures used within the estimation code: the first selects optimum step sizes for approximating the partial derivatives of the model; and the second checks the validity of a user-supplied derivative subroutine.

TN1070. Ely, J. F.; Baker, J. K. **A review of supercritical fluid extraction.** *Natl. Bur. Stand. (U.S.) Tech. Note 1070;* 1983 December. 84 p. SN003-003-02537-2.

Key words: extraction; fluids; research needs; review; supercritical.

During the past ten years there has been intense interest in the application of dense gas separation techniques to various chemical processing problems. An example is known as supercritical fluid extraction. The purpose of this report is to summarize various aspects of supercritical fluid extraction including a definition of the phenomena, current industrial applications, technical difficulties and, where possible, the identification of areas where further research would be of value. In addition, processing aspects which impact on the cost effectiveness of supercritical fluid extraction are considered.

Current research which bears upon the development of supercritical fluid extraction is presented and recommendations for certain high risk research activities are summarized. In addition, a brief review of supercritical fluid chromatography is presented and chemical kinetics in supercritical phases are briefly discussed.

TN1071. Daywitt, W. C. **Design and error analysis for the WR10 thermal noise standard.** *Natl. Bur. Stand. (U.S.) Tech. Note 1071;* 1983 December. 45 p. SN003-003-02538-1.

Key words: antenna efficiency; diffraction; error analysis; millimeter wave; noise standard; plane-wave scattering matrix.

This note describes the design and error analysis of a WR10 thermal noise power standard. The standard is designed to operate at the boiling point of liquid nitrogen with a noise temperature output accurate to ± 1 K.

TN1113-3. Flynn, D. R.; Yaniv, S. L. **Highway noise criteria study: Relations among frequency rating procedures.** *Natl. Bur. Stand. (U.S.) Tech. Note 1113-3;* 1983 February. 57 p. SN003-003-02474-1.

Key words: acoustics; environmental pollution; highway noise; motor vehicle noise; noise; noise control; sound; traffic noise; transportation noise.

A series of calculations was performed to ascertain how well one frequency-weighted rating, such as weighted sound level, loudness level, or perceived noise level, may be predicted from another such rating. A total of 103 average sound level spectra, measured at several distances from different types of highways, were used in these calculations. It was found that knowing a single noise rating, such as the A-weighted sound level, enables one to predict other outdoor ratings in this set of 103 spectra with a standard deviation of the order of 1 to 2 dB. If, in addition, traffic speed and mix and the distance to the highway are taken into account, these standard deviations can be reduced to 0.5 to 1 dB, depending upon the particular noise rating of interest. Equations are given for predicting one rating from another; the associated standard deviations are presented as a measure of how well any given rating can be predicted from a single measured, or otherwise known, noise rating. It is concluded that it is not very critical which frequency-weighting procedure is used in conjunction with highway noise criteria since one descriptor can be predicted from another with a rather small statistical uncertainty. Thus, if human response criteria, or stimulus-response relationships, have been developed in terms of one frequency-weighting procedure, these may be translated into equivalent criteria expressed in terms of a metric that is easier to measure or predict.

TN1172. Weber, S. F.; Lippiatt, B. C. **Productivity measurement for the construction industry.** *Natl. Bur. Stand. (U.S.) Tech. Note 1172;* 1983 February. 39 p. SN003-003-02472-4.

Key words: construction industry; economics; index; input; output; productivity measurement; single factor productivity; total factor productivity.

The fundamental concept underlying all productivity measures is a comparison of the output of a production process, an enterprise, an industry, or an economy with the corresponding factors of production (inputs) required to generate that output. Productivity measures are formulated as a ratio of output to one or more of the inputs. This report evaluates alternative productivity measures and concludes that the comprehensive Total Factor Productivity (TFP) method is preferred to the Single Factor Productivity method. To combine the multiple components in the denominator of a TFP index, a weighting system based on relative factor cost shares is recommended. A measurable index of the instantaneous rate of change in TFP between two time periods is derived from a general production function. The report also investigates the specific data requirements for implementing this TFP measure in the construction industry. An annotated bibliography is included.

TN1173. Cohen, J. **Three guises of generation-recombination noise.** *Natl. Bur. Stand. (U.S.) Tech. Note 1173;* 1983 April. 12 p. SN003-003-02482-1.

Key words: generation-recombination; junction; noise; semiconductors.

It is shown that the noise in a zero-biased junction may be just a manifestation of the normally-occurring generation-recombination process, rather than shot noise, as is usually presumed. In addition, an attempt is made to clarify some noise mechanisms in semiconductors by addressing mathematical interpretation and terminology. In particular, for a biased homogeneous material at low frequencies, where the relevant transport mechanism is drift, a shot-like expression of the g-r noise equation is derived. For a zero-biased junction at low frequencies, where the relevant transport mechanism is diffusion, a pure shot-like expression of the g-r noise equation and an equivalent thermal (Nyquist) expression is derived. In both the homogeneous and the junction cases, however, the true noise remains generation-recombination noise, i.e., the origin of the noise is the fluctuations in the rates of generation and recombination of free carriers.

TN1174. Treado, S.; Barnett, J.; Kusuda, T. **Energy and cost evaluation of solar window film use in an office building.** *Natl. Bur. Stand. (U.S.) Tech. Note 1174;* 1983 March. 127 p. SN003-003-02483-0.

Key words: building energy analysis; cooling loads; heating loads; solar film; solar heat gain; window management.

The impact of solar window film utilization on building HVAC system loads, energy consumption and costs, is examined for a typical office building. The evaluation includes characterization and measurement of important film properties, performance of single-glazing window systems with and without film, simulation of annual building energy performance using the DOE-2 computer program, and a life-cycle cost analysis. Six window film options are compared to clear glass performance for seven climatic regions throughout the United States.

Guidelines are developed for effective solar film utilization in office buildings, in terms of energy performance and cost-effectiveness. Results indicate that solar films can be effective in reducing building energy requirements and costs in areas with high cooling loads, with less savings expected in areas with lower cooling loads and higher heating loads, and no savings in regions with high heating loads.

TN1175. Eckerle, K. L.; Weidner, V. R.; Hsia, J. J.; Chao, Z. W. **Extension of a reference spectrophotometer into the near infrared.** *Natl. Bur. Stand. (U.S.) Tech. Note 1175;* 1983 April. 34 p. SN003-003-02477-5.

Key words: lead sulfide detector; near infrared; photomultiplier; reference spectrophotometer; silicon photodiode; spectrophotometry; transmittance; wavelength.

The purpose of this paper is to document adaptation of an existing reference spectrophotometer to the near infrared. Its previous wavelength range was from approximately 200 to 800 nm. The present adaptation increases its wavelength range to 2500 nm. The hardware and software necessary to achieve this were implemented along with tests necessary to characterize the instrument when it is operated in the near infrared (800 to 2500 nm). The accuracy of the transmittance measurements ranges from approximately 0.0002 to 0.012 transmittance units depending on instrument configuration, wavelength, and the sample itself. Incidental to the success of this work was conversion to a dedicated microcomputer with interface boards. Many of the latter were designed at NBS.

TN1176. Dick, C. E.; Hilsenrath, J. **Utility programs for generating the Hershey character fonts on microcomputers and laboratory plotters.** *Natl. Bur. Stand. (U.S.) Tech. Note 1176;* 1983 June. 45 p. SN003-003-02490-2.

Key words: applesoft basic programs; camera-ready illustrations; digitized graphic symbols; Hershey character fonts; microcomputers.

Two programs are described that allow for the storage and manipulation of digitized fonts of graphic arts symbols and characters on the Apple II computer system. These fonts are based on the work of A. V. Hershey and provide the user with a repertory of digitized characters suitable for use in the preparation of camera-ready illustration in the laboratory environment. The programs described contain routines for reading files of the Hershey coordinates, storing them as text files, displaying them as individual characters or combined text on the high resolution display, and two methods for editing them or creating special symbols and graphics.

TN1177. Cohen, J. **Elements of thermography for nondestructive testing.** *Natl. Bur. Stand. (U.S.) Tech. Note 1177;* 1983 May. 35 p. SN003-003-02491-1.

Key words: heat; imagery; infrared; nondestructive testing; passive; radiation; remote sensing; temperature; thermography.

This paper presents an elementary review of thermal imaging systems, with emphasis on the application of thermography to nondestructive testing. Topics discussed include heat radiation theory; early and contemporary thermal imaging systems; performance characteristics; effects of emissivity, background temperature, atmosphere, and field of view. Examples of various applications of thermography to nondestructive testing are given. A bibliography is included.

TN1178. Shorten, F. J., ed. **NBS reactor: Summary of activities July 1981 through June 1982.** *Natl. Bur. Stand. (U.S.) Tech. Note 1178;* 1983 June. 231 p. SN003-003-02493-7.

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 1981 through June 1982. The programs range from the use of neutron beams to study the structure and dynamics of materials through nuclear physics and neutron standards to sample irradiations for activation analysis, isotope production, radiation effects studies, neutron radiography, and nondestructive evaluation.

TN1179. Ramboz, J. D.; McAuliff, R. C. **A calibration service for wattmeters and watthour meters.** *Natl. Bur. Stand. (U.S.) Tech. Note 1179;* 1983 July. 111 p. SN003-003-02505-4.

Key words: calibration; electric power and energy; electric standards; NBS services; watthour meters; wattmeters.

An NBS calibration service for wattmeters and watthour meters is described. The service offers measurements of percentage registration for watthour meters and percentage correction for wattmeters over a range of voltages and currents at a frequency of 60 Hz. Measurements are limited to power factors of 1.0 and 0.5, leading and lagging. The Measurement Assurance Program (MAP) for electric energy is discussed. National standards for electric energy, NBS services, special equipment and instruments, and measurement methods and procedures are described, as are error estimates and quality control. A representative Report of Calibration is included.

TN1180. Howett, G. L. **Size of letters required for visibility as a function of viewing distance and observer visual acuity.** *Natl. Bur. Stand. (U.S.) Tech. Note 1180;* 1983 July. 72 p. SN003-003-02502-0.

Key words: acuity, visual; angle, visual; contrast; distance, viewing; letters; luminance; resolution, eye; signs; Snellen chart; stroke width; visual acuity; visual angle.

A formula is derived giving the letter stroke-width needed for legibility of words on a sign at any given distance by an observer with any given visual acuity. The stroke width, in turn, determines the letter size, depending upon the characteristics of the type face used. The derivation is strictly mathematical and is based on the assumption that beyond a distance of a few meters, a person's visual acuity is specifiable by a fixed visual angle, independent of the distance. The information implicit in the formula is also presented graphically, in four plots that apply to four different combinations of length units for measuring stroke width and viewing distance. Also presented are formulas and graphs for correcting the critical stroke width for nonstandard contrast or background luminance. These correction formulas are based on a body of data on visual acuity as a function of contrast and background luminance, and a formula fitting the mid-ranges of the data, both published recently by other researchers.

TN1181. Purtell, L. P. **A high-speed data acquisition system for fluid mechanics measurements.** *Natl. Bur. Stand. (U.S.) Tech. Note 1181;* 1983 November. 31 p. SN003-003-02536-4.

Key words: data acquisition; fluid mechanics; hot-wire anemometry; measurement; minicomputers; turbulence.

The requirements, characteristics, and performance of a minicomputer-based data acquisition and analysis system suitable for research in fluid mechanics processes are presented. The particularly stringent requirements imposed by unsteady and turbulent flows are discussed including estimates of the required data acquisition rates and durations.

TN1182. Schoenwetter, H. K. **AC voltage calibrations for the 0.1 Hz to 10 Hz frequency range.** *Natl. Bur. Stand. (U.S.) Tech. Note 1182;* 1983 September. 58 p. SN003-003-02522-4.

Key words: ac voltage calibrations; ac voltage calibrators; ac voltage standards; infrasonic voltage measurements; low-frequency voltage measurements; rms voltmeters.

The development of voltmeters to meet the need for rms voltage measurements in the infrasonic frequency range is discussed as well as the need to trace these measurements to the U.S. legal unit of voltage. A new method for supporting voltage measurements in the 0.1 Hz–10 Hz range was described in a 1979 paper and is discussed further. The principles of the method are embodied in detailed procedures given for calibrating sine-wave voltage standards and rms voltmeters over the 0.1 Hz–10 Hz frequency range, using the NBS AC Voltmeter/Calibrator. The sine-wave calibrator of this instrument, used for these calibrations, has an accuracy of 0.020 percent over the 0.5 mV–7 V range.

5.12 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.

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 81-2253. Haar, L.; Gallagher, J. S.; Kell, G. S. **A thermodynamic surface for water: The formulation and computer programs.** 1983 June. 35 p. Available from: NTIS; PB 83-249789.

Key words: enthalpy; entropy; equation of state; heat capacity; Helmholtz function; internal energy; Joule-Thomson coefficient; second virial coefficient; speed of sound; the critical region; thermodynamic surface; water.

A FORTRAN 77 program is given with which thermodynamic properties for liquid and gaseous states for water can be calculated for the temperature and pressure range, $250 \leqslant T(K) \leqslant 4000$ and $0 \leqslant P \leqslant P_{max}$, where P_{max} is the lesser of the pressure of melting ice or 4 G Pa (40,000 bar). The program yields values for enthalpy, entropy, heat capacity, speed of sound, Joule-Thomson coefficient, second virial coefficient, isothermal compressibility coefficient, coefficient of thermal expansion, and $P\rho T$ relations that are everywhere in accord with accurate data for water. Included is a brief outline of the derivation of the equations.

NBSIR 81-2301. Fulcomer, P. M. **Field circuit breaker tester.** 1982 May. 52 p. Available from: NTIS; PB 83-136382.

Key words: circuit breaker; constant current; Consumer Product Safety Commission; electric power meter; on-site testing; overcurrent protection device; portable; residential applications; service entry; test.

Overcurrent protection devices are required within an electrical distribution system to minimize the possibility of electrically initiated fires caused by circuit overloads. Circuit breakers are the most commonly used form of overcurrent protection in new and recent residential construction. However, the complexity of the circuit opening mechanism typical of these devices makes them susceptible to mechanical deterioration, which can affect their operation. A circuit breaker so affected may perform its intended function for a direct short type of fault but may not respond adequately to a less severe circuit overload condition.

The possibility that an unknown number of installed circuit breakers might not perform as intended under certain overload conditions prompted the Consumer Product Safety Commission (CPSC) to initiate an investigative testing program. The program will include visiting various field locations, subjecting installed circuit breakers to controlled overcurrent conditions, and evaluating their performance. In order to obtain valid field performance data, the testing will be accomplished without removing or otherwise disturbing the circuit breakers.

Test equipment developed at NBS for the CPSC to evaluate the performance of single-pole circuit breakers in residential installations is described in this report, along with instructions for its use. The procedures are intended to be carried out by a test crew of at least two persons.

NBSIR 81-2302. Hardgrave, W. T.; Salazar, S. B. **The positional set processor: A tool for data modeling.** 1981 November 30. 22 p. Available from: NTIS; PB 83-198283.

Key words: database management systems; databases; DBMS; software tool.

The Positional Set Processor (PSP) is a software tool for manipulating mathematical objects such as sets, sequences, ordered pairs, etc. The PSP serves as the underpinning for a Data Model Processor (DMP), an experimental system for emulating commercial and prototype database management systems. The PSP also provides a mathematical basis for semantic specification and interpretation of database operations. While its powerful query facilities make the PSP itself appear to be a database management system, it has no explicit concept of data definition, no access control, no integrity control, etc. The authors prefer to view the PSP as a tool for specifying and building database management systems. This paper reviews the mathematical formalism, Positional Set Notation, and describes the design of the Positional Set Processor.

NBSIR 81-2341. Garvin, D.; Parker, V. B.; Wagman, D. D. **Chemical thermodynamic data banks.** 1981 August. 30 p. Available from: NTIS; PB 83-154542.

Key words: chemical thermodynamics; data banks; data evaluation; information systems; networks of data; standard reference data; thermochemistry.

A substantial critical evaluation of chemical thermodynamic measurements on inorganic and C_1–C_2 organic compounds has recently been completed. This provides selected values for some 14300 substances, based on a collection of 250,000 measurements. This work is placed in a historical context of three earlier comprehensive evaluations of thermochemical data.

During the course of this work data banks of several types have been developed: bibliography, extracted unevaluated data, evaluated measurements (catalogs of reactions) and selected chemical thermodynamic properties for individual substances. The design, structure and use of those data banks are described.

The course of modern data evaluation, based on these files, is discussed briefly in terms of tests for inter-measurement consistency and automated solutions of large networks of data.

A complementary thermodynamic data system developed at the Institute for High Temperatures, Moscow, USSR is described briefly. Proposed international activities are outlined.

NBSIR 81-2351. Mordfin, L., ed. **NDE Publications: 1979.** 1981 September. 32 p. Available from: NTIS; PB 83-184630.

Key words: abstracts; acoustic emission; bibliography; eddy currents; index; leak testing; magnetic testing; National Bureau of Standards; nondestructive evaluation; publications; radiography; ultrasonics.

This is the third in a series of bibliographies of NBS publications on nondestructive evaluation (NDE). It provides bibliographic citations, with selected abstracts, for 114 publications that appeared in the open literature, primarily during calendar year 1979. A detailed subject index is included as well as information on how copies of many of the publications may be obtained.

NBSIR 81-2364. Mordfin, L., ed. **NDE Publications: 1980.** 1981 October. 47 p. Available from: NTIS; PB 83-184622.

Key words: abstracts; acoustic emission; bibliography; eddy currents; index; leak testing; magnetic testing; National Bureau of Standards; nondestructive evaluation; publications; radiography; ultrasonics.

This is the fourth in a series of bibliographies of NBS publications on nondestructive evaluation (NDE). It provides bibliographic citations, with selected abstracts, for 108 publications that appeared in the literature, primarily during calendar year 1980. A detailed subject index is included as well as information on how copies of many of the publications may be obtained.

NBSIR 81-2405. Davies, A. D.; Cramp, A. P. **Coal taxonomy thesaurus of terms.** 1981 December. 81 p. Available from: NTIS; PB 83-215632.

Key words: coal; environment; health; index; safety; taxonomy; technology; terms; thesaurus.

This report contains a thesaurus to help public and private users find and retrieve information on regulations and standards which apply both to coal technologies and coal-related environmental, safety and health issues. Document indexers may also find it helpful. The thesaurus was designed to be structurally compatible with the document storage and retrieval systems now in use by the Department of Energy (DOE) so that absorption into DOE's system could be convenient and practical. The arrangement of the thesaurus, the code system that represents the terms used in the indexing and search processes, and instructions for its use are described. The

hierarchies of index terms in the thesaurus are illustrated.

NBSIR 81-2411. Pearl, M. H. **An examination of the state of the art in inland waterways system lock research.** 1982 March. 111 p. Available from: NTIS; PB 83-162727.

Key words: capacity; dam; lock; queue; simulation; waiting time.

Locks which pass waterborne traffic through dams act as bottlenecks and interfere with the free flow of traffic. Two complementary mathematical tools have been used to determine the maximum capacity of a lock and the operating procedures which achieve this capacity. These are i) computer simulations of traffic flows, and, ii) the mathematical theory of queues. A large-scale, multi-purpose simulation package was developed at the Pennsylvania State University and expanded by the Army Corps of Engineers. Several researchers have attempted to model the operation at a lock using mathematical queueing theory. In addition, queueing theory has been applied to analyze traffic flow through a bottleneck on other modes of transportation. Also, queueing theory has been used to study problems which arise in the use of computer simulations.

NBSIR 81-2418. Bur, A. J.; Tsao, A. K. **Fabrication of ultra-drawn thick PVDF transducers.** 1981 December. 24 p. Available from: NTIS; PB 83-215715.

Key words: draw ratio; modulus; orientation; piezoelectricity; poly(vinylidene fluoride); pyroelectricity; ultra-drawn; x ray.

Ultra-drawn PVDF (polyvinylidene fluoride) transducers have been fabricated from pellet resin material with thicknesses of 0.23, 0.30 and 0.50 mm. The samples were mechanically ultra-drawn beyond their natural 4:1 draw ratio to a 7:1 ratio in order to enhance the molecular orientation and thereby optimize the piezoelectric activity. The samples were characterized using modulus and x-ray measurements which showed that modulus increases with increasing draw ratio and that the crystalline portion of the 7:1 drawn material was mostly β phase. Ten out of fourteen samples were successfully poled at room temperature with fields ranging from 1.6 to 2.5 MV/cm. The pyroelectric activities ranged from 2.0 to 4.1 nc/cm^2K and the hydrostatic piezoelectric coefficients ranged from 8.6 to 15.6 pC/N.

NBSIR 81-2426. Taylor, B. N. **Numerical comparisons of several algorithms for treating inconsistent data in a least-squares adjustment of the fundamental constants.** 1982 January. 87 p. Available from: NTIS; PB 83-216358.

Key words: data analysis; discrepant data; fundamental constants; inconsistent data; least-squares adjustments; physical constants.

A number of recently proposed algorithms for treating inconsistent or discrepant data in a least-squares adjustment of the fundamental physical constants, along with several new but related algorithms, are compared in detail. The comparisons are first made by means of the numerical results the algorithms yield when applied to the same data considered by Cohen and Taylor in their 1973 adjustment which led to the recommended set of constants adopted by CODATA and in current use. A selected number of the algorithms are then further compared through the numerical results they yield when applied to the data considered by Taylor, Parker and Langenberg in their 1969 adjustment and by Cohen and DuMond in their 1963 adjustment. The principal conclusion of this paper is that the actual algorithm used to carry out an adjustment is much less important than the data finally selected for inclusion in the adjustment.

NBSIR 81-2435. Waxman, M.; Klein, M.; Gallagher, J.; Levelt Sengers, J. M. H. **Thermodynamic properties of isobutane.** 1982 February. 175 p. Available from: NTIS; PB 83-111005.

Key words: Helmholtz free energy functions; isobutane; saturated vapor pressure; thermodynamic properties.

A thermodynamic surface is presented for the thermodynamic properties of isobutane for temperatures from 250 to 600 K and pressures up to 40 MPa, exclusive of the critical region. The surface expressed analytically is in the form of the Helmholtz free energy as a function of temperature and density. The Helmholtz free energy is based upon three contributions: that of the ideal gas, of a physically based function incorporating the effects of molecular repulsion and attraction, and of a sum of residual terms that compensate for inadequacies of the physically based function. The surface is in accord with selected validated pressure-density-temperature data to within an average density tolerance of 0.1 percent and the liquid region with the exception of the critical region. Thermodynamic tables of isobutane expressed in three different unit systems and the computer programs for generating the properties are presented in the paper.

NBSIR 81-2456. Barnett, J. P. **Selected measured data from residential housing for use in testing and verification of building energy analysis programs.** 1982 January. 62 p. Available from: NTIS; PB 83-216341.

Key words: building energy analysis program; data tape; measured hourly data; testing and verification.

A set of measured residential data has been culled from three larger data sets for use in the testing and verification of building energy analysis programs. The data consist of hourly values for heating/cooling system performance and weather conditions that are sufficient in detail, it is believed, for all existent computer programs. These data have been encoded onto a magnetic tape. In addition, general information has been collected on the houses, occupants/occupant use, and heating/cooling systems.

NBSIR 81-2459. Dehl, R. E.; Grant, W. H.; Cassel, J. M. **Characterization of porosity in porous polymeric implant materials.** 1982 January. 60 p. Available from: NTIS; PB 83-172023.

Key words: pore size; pore volume; porous implants; porous polyethylene; PTFE-carbon composite.

In this report, we describe the application of several methods of porosity characterization to two commercial polymeric implant materials, a porous polyethylene and a composite of PTFE and carbon. In exploring the use of mercury porosimetry to determine interconnecting pore size distributions in the composite, we have found that, contrary to widespread belief, this rather soft and deformable material was not distorted by the mercury pressures required to measure its pore size distribution. The mercury intrusion technique indicated that the porous polyethylene has a narrower distribution of pore sizes than the composite. In the polyethylene and the composite, the weighted average interconnecting port "diameters" were found by this technique to be, respectively 30 μm and 50 μm. The average pore diameters were also estimated by measurement of specific surface area and pore volume. Assuming a spherical pore shape, the average pore diameters in polyethylene and composite were calculated to be, respectively, 60 μm and 25 μm. The accessible pore volumes of the materials were measured by three different techniques, a simple "apparent density" method, mercury intrusion, and bulk compression, the last for the composite only. For the polyethylene and composite we found pore volumes of about 45 and 70 percent, respectively.

NBSIR 82-2481. Early, J. G.; Ballard, L. D. **Analysis of foreign and domestic material specifications for ships components.** 1982 May. 266 p. Available from: NTIS; PB 83-148494.

Key words: ASTM; copper alloys; DIN; equivalency; foreign specifications; JIS; metal specifications; ships components; specifications; steel.

Under United States law, United States flag vessels must satisfy applicable United States codes, and further, the materials of construction of these vessels must satisfy the material requirements specified in these codes. For vessels manufactured in foreign countries, a determination must be made as to whether materials of construction produced under foreign specifications for specific components such as piping and flanges, are acceptable in performance to materials produced under approved U.S. specifications.

A program has been initiated at the National Bureau of Standards under the sponsorship of the United States Coast Guard to develop a manual of equivalent engineering standards which specifies those foreign specifications that are equivalent to acceptable domestic specifications, those foreign specifications that are not equivalent, and those that would be equivalent if certain additional criteria are met. Results are presented here of a detailed technical comparison between foreign specifications, principally Deutsche Industrie-Normen (DIN) standards and Japanese Industrial Standards (JIS), and selected domestic material specifications issued by the American Society for Testing and Materials (ASTM) and the American Society of

Mechanical Engineers (ASME). This comparison has identified technical areas of commonality, difference, and omission that could have a significant impact on component performance.

NBSIR 82-2485. Collins, B. L.; Lerner, N. D.; Pierman, B. C. **Symbols for industrial safety.** 1982 June. 157 p. Available from; NTIS: PB 82-237850.

Key words: communication; hazard; pictogram; safety; signs; standards; symbols; visual alerting; warnings.

Written signs are commonly used in industrial sites to provide hazard warnings and safety information. The use of safety symbols may increase the effectiveness of safety communication, because such signs are language-free, and because they can be recognized more rapidly and accurately than written text even under some conditions of interference and distraction. The effectiveness of safety symbols critically depends upon the selection of symbolic images which are readily understandable to the intended audience. A four phase evaluation of a set of selected industrial worksite symbols is described. The four phases involved identification of 33 key safety messages, selection of candidate symbols for each message, evaluation of the understandability of the candidate symbols, and determination of the preference for the 87 candidate images, using both industrial and nonindustrial (naive) personnel. Symbol understandability, in terms of percentage of correct responses and confusions, varied widely for the thirty-three referents. Despite standardized use for a number of years, the radiation, biohazard, and laser symbols were frequently misidentified. Symbols for protective gear, first aid, and emergency equipment were generally correctly identified. The different images selected for various hazards show the greatest range in understandability, with the results for symbolic versions of entanglement, electricity, corrosion, and overhead hazard being quite different. The most frequently correct image was usually also the most preferred.

NBSIR 82-2489. Parken, W. H.; Kao, J. Y.; Kelly, G. E. **Strategies for energy conservation in small office buildings.** 1982 July. 55 p. Available from: NTIS; PB 82-245820.

Key words: building control strategies; building energy conservation; building thermal performance; HVAC.

A comparative analysis is made of the thermal performance of a small office building using various HVAC systems and commonly employed strategies. The comparisons are made for seven geographical locations representing wide climatic variations within the continental United States.

Results were obtained for fan, space heating hot water, and chilled water energy consumption through hour-by-hour simulations using the BLAST computer program. A small office building model was used in the simulations along with several HVAC systems; a constant volume reheat unit (serving the entire building), dual constant volume reheat units (serving separate zones of the building), and a variable air volume reheat unit. The strategies investigated included supply air temperature reset (constant, zone-controlled, and outdoor air-controlled), economy cycles (temperature and enthalpy), continuous conditioning versus conditioning only during occupied hours, changes in reheat set point temperature, and changes in minimum variable air volume ratio. For comparable control strategies, the variable-air volume terminal reheat system exhibited the least energy consumption for chilled water, hot water and circulating fan. The system incorporating two independently-operating constant volume terminal reheat units ranked second in energy consumption while the single constant volume terminal reheat unit ranked last. Changes in thermal performance resulting from implementing one strategy in place of or in combination with another were found to vary significantly by climate and the type of HVAC system employed.

NBSIR 82-2495, Volume I. Gray, A. G. **Conservation and substitution technology for critical materials—Proceedings of public workshop sponsored by U.S. Department of Commerce/National Bureau of Standards and U.S. Department of Interior/Bureau of Mines. Volume I.** 1982 April. 488 p. Available from: NTIS; PB 83-180984.

Key words: chromium; cobalt; conservation; critical materials; strategic materials; substitution; tantalum; titanium.

The United States is highly vulnerable to problems in supply of critical and strategic materials and it is recognized that there is a whole spectrum of options for responding to such crises. While a number of supply oriented options are under study by various groups, the focus of this Workshop was on the technical options.

The Workshop was held principally to develop information for the report required by the Department of Commerce, but should also be useful to the other agencies in their responsibilities. The DoC report is supposed to identify a materials needs case related to national security, economic well-being, and industrial productivity, to assess critical materials needs, and to recommend programs to meet these needs.

NBSIR 82-2495, Volume II. Gray, A. G. **Conservation and substitution technology for critical materials—Proceedings of public workshop sponsored by U.S. Department of Commerce/National Bureau of Standards and U.S. Department of Interior/Bureau of Mines. Volume II.** 1982 April. 579 p. Available from: NTIS; PB 83-180992.

Key words: chromium; cobalt; conservation; critical materials; strategic materials; substitution; tantalum; titanium.

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NBSIR 82-2505. Gevarter, W. B. **An overview of expert systems.** 1982 May. 73 p. Available from: NTIS; PB 82-227547.

Key words: applications; artificial intelligence; expert systems; forecast; funding sources; intelligent computer programs; knowledge engineering; machine intelligence; overview; research; state-of-the-art.

This report provides an overview of Expert Systems—currently the hottest topic in the field of Artificial Intelligence. Topis covered include what it is, techniques used, existing systems, applications, who is doing it, who is funding it, the state-of-the-art, research requirements, and future trends and opportunities.

NBSIR 82-2510. Chang, Y. M. L.; Grot, R. A. **Quality of inspections utilizing infrared technology on weatherization retrofit installations.** 1982 November. 109 p. Available from: NTIS; PB 83-146936.

Key words: building heat losses; comparison of inspections; infrared scanning systems; insulation voids; interpretation of thermograms; thermal deficiencies; thermographic inspections; weatherization retrofits.

A comparative evaluation of various portable infrared sensing systems used for detecting heat loss anomalies within building envelopes was performed. This is the second of a two-stage applied research program sponsored by the Department of Energy to assess the application and reliability of using infrared technology. Twelve single-family residences in three cities from the Weatherization Program of the Community Services Administration were employed as field samples. The results of infrared surveys carried out by thermographic surveying firms and those by the National Bureau of Standards were analyzed and compared in the categories of: completeness of scanning, identification of defects, weather condition of inspection, and method of equipment operation. The thermograms of uninsulated areas, sketches of observed thermal deficiencies, and total areas of defects for each dwelling are presented. Through the comparison, the degree of completeness of inspecting the residences thoroughly was evaluated to be the most important factor for defect identification. The results of thermographic inspection of the homes showed that serious thermal anomalies still existed in most of these 'weatherized' residences, with a majority exhibiting between 5 percent and 15 percent of the wall areas uninsulated, or defective. The total uninsulated areas observed by each surveyor was found to be affected by the quality of thermograms submitted.

NBSIR 82-2516. Peacock, R. D.; Breese, J. N. **Computer fire modeling for the prediction of flashover.** 1982 May. 88 p. Available from: NTIS; PB 82-245812.

Key words: compartment fires; computers; fire growth; flashover; mathematical models.

This study presents an initial look at the potential for the use of fire growth models. A technique is presented, based upon numerous fire growth predictions, to estimate the minimum energy required to produce temperature levels capable of promoting flashover in a variety of room configurations. The parameters investigated included room size, room ventilation, ceiling height and room lining material. A comparison is presented of the predictions made with available full-scale fire test data and with other predictions. The technique, although needing refinement, shows promise to estimate flashover potential.

NBSIR 82-2530. Brown, D. W.; Lowry, R. E.; Smith, L. E. **Prediction of the long term stability of polyester-based recording media.** 1982 June. 44 p. Available from: NTIS; PB 83-172668.

Key words: degradation; film base; hydrolysis; photographic film; polyester; poly(ethylene terephthalate); recording media; stability.

The stability of poly(ethylene terephthalate) is being studied in order to predict its long term behavior as the base of the film and tape used to record archival information. This report contains results of the first year's work. Film base, with and without photographic and other coatings, was aged at several temperatures and humidities. Mechanical and calorimetric properties and molecular weights were measured at intervals. Degradation was relatively rapid at temperatures of 115, 100, and 85°C at 100% relative humidity. The scission rate at 85°C was about 10^{-6} mol scission/g-day and the activation energy was 113 k J/mol. Rates decreased strongly with relative humidity, becoming negligible in dry air and nitrogen. At 55°C and 100% relative humidity degradation was not significant in 163 days. Samples are seriously embrittled by the introduction of about one scission per molecule—about 10^{-4} mol scission/g. Differential scanning calorimetry showed little change in melting behavior of semicrystalline samples aged at 55 and 85°C. Glassy samples crystallized during aging at 85°C but not at 55°C.

Magnetic tapes based on poly(ethylene terephthalate) usually have a polyester polyurethane binder that holds the magnetic particles. The binder is thought to be more sensitive to hydrolysis than the tape base. Results obtained with a thermoplastic polyester polyurethane imply that there may be an equilibrium extent of degradation for any storage condition. It is anticipated that the study will go on for four more years.

NBSIR 82-2543-1. Fuller, E. G.; Gerstenberg, H. **Photonuclear data index 1973 through 1981.** 1983 August. 154 p. Available from: NTIS; PB 83-251363.

Key words: bibliography; data index; elements; isotopes; nuclear physics; photonuclear reactions.

This index, a supplement to NBS Special Publication 380, *Photonuclear Reaction Data, 1973,* primarily covers data published in the period from January 1973 through December 1981. It supersedes the first supplement to Special Publication 380 issued in August 1978. Organized by element and isotope, each entry in the index is for a specific reaction reported in a given reference. Information is given on the type of measurement, excitation energies studied, source type and energies, detector type and angular ranges covered in the measurement. Also included is an index to the more than 1200 data sets currently available in the Photonuclear Data Group's digital data library.

NBSIR 82-2547. O'Connell, J. S. **Electromagnetic nuclear reactions: I. Introduction, operators, and sum rules.** 1982 September. 119 p. Available from: NTIS; PB 83-109330.

Key words: deuteron; electromagnetic; electron; helium; nucleus; photon.

This monograph covers the data and theoretical models of nuclear reactions initiated by electrons and photons. The main emphasis is on the nonrelativistic calculations of the differential cross sections of the major reaction channels.

NBSIR 82-2550-A. Berger, M. J.; Seltzer, S. M. **Stopping powers and ranges of electrons and positrons.** 1982 December. 173 p. Available from: NTIS; PB 83-175687.

Key words: collision stopping power; electrons; positrons; radiation yield; radiative stopping power; range.

Tables of stopping powers and related data are given for electrons in 25 elements and 46 mixtures and compounds, and for positrons in 14 materials. The tables include: (1) collision stopping powers (ionization and excitation losses); (2) radiative stopping powers (bremsstrahlung losses); (3) total stopping powers; (4) ranges (rectified pathlengths computed in the continuous-slowing-down approximation); (5) radiation yields (fraction of initial electron energy converted to bremsstrahlung in the course of slowing down); and (6) the logarithmic derivatives of all these quantities with respect to the mean excitation energy of the medium (the key parameter of the Bethe stopping power formula). The results are tabulated at 81 energies between 1000 MeV and 10 keV. Collision stopping powers for electrons in materials of low atomic number are given also for energies down to 1 keV. The principal new ingredients in the preparation of the tables are: (1) improved values of the mean excitation energies for elements and compounds, derived from stopping-power and range measurements and from semi-empirical oscillator-strength distributions and dielectric-response functions; (2) density-effect corrections evaluated according to the method of Sternheimer, using up-to-date input parameters; and (3) use of new theoretical cross sections of Pratt and Tseng for electron-nucleus bremsstrahlung and of Haug for electron-electron bremsstrahlung.

NBSIR 82-2555. Van Brunt, R. J.; Misakian, M.; Leep, D. A.; Beaty, E. C.; Gallagher, J. W.; Cooke, C. M.; Wyatt, K.; Gels, R. G. **1981 Annual Report: Technical assistance for future insulation systems research.** 1982 November. 157 p. Available from: NTIS; PB 83-149187.

Key words: corona discharges; decomposition; electron avalanches; electronegative gases; electron swarm data; optogalvanic spectra; oxyfluorides; SF_6; sulfur hexafluoride; water vapor.

A system for measuring the electrical properties of corona pulses has been characterized and is discussed. Additional data on the pulse height distributions of positive and negative corona pulses in pure SF_6 for point-plane electrode geometries are presented. Basic mechanisms for initiation of electric discharges in SF_6 for highly nonuniform fields have been investigated in a collaborative effort between NBS and the High Voltage Research Laboratory of the Massachusetts Institute of Technology. Effects of radiation, electrode geometry, and polarity on corona inception in SF_6 have been measured. Corona inception voltages and discharge initiation volumes have been calculated using the streamer criterion. Limitations of the streamer criterion as applied to SF_6 in highly nonuniform fields are discussed.

The statistics of electron avalanche growth in SF_6 have been measured and compared with results of theory. While the avalanche pulses, on average, followed expected theoretical behavior, the distribution was not found to be regular or to follow a simple stochastic theory. A thorough compilation and survey of electron swarm data for electronegative gases used, and proposed for use, as components of gaseous dielectrics was completed. The parameters considered include: electron drift velocity, attachment coefficient, ionization coefficient, electron growth constant, diffusion coefficient, detachment coefficient, and characteristic energy. These are quantities needed for prediction of breakdown and modeling of gas discharges. Some of the important gases included in this study are: O_2, CO_2, SF_6, H_2O, air, nitrogen oxides, halogens, and various halogenated hydrocarbons, e.g., CF_4, C_2F_6, C_3F_8, C_4F_{10}, CCl_2F_2, $CClF_3$, c-C_4F_8, c-C_5F_8, CH_3Br, CH_2Cl_3, $CHCl_3$, etc. In this report we include only an example of the data collected, namely that for SF_6. Using a gas-chromatograph/mass spectrometer, absolute concentrations of SOF_2 and SO_2F_2 and relative concentrations of H_2O in SF_6 have been measured as a function of total energy dissipated in corona discharges operated at power levels between 50 and 700 mW. The observed production rates for SOF_2 and SO_2F_2 appear to be proportional to power level, and the ratio of SO_2F_2 to SOF_2 concentrations for corona is considerably higher than that typically observed for arc discharges in SF_6.

Estimates have been performed to determine the sensitivity of a technique to detect polar gas contaminants in gaseous SF_6 using an accurate ppm measurement of changes in the low frequency (dc) dielectric constant of the gas. Measurements have been performed of optogalvanic spectra from glow discharges in Ne, N_2 and mixtures of these with SF_6. The effect of SF_6 in quenching metastables in these gases is discussed.

NBSIR 82-2561. Fletcher, R. A.; Bright, D. S. **NBS portable ambient particulate sampler.** 1983 January. 43 p. Available from: NTIS; PB 83-165019.

Key words: inhalable aerosol; inlet efficiency; isokinetic probes; portable aerosol sampler; respirable aerosol.

The NBS portable ambient particulate sampler is designed to collect the respirable and inhalable particle size fractions at a sampling rate of 6 L/min for 24 hour sampling periods. Particulates are fractionated and collected by series filtration. The collection efficiency of the inlet is measured by comparison with isokinetic probes in the wind tunnel. The collection efficiency and sampling size characteristics of two small personal cyclone samplers are also reported.

This work was sponsored by the Environmental Protection Agency under interagency agreement no. AD-13-F-1-535-0.

NBSIR 82-2564. Parker, W. J. **An assessment of correlations between laboratory and full scale experiments for the FAA Aircraft Fire Safety Program, Part 3: ASTM E 84.** 1983 January. 57 p. Available from: NTIS; PB 83-164251.

Key words: ASTM E 84; fire tests; flame spread; heat release; room fires.

A comparison is presented between the room fire performance in four different full scale fire test series and the flame spread classification obtained by the ASTM E 84 tunnel test for a wide range of materials. A good correlation is obtained only for conventional interior finish materials. A flame spread hypothesis is presented to account for the stopping of the flame in the tunnel and the difference in the fire performance of materials in the tunnel test and in the room fire test.

NBSIR 82-2565. Powell, P. B., ed. **Profiles of computer programmers in the executive branch of the Federal Government.** 1983 March. 81 p. Available from: NTIS; PB 83-193102.

Key words: computer programmers; computer specialist; Federal civilian organizations; OPM data base; profile of computer programmers.

The report is a detailed programmer survey compiled from interviews with eight selected organizations and an OPM data base. The survey includes staffing, hardware, programming activities and languages, contract support, programmer recruiting, quality control, personnel profile, and programmer activities. The OPM data base is summarized by age, grade and education for Computer Specialists in the Washington Metropolitan Area.

NBSIR 82-2566. Trahan, C. Y.; Jensen, S. W. **BASIC utility graphics software for a desktop computer.** 1982 October. 151 p. Available from: NTIS; PB 83-175760.

Key words: BASIC; CRT; digital plotter; graphs; HP 9845B desktop computer; interactive; internal thermal printer; magnetic cassette tape; plot; software; X,Y data.

This report describes an interactive BASIC language graphics utility program designed to facilitate easy plotting of X,Y data. The program operates on a Hewlett-Packard 9845B desktop computer, in its standard configuration, and uses a Hewlett-Packard 9872 A four pen digital plotter. The program allows the user to view X,Y data graphically, and provides a broad range of plotting options so that publication quality graphs and transparencies may be created using up to four colors on the digital plotter. Data may be digitized from a user's graph on the digital plotter, generated as a user defined function, or input directly from the computer keyboard or magnetic tape cassette. Data may be plotted on the computer CRT, on the computer's internal thermal printer, or on the digital plotter.

NBSIR 82-2568. Chung, R. M.; Yokel, F. Y. **Contribution to the ASTM resonant column round robin testing program.** 1982 December. 64 p. Available from: NTIS; PB 83-151161.

Key words: damping; resonant column; round robin tests; shear modulus; soil dynamics; test methods; torsional vibrations.

Results from National Bureau of Standards (NBS) resonant column tests to determine shear moduli and damping ratios for Monterey No. 0 sand are presented to supplement the ASTM resonant column round robin program. In addition to testing solid specimen as specified for the initial ASTM round robin program, hollow cylindrical specimens were tested to provide an independent check on the validity of the results.

The NBS test data on shear moduli are consistently lower than the average values obtained from the initial round robin program, but they are within the range of the initial round robin test data. It is believed that, at least in part, the difference between the NBS and the round robin data was caused by the fact the NBS specimens had a lower average relative density which was also closer to 60 percent relative density specified for the round robin tests. Damping ratios obtained by NBS fit rather closely the curve obtained from the initial round robin program.

No significant difference was found between the maximum shear moduli and damping ratios obtained from the testing of solid specimens and hollow cylindrical specimens.

NBSIR 82-2571. Early, J. G. **Recycling municipal ferrous scrap.** 1982 September. 35 p. Available from: NTIS; PB 83-156968.

Key words: ferrous scrap; iron; municipal ferrous scrap; municipal solid waste; recycling resource recovery; standards; steel.

The secondary metals industry associated with the recycling of ferrous scrap is tied to the development in the 1850's of the acid-Bessemer furnace, the first large capacity steelmaking process. Within twenty-five years of this development, the recycling of ferrous scrap became an established industry. Changes in steelmaking technology since World War II, especially since the 1960's, are impacting the traditional ferrous scrap industry. The increased demand for old scrap is due to growth in electric-arc furnace steelmaking capacity, reduced availability of home scrap and prompt industrial scrap, and larger scrap exports. Ferrous scrap recovered from municipal solid waste is one of the new sources of old scrap that may satisfy these increased demands. Systems for the recovery of the ferrous fraction from municipal solid waste have been developed, although increased usage of municipal ferrous scrap has been very slow due to institutional and technical barriers. The technical barriers posed by the physical and chemical characteristics of municipal ferrous scrap strongly inhibit the development of markets for this new material. The real and potential markets for increased consumption of municipal ferrous scrap are discussed in terms of these barriers together with the important role of standards for municipal ferrous scrap in improving communications between buyers and sellers.

NBSIR 82-2574. Tighe, N. J. **Analysis of oxide + matrix interfaces in silicon nitride.** 1983 February. 26 p. Available from: NTIS; PB 83-178699.

Key words: analysis; electron microscopy; enstalite; microstructure; oxidation; silica; silicates; silicon nitride; STEM; TEM.

In order to understand the strength and microstructural changes that are produced during oxidation, it is necessary to examine the oxide scale, the oxide:silicon nitride interface and the silicon nitride below the oxide:matrix interface. In the present study, these three interfacial layers were removed and analyzed using transmission electron microscopy, light microscopy, x-ray energy analysis and x-ray diffraction. Oxide scales were produced on hot-pressed silicon nitride samples by heating in air at 1000°C, 1200°C, and 1400°C for 1/2 to 1000 hr. The phases in the oxide scale were found to occur in layers that were ordered according to the phase diagrams for the oxide mixtures. Crystalline and amorphous phases were present in all specimens examined. The oxynitride and amorphous phases are present in as-pressed billets at triple junctions and along grain boundaries. The elements in the amorphous phases were identified using energy dispersive x-ray analysis. In this paper, the phases found

in the oxide scales are characterized and the relationships between the oxide scale, the oxide:matrix interface and the mechanical properties are discussed.

NBSIR 82-2576. Lentner, K. J.; Tremaine, S. G. **A semiautomatic ac/dc thermal voltage converter calibration system.** 1982 September. 62 p. Available from: NTIS; PB 83-180224.

Key words: ac/dc difference; ac voltage measurement; automation; calibration; metrology; thermal voltage converter.

A semiautomatic ac/dc difference calibration system is described. The system operates over a frequency range of 20 Hz to 100 kHz, covering the voltage range from 0.5 V to 1 kV. For all voltages at frequencies in the range from 20 Hz to 20 kHz, the total uncertainty is 50 parts per million (ppm), and 100 ppm for voltages at frequencies between 20 kHz and 100 kHz. In addition to ac/dc difference testing, the system can be readily adapted to calibrate precision ac digital voltmeters or ac calibrators. Results of extensive intercomparison testing of the new system against a manual test system are reported, using a multirange thermal transfer instrument as a transport standard. The results indicate that the ac/dc differences measured are well within the combined total uncertainty limits of the two systems.

NBSIR 82-2577. Parks, E. J.; Johannesen, R. B.; Brinckman, F. E. **Advances in the SEC characterization of organometallic copolymers and copolymerization: Desorption of charged species by injected dilute acetic acid.** 1982 September. 30 p. Available from: NTIS; PB 83-178681.

Key words: acetic acid; adsorption; differential refractive index; fractionation; graphite furnace atomic absorption; kinetics; methyl methacrylate; organometallic copolymer; SEC; stability; tributyltin acetate; tributyltin methacrylate.

The chemical characterization of controlled-release, biocidal triorganotin-containing copolymers (organometallic polymers, OMPs) is necessary for predicting the in-service performance of these important materials. An OMP investigated in the present research was prepared by the free radical copolymerization of tributyltin methacrylate (TBTM) and methylmethacrylate (MMA). Size exclusion chromatography (SEC) on μStyragel, coupled with an in-line graphite furnace atomic absorption detector (GFAA) quantitates the bioactive tin in at least two well-resolved fractions: a polymer fraction, and, probably, unreacted TBTM. However, THF slowly elutes a third component, now believed to be an adsorbed ionic tin-containing compound.

We now verify that a one percent solution of acetic acid (HOAc), injected into the THF mobile phase after a measured delay, efficiently desorbs the third species, without hydrolyzing polymeric TBT-substituted esters.

Tin-selective SEC-GFAA of a series of partially reacted OMPs indicates that the TBT-substituted esters partially decompose during one year of storage at −78°C, but mass sensitive SEC-ΔRI indicates that the polymer backbone remains intact. Comparison of SEC-GFAA and SEC-ΔRI suggests a convenient chromatographic method for determining reaction kinetics of both MMA and TBTM simultaneously.

NBSIR 82-2579. Berger, M. J.; Seltzer, S. M. **Tables of energy deposition distributions in aluminum and copper irradiated by point-monodirectional electron beams with energies from 1 to 60 MeV.** 1982 October. 39 p. Available from: NTIS; PB 83-186775.

Key words: absorbed-dose distribution; aluminum; copper; electron; point-monodirectional beam; superposition.

This report presents tables of energy deposition distributions in aluminum and copper media irradiated by monoenergetic point-monodirectional electron beams. The distributions are given as functions of the depth in the medium and of the radial distance from the incident beam. Results are given for 7 beam energies between 1 MeV and 60 MeV. As shown earlier in National Bureau of Standards Report NBSIR 82-2451 (1982), the tabulated results from monoenergetic, point-monodirectional sources can be used, by superposition, to obtain spatial distributions of the energy imparted to the medium by parallel beams with arbitrary spectrum and finite arbitrary cross section.

NBSIR 82-2589. Harris, J. R.; Leyendecker, E. V., eds. **Plan for a trial design program to assess amended ATC 3-06 tentative provisions for the development of seismic regulations for buildings.** 1982 November. 28 p. Available from: NTIS; PB 83-172676.

Key words: building structures; earthquake codes; earthquake engineering; earthquake standards; seismic design; trial designs.

This report presents a trial design program to establish the technical viability of the recommendations contained in the report *The Tentative Provisions for the Development of Seismic Regulations for Buildings* developed by the Applied Technology Council and subsequently modified in a review project conducted by the building Seismic Safety Council (BSSC) and the National Bureau of Standards. The trial design program is intended to provide information for estimating the impact of adopting the recommendations in the *Tentative Provisions,* evaluate the useability of the *Tentative Provisions,* establish the technical viability of the *Tentative Provisions* and obtain objective information for the future resolution of disputes concerning specific provisions. The trial design program is a phased program. Phase 1, being conducted by the BSSC, consists of designs of twenty-seven buildings and is underway. The BSSC is actively pursuing completion of the trial design program through additional funding and voluntary effort.

NBSIR 82-2594. Cunningham, D. **Data bases available at the National Bureau of Standards Library.** 1982 October. 102 p. Available from: NTIS; PB 83-155986.

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 are also supplied.

NBSIR 82-2595. Wise, S. A.; Allen, C. F.; Chesler, S. N.; Hertz, H. S.; Hilpert, L. R.; May, W. E.; Rebbert, R. E.; Vogt, C. R. **Characterization of air particulate material for polycyclic aromatic compounds.** 1983 January. 57 p. Available from: NTIS; PB 83-155580.

Key words: air particulate matter; biological testing; chemical fractionation; fluorescence detection; gas chromatography (GC); liquid chromatography (LC); mass spectrometry (MS); polycyclic aromatic hydrocarbons (PAH); SRM's.

In studies to evaluate the potential health and ecological effects of atmospheric emissions, bioassays have been employed in conjunction with chemical characterization to correlate mutagenic and/or carcinogenic activity with chemical composition. The complexity of an air particulate extract necessitates the prefractionation of the mixture into suitable subfractures or chemical classes prior to chemical characterization and/or biological testing. The goal of this project was to evaluate such a fractionation scheme for air particulate material with respect to chemical characterization of the various fractions with particular emphasis on the identification of polycyclic aromatic hydrocarbons (PAH). In this study we have used three chromatographic approaches to separate, identify, and quantify the complex mixture of PAH extracted from SRM 1649 (Urban Dust/Organics): (1) capillary GC, (2) LC with selective fluorescence detection, and (3) multidimensional chromatographic techniques.

NBSIR 82-2596. Stiefel, S. W. **Use of decision analysis in arson program planning.** 1982 November. 22 p. Available from: NTIS; PB 83-146944.

Key words: arson; Arson Information Management System (AIMS); cost benefit analysis; decision analysis; program management.

A decision analysis approach is formulated and demonstrated to provide a planning tool for decision makers in a city or community concerned with selection and application of arson strategies. The Arson Information Management System (AIMS) is used to provide information to describe the arson problem (classify causes/motivation,

incidence and magnitude for each area in the city/community) and to establish which strategies are appropriate to address the causes. This AIMS data plus an assessment of the cost and effectiveness of arson strategies are combined in a decision analysis framework. The framework specifies data requirements and provides a data analysis structure. The decision analysis has been designed to provide a measure of the net benefits for various strategies for each area in the city/community. A method for using the outputs from the decision analysis to provide the most cost-effective use of an arson budget has been developed.

NBSIR 82-2597. Chamberlain, D. L. **Heat release rate properties of wood-based materials.** 1983 July. 90 p. Available from: NTIS; PB 83-248682.

Key words: acoustical tile; Douglas fir; fire retardants; hardboard; heat release rate; heat release rate calorimeters; irradiance; particle board; plywood; redwood; southern pine.

A background to the present heat release rate calorimetry is presented. Heat release rates and cumulative heat release were measured for 16 different lumber and wood products, using three different heat release rate instruments. The effects of moisture content, exposure heat flux, density of product, and fire retardant on rate of heat release were measured. The three small-scale heat release rate calorimeters were compared, and equations relating the data from each were developed.

NBSIR 82-2598. Parker, W. J. **An assessment of correlations between laboratory and full-scale experiments for the FAA Aircraft Fire Safety Program, Part 6: Reduced-scale modeling of compartments at atmospheric pressure.** 1983 March. 59 p. Available from: NTIS; PB 83-193052.

Key words: aircraft fires; fire tests; flashover; reduced-scale model; room fire tests.

The temperatures, heat fluxes, air velocities, and times to flashover were compared between a number of previously reported full- and reduced-scale room fire tests. The model tests were usually similar but somewhat less severe than their full-scale counterparts. A simplified analysis is presented to account for the lower temperatures observed in the models. Some recommendations are made with regard to physical modeling of the aircraft postcrash fires.

NBSIR 82-2600. Chapman, R. E. **A cost-conscious guide to fire safety in health care facilities.** 1982 November. 65 p. Available from: NTIS; PB 83-150466.

Key words: building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; renovation.

This study focuses upon the use of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards for determining equivalence to the Life Safety Code for health care facilities. The Life Safety code, a voluntary code developed by the National Fire Protection Association, is a widely used guide for providing fire safety in buildings. This study outlines the Fire Safety Evaluation System Cost Minimizer (FSESCM) computer program. The FSESCM program is intended for use as a management tool to identify a series of optimal compliance strategies which are equivalent to the prescriptive provisions of the Life Safety Code in health care facilities. The mathematical optimization techniques which form the basis of the FSESCM program make it possible to quantify the cost savings attributable to the use of the Fire Safety Evaluation System over prescriptive compliance to the Life Safety Code. An in-depth analysis of a typical health care facility is used as a case study to demonstrate that cost savings of 50 percent or more over those associated with prescriptive compliance to the Life Safety Code are possible.

NBSIR 82-2602. Winter, F.; Galowin, L. **Experimental evaluation of circulation loop drain and vent plumbing modifications for building rehabilitation.** 1982 December. 94 p. Available from: NTIS; PB 83-162339.

Key words: innovative venting; plumbing; plumbing renovation; rehabilitation; vents for plumbing.

Rehabilitation or modernization of existing buildings frequently imposes increased loads on the plumbing water supply and drainage system. The requirement for venting in U.S. practice is intended to prevent trap seal loss from exceeding values prescribed in model plumbing codes. The vent piping in older buildings may be marginal for retrofit under code requirements for new construction with the same or increased numbers of fixtures and devices installed into the plumbing system.

An experimental laboratory investigation of a "circulation loop" modification to a drain-waste-vent (DWV) system was conducted to determine the change in performance. An experimental evaluation of the performance of the modified system and a conventional system were undertaken for a variety of simulated wastewater-loads with various plumbing fixtures and multi-story soil stack loads. The performance parameters considered were trap seal failures, backflow, and the siphonic action of the water closets. Also, the dynamic responses to pressure excursions and air flow rates in the branches were measured. Both systems were tested to the limiting condition for single-stack performance over a range of air flow rates into the soil and vent stack.

The circulation loop system was found to decrease the pressure difference in the upper portion of the soil stack, and to provide limited benefits in reducing trap seal failures and failure due to reduced siphonic action in the lower level water closets. With vent valves open, both the conventional and modified loop systems provided satisfactory venting except at the highest loads. Additional research should be undertaken to develop methods for sizing the soil stack and vent connection fitting connection to the circulation loop. Further testing should also be done with small regulated air flows into the vent stack.

NBSIR 82-2604. Babrauskas, V.; Lawson, J. R.; Walton, W. D.; Twilley, W. H. **Upholstered furniture heat release rates measured with a furniture calorimeter.** 1982 December. 73 p. Available from: NTIS; PB 83-165050.

Key words: burning rate; chairs; fire tests; flammability tests; furniture; heat release rate; plastics; textiles; upholstered furniture.

Accurate burning rate information on upholstered furniture is important for two purposes—to predict the room fire development history for a fire involving the furniture, and to relatively, but adequately, rank commercial products for a given application. Small-scale test results data not referenced to full-scale fires lack validity, while full-scale room fires are costly and lack generality. To enable simplified but realistic full-scale testing to be done, a new apparatus, termed a furniture calorimeter was developed. Rates of heat release are measured by using the oxygen consumption principle. Tests were conducted in the furniture calorimeter on thirteen different specimens of upholstered furniture, representing typical, but carefully controlled construction. The results showed significant heat release differences between thermoplastic and cellulosic fabrics, between frame types and between padding materials. For polyurethane foam padding, however, performance was unrelated to results of Bunsen burner type tests on the foam. The data developed (1) can be used directly in the calculation of room fire growth; (2) will form some of the reference data for development of appropriate bench-scale test procedures; and (3) can be used in some cases to estimate burning rates of similar but not identical furniture.

NBSIR 82-2605. Grot, R. A.; Burch, D. M.; Silberstein, S. **Measurement methods for diagnostic procedures in evaluation of thermal integrity of building envelopes.** 1982 November. 140 p. Available from: NTIS; PB 83-180174.

Key words: air infiltration rates; envelope thermal performance; infrared imaging; radiometers; thermal bridges; thermographic surveys; tracer gas techniques.

This report presents reviews of various measurement and inspection techniques appropriate for the development of detailed diagnostic procedure for assessing the thermal performance of the exterior envelopes of federal buildings. The inspection techniques include the use of ground-based infrared thermographic surveys, aerial infrared surveys, tracer gas air infiltration measurement, pressurization tests for measuring the tightness of the building envelope, and spot radiometer surveys for detecting gross defects. Heat flow meters, a portable calorimeter, and a microprocessor-driven envelope testing

unit are also considered.

For each technique recommended procedures are provided; they include equipment requirements, conditions under which the techniques can be carried out, calibration, accuracy, and limitations. The detailed diagnostic procedures specific to small and large federal buildings require further development from on-site field testing of representive buildings.

An Executive Summary provides an overview of the Building Diagnostic Program of which Phase 1 is covered in this report. Field test evaluations will be carried out in Phase 2 and implementation under Phase 3.

NBSIR 82-2606. Klein, S. A. **A model of the steady-state performance of an absorption heat pump.** 1982 October. 56 p. Available from: NTIS; PB 83-152314.

Key words: absorption heat pump; ammonia-water; ARKLA water chiller; experimental performance; mathematical model; steady-state performance.

A mathematical model of the steady-state performance of an absorption heat pump is described. The model is compared with experimental data from a residential-sized water chiller. It is also used to determine the sensitivity of the heat pump performance to its design variables.

NBSIR 82-2607. Eby, R. K.; Broadhurst, M. G.; Davis, G. T.; Wang, F. W.; Fanconi, B. M.; Cassel, J. M.; Sanchez, I. C. **Polymer Science and Standards Division: Annual report 1982.** 1983 March. 100 p. Available from: NTIS; PB 83-200105.

Key words: characterization; chemical durability; dental and medical materials; dielectric plastics; mechanical durability; migration; performance; polymers.

Although synthetic polymers have been used as materials of technology for only 3 quarters of a century, they have left little of our economy, technology, industry, science & culture untouched. We have moved rapidly into an age in which an overgrowing number of humanity's needs are served by polymers. The volume currently produced exceeds that of steel & forms the basis of industries which add ove. relative economic importance of manufacturing among industries) and provides 3.4 million jobs. Recent summaries show that polymers and polymer composite research already accounts for about 47% of the total industrial R&D expenditure for metals, polymers, & inorganic materials. Among these materials, polymers also constitute about 39% of the value added by manufacturer, 49% of the jobs, 45% of the number of scientific publications, and 39% of the ASTM standards.

NBSIR 82-2610. Yaniv, S. L.; Flynn, D. R. **Highway noise criteria study: Executive summary.** 1982 October. 38 p. Available from: NTIS; PB 83-149831.

Key words: acoustics; general adverse response to noise; noise measurement; sound.

This report summarizes a multifaceted research program carried out by the acoustics staff of the National Bureau of Standards at the request of the Federal Highway Administration. The program was designed to (1) identify and quantify the important physical parameters associated with time-varying highway noise caused by various densities of both free-flowing and stop-and-go traffic conditions; (2) investigate, evaluate and compare measures and computational procedures for rating time-varying noise in terms that are relevant to human response; and (3) determine by means of a laboratory study which among several time-varying rating schemes best predicts acceptability and annoyance caused by traffic noise as heard both outdoors and indoors. The results of this program are briefly described and the implications of the major findings discussed.

NBSIR 82-2611. Babrauskas, V. **Development of the cone calorimeter—A bench-scale heat release rate apparatus based on oxygen consumption.** 1982 November. 84 p. Available from: NTIS; PB 83-151266.

Key words: calorimeters; combustion; fire tests; heat of combustion; heat release rate; ignition; oxygen consumption; plastics.

A new bench-scale rate of heat release calorimeter utilizing the oxygen consumption principle has been developed for use in fire testing and research. Specimens may be of uniform or composite construction and may be tested in a horizontal, face-up orientation, or, for ones which do not melt, also vertically oriented. An external irradiance of zero to over 100 kW/m^2 may be imposed by means of a temperature-controlled radiant heater. The rate of heat release is determined by measuring combustion product gas glow and oxygen depletion, while the mass loss is simultaneously recorded directly. The instrument has been designed to be capable of higher accuracy than existing instruments and yet to be simple to operate and moderate in construction cost. The instrument is termed a "cone calorimeter" because of the geometric arrangement of the electric heater.

NBSIR 82-2612. Cherry, S. M. **Sixth annual conference on fire research.** 1982 November. 182 p. Available from: NTIS; PB 83-155887.

Key words: combustion; decision analysis; fire models; flame spread; human behavior; ignition; polymers; smoke; soot; toxicity; wood.

This report contains extended abstracts of grants and contracts for fire research sponsored by the Center for Fire Research, National Bureau of Standards, as well as descriptions of the internal programs of the Center for Fire Research.

NBSIR 82-2614. Swaffield, J. A. **The prediction of floating solid velocities in unsteady partially filled pipe flow.** 1983 July. 35 p. Available from: NTIS; PB 83-258598.

Key words: floating solids; partially filled pipe flows; pipe flow with solids; plumbing drains.

The method of characteristics is applied to solve the unsteady partially filled pipe flow equations and to predict the velocity of floating solids assumed to travel at a fixed percentage of the local flow velocity.

Experimental verification for the technique is provided for cylindrical solids in 100 mm diameter drainage pipe at a range of gradients from 1/40 to 1/150.

The system upstream boundary conditions are shown to be capable of representation in terms of the inflow energy at the pipe entry section.

Steady flow floating solid to flow velocity ratios are presented at 1/150 pipe gradient and further areas of experimental work to determine the variation of these ratios with pipe gradient and flow depth are identified.

NBSIR 82-2615. Phillips, J. C. **Mechanical relaxation of liner materials in acetic acid.** 1983 January. 26 p. Available from: NTIS; PB 83-191106.

Key words: acetic acid; liner materials; mechanical relaxation; recovery; stress cracking.

This report describes stress relaxation of three liner materials [high density polyethylene (HDPE), chlorinated polyethylene (CPE), and polyvinyl chloride (PVC)] in air and acetic acid (HAc) environments. Additional experiments of environmental stress cracking (ESC) and recovery were also performed.

Experimental data for stress relaxation were obtained at temperatures of 30°C, 50°C and 72°C. At the latter temperature (72°C) stress relaxation experiments were performed on high density polyethylene (HDPE) as a function of elongation and concentration (Acetic Acid/H_2O mixtures). Environmental stress cracking experiments at 60°C and 90°C were also done for HDPE using acetic acid and Igepal as ESC agents.

The stress relaxation modulus, E(t), from the stress relaxation data was compared for the three liner materials at different temperatures (30°C, 50°C, and 72°C) and strain levels. The logarithm of E(t) versus the logarithm of time and the ratio of the modulus in acetic acid to that in air showed a greater stability in strength for HDPE over the temperature and time ranges used. Chlorinated polyethylene exhibited the most deviations from linear log-log behavior with PVC being intermediate between HDPE and CPE at all temperatures and strains tested. These results seem to suggest that the stress relaxation modulus measurements coupled with other data from such measurements as ESC and recovery may be quite useful in helping to

assess the mechanical and transport behavior of a given liner material.

NBSIR 82-2617. Yolken, H. T. **Technical activities, 1982, Office of Nondestructive Evaluation.** 1982 December. 185 p. Available from: NTIS; PB 83-155531.

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 FY1982 is presented in this annual report.

NBSIR 82-2619. Konig, P. A.; Goldfine, A.; Newton, J. J. **Functional specifications for a Federal Information Processing System Data Dictionary System.** 1983 January. 410 p. Available from: NTIS; PB 83-169441.

Key words: computer program; database; database management system; data dictionary system; data inventory; data management; data standards; documentation; Federal Information Processing Standards Publication; requirements; software.

This interim report contains Functional Specifications for the basic functions that data dictionary software must perform to satisfy Federal agency requirements. The functionality specified will be incorporated into a planned Federal Information Processing Standard (FIPS) Data Dictionary System (DDS). The complete FIPS DDS also will contain additional specifications for such things as the user interface. Comments are being solicited from Federal agencies and suppliers of data dictionary software to determine any modifications that should be made to the Functional Specifications. Information about the effort to develop the planned FIPS DDS and a Management Overview of the Functional Specifications appear in Part I of this document. The Functional Specifications are in Part II.

NBSIR 82-2621 (DoE). Liu, S. T. **Thermal comfort conditions in the NBS/DoE direct gain passive solar test facility.** 1982 December. 48 p. Available from: NTIS; PB 83-162032.

Key words: ASHRAE Comfort Standard 55-1981; black globe temperature; comfort envelope; direct gain room; operative temperature; passive solar test facility; solar radiation; thermal comfort.

The thermal comfort conditions in a direct gain cell of the NBS/DoE passive solar test facility were analyzed in accordance with the criteria specified in the recently revised ASHRAE Comfort Standard 55-1981, using test data collected during the month of October 1981 and the month of January 1982. It was found that the daytime operative temperature (as measured by the black globe temperature sensors) in an area near the large south glazing exceeded the upper boundary of the ASHRAE comfort envelope by a large amount in a clear day during both the thermal transition month of October and the cold winter month of January. The generally accepted method of computing the mean radiant temperature based only on the interior surface temperatures was found to produce large errors. The reflected solar radiation from the interior surfaces and the snow covered ground was believed to play a significant role on the measured black globe temperature and should be included in the computation of the mean radiant temperature for a space with large glazed areas.

NBSIR 82-2623. Cassel, J. M.; Tesk, J. A.; Brauer, G. M.; Antonucci, J. M.; Wu, W.; McKinney, J. M. **Properties and interactions of oral structures and restorative materials.** 1982 December. 151 p. Available from: NTIS; PB 83-147546.

Key words: castability; cements; compatibility; composites; polymerization; porcelain/alloy; wear resistance.

Dental cements based on esters of vanillic acid display excellent long term solubility characteristics. Modification of formulations yield uniquely high strength properties and the potential for high strength intermediate restorative resins. Polmeric formulations designed to reduce curing shrinkage, residual unsaturation and hydrophilicity in composites have been developed. A high molecular weight polythiol, pentaerythritol tetra(3-mercaptopropionate), contributes toward this goal and improves color and color stability. Deterioration of composite restorative materials exposed to solvents simulating food debris is maximal in 75% ethanol-water solutions as judged by silver stain examination, changes in surface hardness and wear loss. The resin matrix as cured at 37°C has a low degree of polymerization (DP) and is susceptible to softening by penetrating molecules. Infrared spectroscopy revealed that the DP in a composite is more sensitive to monomer composition than to initiator type or concentration. The rate of solvent-induced softening of composites depends on the cure temperature. A bending beam porcelain-metal specimen was designed. Initial four point bending results obtained in collaboration with dental manufacturers indicate the potential for a simple, reproducible, informative test. Alloy castability values generated in a new test method are strongly dependent on mold and alloy temperatures. Data variance can be used to optimize casting conditions.

NBSIR 82-2625. Houghton, R. C., Jr. **A taxonomy of tool features for the Ada Programming Support Environment (APSE).** 1983 February. 31 p. Available from: NTIS; PB 83-179002.

Key words: Ada Programming Support Environment; APSE; software development; software engineering; software tools; taxonomy.

A categorization of the software development tool features of the Ada Programming Support Environment (APSE) is presented. The features of two Ada environments, the Ada Language System (ALS) and the Ada Integrated Environment (AIE), are compared. The underlying features of the APSE are presented.

NBSIR 82-2626. Leyendecker, E. V., ed. **Amendments to ATC 3-06 Tentative Provisions for the development of seismic regulations for buildings for use in trial designs.** 1982 December. 91 p. Available from: NTIS; PB 83-158543.

Key words: building structures; earthquake codes; earthquake engineering; earthquake standards; seismic design; trial designs.

The report presents amendments to the seismic design recommendations contained in the report "Tentative Provisions for the Development of Seismic Regulations for Buildings" developed by the Applied Technology Council. These amendments were prepared in a review project conducted by the Building Seismic Safety Council and the National Bureau of Standards. The amendments plus the Tentative Provisions will be used in a trial design program to provide information for estimating the impact of adopting the recommendations.

NBSIR 82-2628. Chuang, T. J. **On the energy-release rate associated with diffusional crack growth.** 1982 December. 35 p. Available from: NTIS; PB 83-165076.

Key words: creep cavitation; creep fracture; diffusional crack growth; energy release rate; high temperature fracture; J-integral; nonequilibrium thermodynamics; steady state crack propagation.

A general expression for the energy release rate (G) that arise during steady state crack propagation by diffusion is derived from the standpoint of irreversible thermodynamics. Three contributing components of G are identified: (i) the Griffith energy (G_{Gr}); (ii) heat generated in the process of surface diffusion; and (iii) grain-boundary diffusion. Further, the total G is shown to be directly related to the well-known J-integral if formulated in the framework of finite deformation elasticity. This expression for G is valid in general even if the response of the material is not linear and the mass transport kinetics does not follow Fick's law. Quantitative evaluations of each component are made for the linear case where field solutions are available. The results show that component (ii) is approximately equal to G_{Gr} and is independent of the crack velocity (v) whereas component (iii) is a monotonically increasing function with G starting from 0.85 G_{Gr} when v is at threshold value; and that strain energy contributions can be neglected leading to $G=J=(1-\nu^2)K^2/E$. This means that G is not primarily associated with the release of the strain energy rather, it stems mostly from the negative work done by the normal stresses on the thickening of the grain boundary due to non-uniform deposition of matter along it.

NBSIR 82-2629. Hebner, R. E., Jr.; Kelley, E. F.; Hagler, J. N. **1981 Annual report: Optical measurements for interfacial conduction and breakdown.** 1983 January. 82 p. Available from: NTIS; PB 83-193110.

Key words: breakdown; composite insulation; dielectrics; electric field calculation; electro-optics; high voltage; insulation; interfaces; Kerr effect; liquids; solids.

This report presents measurements and calculations contributing to the understanding of space and surface charges in practical insulation systems. Calculations are presented which indicate the size of charge densities necessary to appreciably modify the electric field from what would be calculated from geometrical considerations alone. Experimental data is also presented which locates the breakdown in an electrode system with a paper sample bridging the gap between the electrodes. It is found that with careful handling, the breakdown does not necessarily occur along the interface even if heavily contaminated oil is used.

The effects of space charge in the bulk liquid are electro-optically examined in nitrobenzene and transformer oil. Several levels of contamination in transformer oil are investigated. Whereas much space charge can be observed in nitrobenzene, very little space charge, if any, can be observed in the transformer oil samples even at temperatures near 100°C.

NBSIR 82-2630. Kopetka, P.; Galowin, L. **Development and evaluation of a test method for shower heads.** 1983 February. 64 p. Available from: NTIS; PB 83-180406.

Key words: plumbing; showerheads; water conservation; water supply devices.

A proposed test method for the evaluation of low-flow shower heads or flow-restrictor-modified shower heads was developed. The test method provides for the measurement of the principal operating characteristics, i.e., pressure-flow rate dependency and the shower spray distribution. The requirements for laboratory instrumentation suitable for application to the apparatus and the procedures for testing were established. A water collection device, "sector rig," was designed and constructed for the measurement of spray distribution patterns. Experiments were conducted with a small number of shower heads to determine the suitability of the proposed test method. The experimental results indicated the applicability of the method for measurement of spray distribution patterns and other conventional hydraulic performance parameters. A proposed test method for evaluation of shower heads was prepared based upon the analysis of the test results. The test method includes the specification of instrumentation, apparatus, procedures, measurements, and data reduction.

NBSIR 82-2631 (AF). Smith, B.; Brauner, K.; Kennicott, P.; Liewald, M.; Wellington, J. **Initial graphics exchange specification (IGES) version 2.0.** 1983 February. 328 p. Available from: NTIS; PB 83-137448.

Key words: Computer Aided Design (CAD); Computer Aided Manufacturing (CAM); design drawing; electrical information; exchange format; finite element modeling; geometrics; graphics.

This document contains Version 2.0 of the Initial Graphics Exchange Specification, a defined format for the creation of a file which enables data found in today's commercially available CAD/CAM systems to be exchanged or archived. IGES, Version 1.0, published as NBSIR 80-1978 (R) in January 1980, consisted of entity definitions for geometry, drafting and structural information. Definition entities were provied as a means of expanding the utility of IGES.

Version 2.0 of the Specification has been extended in the advanced geometry, electrical, and finite element modeling areas. In addition, the Specification has been reformatted and clarified to enable the user to reference the document more easily.

NBSIR 82-2632. Spellerberg, P. A.; Welborn, J. Y. **A review of the Bituminous Reference Sample Program of the AASHTO Materials Reference Laboratory.** 1982 December. 24 p. Available from: NTIS; PB 83-164608.

Key words: coefficient of variation; laboratory performance; test precision.

The Bituminous Reference Sample Program of the AASHTO Materials Reference Laboratory has been operating for more than fifteen years. This paper provides an overview of the accomplishments of this important cooperative undertaking of the National Bureau of Standards and the American Association of State Highway and Transportation Officials.

Background information on the development of standard specifications and methods of test, the AASHTO and the AMRL, is presented to give a historical perspective and to identify the need for the program. Details concerning its operation are reviewed. The coefficients of variation derived from the analysis of laboratory test data from a number of selected tests are plotted and evaluated. The value of the laboratory rating system and the laboratory performance charts which have been developed is discussed. conclusions are made regarding the effectiveness of the program and the accuracy of established test precision limits.

NBSIR 82-2633. Davies, A. D.; Hendrickson, R. G. **Simulation development for automated manufacturing control systems.** 1983 January. 54 p. Available from: NTIS; PB 83-203802.

Key words: automation simulation; manufacturing process simulation; simulation.

This report presents a conceptual development of a simulation of an automated manufacturing facility. The concept addresses the operations, the planning, and the architecture of the underlying computer command and control system associated with automated processes. The objective of the simulation is to provide a research tool for testing facility design concepts, to develop specifications for emulators and computer control functions, and to analyze data flow and module interface problems. The simulation integrates the production activities of manufacturing parts and the underlying command and control structure of the detailed operations into a unified representation of workshop elements, processes, and architecture. This report is based on a specific requirement to analyze automated manufacturing processes in order to develop standards for command and control requirements, specific features of equipment needs, and interfacing elements of the workshop facility.

NBSIR 82-2634. Snell, J. E.; Levin, B. C.; Fowell, A. J. **Workshop on combustion product toxicity—Summary of presentations, September 10, 1982.** 1983 January. 65 p. Available from: NTIS; PB 83-157479.

Key words: building codes; combustion products; fire growth modeling; hazard assessment; inhalation; materials; test method; toxicity.

This publication is a summary of presentations given September 10, 1982, at a Workshop on Combustion Product Toxicity. Publicity on fire deaths caused by smoke and toxic gases has given impetus to a number of state legislatures to consider requiring material toxicity provisions in building codes and other regulations. The National Bureau of Standards recently published a technical report describing the development of a test method for the assessment of the acute inhalation toxicity of combustion products. This test method is intended primarily for research and for preliminary screening purposes by product researchers and material manufacturers in developing and evaluating materials. The test method is not intended to be used by itself in evaluating the suitability of a material for specific application since additional factors must be considered. Therefore, the National Bureau of Standards sponsored a half-day workshop on combustion product toxicity, 9:00 a.m.–12:00 noon, Friday, September 10, 1982, at NBS in Gaithersburg, Maryland. The purpose of this meeting was to brief fire code and building officials and others on the NBS test method for assessing acute inhalation toxicity of combustion products and to provide an opportunity for discussion of its appropriate use.

NBSIR 82-2636. Walters, E. J., ed. **Semiconductor technology program progress briefs.** 1983 January. 19 p. Available from: NTIS; PB 83-165043.

Key words: compound semiconductors; electronics; GaAs; integrated circuits; measurement technology; microelectronics; semiconductor devices; semiconductor materials; semiconductor process control; silicon.

This report provides abstracts of recent publications of NBS work on measurement technology for semiconductor materials, process control, and devices. Emphasis is placed on silicon and silicon-based devices. Topics include: defects and impurities, IC test structures, micrometrology, packaging, physical analysis, power devices, process and device modeling, and radiation effects. In addition, publications in

press and conference presentations are listed. Information is also given on recent seminars, workshops, and symposia and those scheduled for the near future.

NBSIR 82-2656. Moore, R. T.; Holt, A. W.; Koenig, A. L.; Mink, A.; Nacht, G. **Simulation of the guard control station in a computerized site security monitor and response system.** 1983 February. 105 p. Available from: NTIS; PB 83-179028.

Key words: Computerized Site Security Monitor; controls; displays; Guard Control Station; mock-up; Response System.

This report describes a mock-up of a Guard Control Station that was used in simulating the performance of this component of a Computerized Site Security Monitor and Response System. The mock-up was interconnected to three microcomputer systems in an arrangement that permitted simulation of physical security scenarios in an interactive mode. Seven different individuals were allowed to act as operators of the Guard Control Station Console following a brief period of training. Based both on observations of their actions and on their comments, it was determined that the CSSMRS concepts were effective and easy to learn. The Console was judged to have met most design objectives, but certain controls and displays were identified as candidates for minor modification or relocation to further improve the console's overall effectiveness.

NBSIR 83-2551. Kruger, J.; Ritter, J. J.; Long, G. G. **Passive films, surface structure, and stress corrosion and crevice corrosion susceptibility.** 1983 February. 73 p. Available from: NTIS; PB 83-182402.

Key words: chromates; corrosion; electrochemistry; ellipsometry; EXAFS; Fe-Fe bond lengths; iron; nitrites; organic coatings; oxide films; passivation.

Parts I and II: Transparent organic coatings on iron and steel are used to simulate painted metal surfaces for simultaneous ellipsometric and electrochemical measurements. The studies have revealed that significant changes in the interfacial oxide layer occur as corrosion proceeds. These changes have been, in part, attributed to a dissolution of the interfacial oxide and this phenomenon is identified as one mechanism of cathodic coating delamination. Additional phenomena such as surface roughening, oxide film regrowth, and spatial development of cathodes are discussed. The effects of coating cure and the presence of inhibitors are also presented.

Parts III and IV: The bonding, structure, and composition of passive films are still controversial subjects. A new surface EXAFS technique, capable of probing a passive film on iron in its native aqueous environment has been applied to this problem. The studies show that Fe-Fe distances for passive films formed in nitrite and chromate solutions are different from those of known iron oxides and oxyhydroxides. Moreover, differences in the degree of covalency of iron and in the crystallinity of these films have also been detected.

NBSIR 83-2635. Walton, G. N. **A computer algorithm for estimating infiltration and inter-room air flows.** 1983 February. 35 p. Available from: NTIS; PB 83-174904.

Key words: building energy analysis; building heat transfer; computer modeling; convection; infiltration; ventilation.

This report discusses the extension of an infiltration predicting technique to the prediction of inter-room air movements. The air flow through openings is computed from the ASHRAE crack method together with a mass balance in each room. Simultaneous solution of the mass balances in all rooms having both large and small openings is accomplished by a slightly modified Newton's method. A simple theory for two-way flow through large openings is developed from consideration of density differences caused by different temperatures in adjoining rooms. The technique is verified by comparison to published experimental results. The results indicate that the simple model provides reasonable results for complex two way flows through openings. The model is as accurate as the available data, that is, about $\pm 20\%$. The air flow algorithm allows infiltration and forced air flows to interact with the doorway flows to provide a more general simulation capability.

NBSIR 83-2638. Chi, J.; Didion, D. **A commercial heating boiler transient analysis simulation model (DEPAB2).** 1983 January. 93 p. Available from: NTIS; PB 83-165480.

Key words: boilers; computer model; energy conservation; fire tube boilers; heat transfer.

This report documents a second generation boiler transient analysis computer program DEPAB2. It treats in detail the boiler controllers and different modes of heat transfer (which include conductive, convective and radiative) in the boiler environment; and it is built upon 7 principal subroutines for the controller and interface flux calculations and 16 auxiliary subroutines for fluid properties, fuel/air combustion and heat transfer parameters.

Also included is a guide on using DEPAB2. Included are: (1) Input data requirements for DEPAB2 runs, (2) Procedures for DEPAB2 runs, and (3) Output data interpretation. In addition, a worked example is described and discussed in detail to illustrate: (1) the DEPAB2 runs, (2) quantitative information generated by DEPAB2 runs, and (3) use of information from DEPAB2 runs to design energy conservation strategies.

NBSIR 83-2639. Fiorello, M.; Cugini, J. **Cost-benefit impact study on the adoption of the draft proposed revised X3.23 American National Standard Programming Language COBOL.** 1983 March. 81 p. Available from: NTIS; PB 83-193086.

Key words: COBOL; compatibility of programming language standards; conversion costs for COBOL programs; cost-benefit analysis of COBOL standards; Federal use of COBOL; FIPS for COBOL; standardization of COBOL.

The purpose of the study is to assess the estimated costs and benefits for the Federal Government which would result from adoption of the proposed revision of American National Standard COBOL as a Federal Information Processing Standard (FIPS). Potential benefits of in both the development and maintenance of COBOL programs. Estimated costs o. have been identified, arising principally from the effort needed to convert old COBOL programs to the new specification, which is incompatible in some respects with the current specification. In support of the study, we conducted interviews with Federal ADP managers and officials, and also analyzed over one thousand Federal COBOL programs for various syntactic characteristics. The study concludes that the potential benefits of a new standard outweigh the estimated costs.

NBSIR 83-2640. Whetstone, J. R.; Johnsen, E. G. **Sensors for efficient energy utilization in the paper industry.** 1983 February. 45 p. Available from: NTIS; PB 83-164343.

Key words: instrumentation; measurement technology; paper manufacturing; pulping; recovery boiler.

A survey of the on-line process measurement needs of the paper industry has been completed. The survey focused on pulp and paper mills with one corporate Instrumentation and Control group and one instrumentation and control systems manufacturer included. The results of the survey strongly indicate the need for new measurement technology at the pulping end of the process. Important unit processes identified are: (1) chemical recovery (recovery boiler and lime kiln combustion measurements); (2) digestion (lignin concentration measurement in the pulp or spent liquor); and (3) thermomechanical pulping (consistency measurement). All of the processes are energy intensive and cannot be controlled either partially or completely due to the lack of measurement of specific process parameter.

NBSIR 83-2641. Pitts, W.; Kashiwagi, T. **The application of laser-induced Rayleigh light scattering to the study of turbulent mixing.** 1983 February. 114 p. Available from: NTIS; PB 83-183442.

Key words: axisymmetric jet; concentration flow field; intermittency; laser; ramp-like structures; Rayleigh light scattering; scalar probe; turbulence; turbulent flow.

This work describes the development and characterization of an experimental system employing laser-induced Rayleigh light scattering with digital data acquisition as a time-resolved, quantitative concentration probe in the turbulent flow field of a binary gas mixture. Equations for the expected signal and noise levels are given. Estimates of these parameters for the experimental system used here are in satisfactory agreement with experiment. It is demonstrated the laser Rayleigh light scattering technique does provide highly spatially- and time-resolved measurements within the concentration

flow field. Measurements at various positions in the flow field of an axisymmetric methane jet issuing into a slow flow of air are reported and where possible, compared with appropriate literature results. The statistical properties of the turbulent concentration fluctuations are found to be in good agreement with other independent measurements. Conditionally sampled measurements are also reported and shown to behave in the same manner as the limited number of similar measurements in the literature. The capability of calculating power spectra and correlation functions for the time behavior of the methane concentration is also demonstrated. Other techniques employed for scalar measurements in turbulent flow fields are briefly reviewed and the utility of these techniques for measurements in different types of flow systems are discussed in relation to the Rayleigh light scattering method.

NBSIR 83-2642. Lee, B. T. **Fire hazard evaluation of shipboard hull insulation and documentation of a quarter-scale room fire test protocol.** 1983 August. 47 p. Available from: NTIS; PB 83-261198.

Key words: flammability; flashover; heat release rate; insulation; interior finishes; paints; room fires; ships; small-scale fire tests.

A variety of shipboard hull insulations including damping and acoustical materials, painted and unpainted, were evaluated for their flashover potential using a quarter-scale room fire test developed by the Center for Fire Research at the National Bureau of Standards. Three painted insulations were also evaluated in full-scale room fire tests. Comparison of full-scale and quarter-scale fire behavior again demonstrated that the quarter-scale test can predict full-scale room fire buildup. It was found that decorative paints, including the Navy's chlorinated alkyd formulation, could seriously compromise the fire safety of otherwise low fire risk insulations. A recommended test protocol was developed for determining the flashover potential of hull insulation using the quarter-scale room fire test.

NBSIR 83-2643. Sullivan, F.; Kahaner, D.; Fowler, H. A.; Knapp-Cordes, J. **Wave form simulations for Josephson junction circuits used for noise thermometry.** 1983 January. 56 p. Available from: NTIS; PB 83-165472.

Key words: differential equation; electronic oscillator; Josephson junction; numerical integration; Poincaré maps; relaxation oscillator.

Solutions to the Resistively Shunted Junction (RSJ) Equation: $\beta\ddot{\phi}+(1+\gamma\cos\phi)\dot{\phi}+\sin\phi=\alpha+k\omega\sin\omega t$ for small $\beta(=.001)$ have been approximated using the SDRIVE integration package. Various graphic displays are used to examine the output, including plots of ϕ, $d\phi/dt$, and $\sin\phi$ as functions of time; Poincaré diagrams; and plots of the Lienard coordinate $z=\beta\dot{\phi}+\phi+\gamma\sin\phi$ which has a close connection with the "slow manifold," as a function of ϕ, of $\sin\phi$, and of time. Integration is performed by separation of the second-order equation into a coupled pair of first-order equations, and numerically integrating with respect to time.

Several cases have been examined, for $\gamma<1$, representing quiet behavior of resistively shunted thermometer oscillator devices. The report is an archive record of program-test data.

A case of "jump" (voltage-spike) oscillator performance for $\gamma=1.5$ has been simulated in considerable detail, principally as a test of the integrator. Parallel, independent computer results (Sanders and van Veldhuizen, Amsterdam) were available for comparison. This case is of considerable mathematical interest, and values of $|\gamma|>1$ may also occur in the RSQUID thermometer.

NBSIR 83-2645. Dehl, R. E. **Characterization of porosity in porous polymeric implant materials.** 1983 Febuary. 51 p. Available from: NTIS; PB 83-183459.

Key words: pore size; pore volume; porous implants; porous polyethylene; PTFE-carbon composite; stereology; stress-strain plots; surface area.

In this report, we describe (1) the continued exploration of methods for characterizing the porosity of two commercial implant materials, a porous polyethylene and a composite of polytetrafluoroethylene and carbon, and (2) the compressive stress-strain behavior of these materials. A major emphasis was placed upon optical image analysis of porous polyethylene. The pore volume fraction obtained from analysis of 20 photomicrographs (0.47) agreed well with the fraction previously found by two other methods. The mean intercept length, determined from the same photomicrographs, was about 75 μm, a value considerably higher than the average "interconnecting" pore diameter determined by mercury porosimetry (30 μm). Replotting our mercury porosimetry data, we found that the volume-weighted pore size distribution curve resembled a log-normal distribution, skewed to the right of the "most probable" pore radius. The surface area determined from mercury porosimetry data was somewhat larger (0.125 m^2/g) for the porous polyethylene than that determined by the BET method (0.082 m^2/g), while the reverse was true for the composite material (0.19 vs 0.45 m^2/g). Compressive stress-strain measurements on the laminated composite demonstrated that the initial compression modulus is approximately six times greater when the stress is applied parallel rather than perpendicular to the laminar planes.

NBSIR 83-2646. Frederikse, H. P. R.; Dragoo, A. L.; Kahn, A. H.; Hosler, W. R. **Characterization of ARV antenna window material.** 1983 January. 24 p. Available from: NTIS; PB 83-164350.

Key words: boron nitride; calculated transmissivity; electrical conductivity; high temperatures; microwave radiation.

Boron nitride is a major candidate for use as a microwave window material. To assess its feasibility for this purpose, it is essential to know the electrical and dielectric properties at high temperatures. This report discusses the experimental approach to electrical conductivity measurements above 1800°C and presents some initial results. At the same time, computer calculations have been performed which have yielded values of the reflectivity, absorption, and transmission of boron nitride in the temperature range 2500–3000°C.

NBSIR 83-2647. Fuller, E. G. **The photodisintegration of the deuteron, 1982.** 1983 March. 23 p. Available from: NTIS; PB 83-202531.

Key words: cross section; deuteron; dipole; electric; magnetic; nuclear; photodisintegration; polarizability.

Measurements of the deuteron's photodisintegration cross section made over a thirty year time span are evaluated in terms of the cross section for E1 and M1 transitions calculated in the effective range approximation. The energy range covered is from threshold to 44 MeV. Data that do not depend on a knowledge of a bremsstrahlung spectrum's intensity or spectral distribution are shown to be described very well by the effective-range expressions. The values of the deuteron's electric polarizability is shown to be in fair agreement with a value derived from the observed deviation from Rutherford scattering of deuterons by ^{208}Pb. A comparison is made of the experimental data with three recent calculations of the photodisintegration cross section.

NBSIR 83-2648. Mulroy, W. J.; Park, C. **Experimental and analytical investigation of a residential hot water boiler with finned copper tube heat exchangers.** 1983 March. 64 p. Available from: NTIS; PB 83-201467.

Key words: annual efficiency; annual operating costs; boilers; fossil fuel heating systems; jacket loss; modulating control gas fueled; part-load performance; rating procedures; seasonal efficiency.

In response to a request by a manufacturer of a nontypical boiler, the Department of Energy requested the National Bureau of Standards to perform laboratory measurements under controlled conditions of the effect on seasonal performance of several features (finned copper tube heat exchanger, water circulating pump delay, and gas valve modulation) of this boiler that might cause it to be unfairly treated by the existing test procedure. As a result of this study, recommended changes to the existing test procedure to allow rating tests with water circulating pump delay are presented. A recommended change to the assigned cyclic jacket loss factor and a simplified procedure for experimentally determining this factor are also presented. No change to the current test procedure treatment of gas valve modulation or flue gas mass flow as a function of temperature are recommended.

NBSIR 83-2652. Jones, F. E. **Calculation of compressibility factor for air over the ranges of pressure, temperature, and relative humidity of interest in flowmeter calibration.** 1983 March. 9 p. Available from: NTIS; PB 83-202499.

Key words: air; compressibility factor; extrapolation formulas; flowmeter calibration; pressure; relative humidity; temperature.

A simple yet precise equation has been developed to enable calculation (using programmable calculators) of the compressibility factor, Z, for air from measurements of pressure, temperature, and humidity. The compressibility factor, a factor which accounts for the nonideality of air in real-gas equations of state, is conventionally computed using virial coefficients. In the present paper, an equation is fitted to tabulated values of Z. The deviation between calculated and tabulated values is of the order of 0.01% or less; this does not imply, however, that the *accuracy* of calculated values is of this order.

NBSIR 83-2653. Wise, R. A. **Field test results on the performance of a refrigerator-freezer in a single-family residence.** 1983 February. 23 p. Available from: NTIS; PB 83-179010.

Key words: consumer; defrost; door-openings; energy use; field test; home; ice cubes; ice-maker; refrigerator; refrigerator-freezer.

The operation of a side-by-side 623 L (22 cubic foot) refrigerator-freezer in use in a single family residence was continuously monitored for over two years. During this time, the daily cumulative number of freezer and fresh-food door openings, ice-maker operations, defrost cycles, and compressor cycles were recorded. In addition, the lengths of time the doors were open, the length of defrost heater "on" time, and the watt-hours energy use were recorded. On a weekly basis the amount of accumulated defrost water was measured. All information was entered into a computer file and analyzed to determine the magnitudes, variations, and trends of the data. The effects of such variables as the season of the year, number of people using the test unit, and a slow refrigerant leak were evaluated.

Graphic representations of many of the variables vs. time and vs. each other are included in the report. The small effect that ambient or variable use conditions had on long term cumulative energy use and the great variation found in the use conditions on both a daily and weekly basis are typical observations. Averaged over the entire data collection period, the fresh food compartment door was opened 32.5 times per day for a total of 3.8 minutes per day. The freezer compartment door was opened seven times per day for a total of 1 minute per day, and the ice-maker operated 2.4 times per day producing 14 ice cubes.

NBSIR 83-2655. Walton, G. N. **Thermal Analysis Research Program Reference Manual.** 1983 February. 286 p. Available from: NTIS; PB 83-194225.

Key words: building energy analysis; building heat transfer; computer modeling; load calculation.

The Thermal Analysis Research Program (TARP) has been developed as a research tool for the thermal analysis of buildings. It especially aims to study the interactions of many complex heat transfer phenomena. TARP uses the detailed heat balance method for the simultaneous calculation of the energy requirements of multiple rooms. Interroom conductive and convective processes are simulated in detail. This program reference manual describes the algorithms, input, output, and program structure of TARP. The program is written to be portable and modifiable. It is written in FORTRAN 77 and has run on CDC and UNIVAC computers. Future expansions of the program are anticipated, particularly for the simultaneous simulation of equipment performance and building thermal response.

NBSIR 83-2657. Marshall, H. E. **Recommended practice for measuring net benefits and internal rates of return for investments in buildings and building systems.** 1983 October. 74 p. Available from: NTIS; PB 84-114875.

Key words: adjusted internal rate of return; benefit-cost analysis; building economics; building economics standard; constrained optimization; cost effectiveness; discounting; economic efficiency; internal rate of return; net benefits; net present value.

This report describes how to calculate net benefits (savings) and internal rates of return and how to use them in selecting building designs and building systems that will be cost effective over time. Net benefits are the difference between positive benefits or cost reductions (savings) and project costs, measured in present value or annual value dollars. The net benefits method is used to decide if a given project is cost effective and which size or design for a given purpose is most cost effective when no budget constraint exists. The internal rate of return on an investment is the compound rate of interest that, when used to discount the streams of dollar benefits (savings) and dollar costs over a defined study period, will make the two equal. The internal rate of return is used to determine if a given project is cost effective, to compare the relative cost effectiveness of different purpose projects competing for a limited budget, and, when calculated on incremental changes in benefits and costs, to evaluate which size or design for a given purpose is most cost effective. The report describes formulas for calculating net benefits and the internal rate of return, their applications in selecting cost-effective projects, and limitations in their use. This recommended practice for measuring net benefits and internal rates of return will assist the private and public building communities in making cost-effective decisions in the design, operation, maintenance, and retrofit of buildings.

NBSIR 83-2658. Petersen, S. R. **SOLCOM: A computer program to integrate solar and conservation economics for new commercial buildings.** 1983 February. 138 p. Available from: NTIS; PB 83-182295.

Key words: building design; commercial buildings; energy conservation; engineering economics; heating and cooling equipment; heating and cooling loads; life-cycle cost analysis; optimization algorithms; solar heating.

This report provides a methodology, algorithms and a computer program for determining the least life-cycle cost combination of three interdependent conservation strategies in new commercial buildings. These three strategies include (1) envelope modifications to reduce seasonal and peak load heating and cooling requirements, (2) heating and cooling plant modifications to increase their seasonal efficiency, and (3) the use of an active solar space and water heating system. The resulting computer program, called SOLCOM, can be run on a microcomputer in three stages.

The SOLCOM program performs a complete life-cycle cost analysis for the active solar system and for each envelope and plant modification to be considered, include tax and mortgage effects. The program then determines the optimal combination of envelope modifications and the resulting seasonal and peak load heating and cooling requirements; the optimal space heating, water heating, and space cooling plant efficiencies; and the optimal collector size for the active solar heating system.

NBSIR 83-2659. Nelson, H. E.; Levin, B. M.; Shibe, A. J.; Groner, N. E.; Paulsen, R. L.; Alvord, D. M.; Thorne, S. D. **Fire safety of board and care homes.** 1983 March. 197 p. Available from: NTIS; PB 83-192674.

Key words: apartments; board and care homes; developmental disabilities; egress; elderly persons; evacuation; fire safety; Fire Safety Evaluation System; handicapped; mental retardation; residential buildings.

Board and Care Homes for residents with mental retardation, the infirmities of age, or mental illness are a new type of occupancy, and model fire safety codes do not have requirements specifically for this type of occupancy. In support of efforts to write model codes for this type of occupancy, a Fire Safety Evaluation System has been developed. It can be used for determining if a home has fire safety equivalent to that obtained by meeting the requirements of a given code. The system was calibrated for use with a proposed chapter of the Life Safety Code. There are three sets of requirements: one for small dwelling units, one for large facilities, and one for apartment houses. Within each set, there are four levels of evacuation capability of the residents and staff—prompt, moderate, slow, and impractical, each with a different requirement for fire safety features, so that homes with more capable residents will not be required to have as many fire safety features to meet the desired level of safety. A novel rating system is described for determining the evacuation capabilities of the residents with available staff assistance. A field test is described.

NBSIR 83-2660. Epstein, J. A. **A discussion of GRIDNET algorithms and simulation results.** 1983 February. 39 p. Available from: NTIS; PB 83-181768.

Key words: alternate routing; communications networks; distributed control; network connectivity; packet overhead; packet switching; survivability.

This report is an evaluation of the results of computer simulation of GRIDNET conducted during the period from 17 May 1982 to 12 November 1982.

This report describes the testing and modification of algorithms which permit messages in a GRIDNET to be routed from any source to any destination, in a network having thousands of nodes, and to accomplish this routing in an efficient manner using only limited local knowledge of network operability status. Estimates were developed for algorithm performance and runtime efficiency. Additional studies were made concerning network connectivity, reducing packet overhead, network topology, and resolving packet overflow.

NBSIR 83-2661. Fivozinsky, S. **Technical activities 1982—Office of Standard Reference Data.** 1983 February. 80 p. Available from: NTIS; PB 83-193078.

Key words: data compilation; energy and environmental data; evaluated data; materials data; standard reference data; technical activities 1982; thermochemical and thermophysical data.

The Office of Standard Reference Data is one of four program offices in the National Measurement Laboratory, National Bureau of Standards. The Standard Reference Data Program develops and disseminates data bases of critically evaluated physical/chemical properties of substances. These data bases are available through NBS and private publications, on magnetic tape, and from on-line retrieval systems.

The Office of Standard Reference Data is responsible for management and coordination of the program. Work is carried out through a decentralized network of data centers and projects referred to as the National Standard Reference Data System (NSRDS). This volume summarizes the activities of the program for the year 1982.

NBSIR 83-2662. Ventre, F. T. **Documentation and assessment of the GSA/PBS Building Systems Program: Background and research plan.** 1983 February. 67 p. Available from: NTIS; PB 83-192807.

Key words: building measurement; building systems; Federal buildings; field assessment; office buildings; performance specification; post-occupancy evaluation; procurement; technical innovation.

This report documents the origins and conduct of the General Services Administration/Public Buildings Service (GSA/PBS) Building Systems Program (BSP) undertaken during the 1970s and recommends a research plan for assessing the effectiveness of the BSP. The report proposes specific methods for assessing two outcomes of the BSP: the delivery of specified levels of performance for four attributes in the six buildings completed under the BSP and the wider effects of the BSP on the building community.

NBSIR 83-2664. Wiederhorn, S. M.; Tighe, N. J. **Structural reliability of yttria-doped, hot-pressed silicon nitride at elevated temperatures.** 1983 March. 29 p. Available from: NTIS; PB 83-192666.

Key words: ceramics; creep; creep rupture; fracture; silicon nitride; strength.

The strength of yttria-doped, hot-pressed silicon nitride was investigated as a function of temperature and applied load. Data collected at 1200°C are presented in the form of a strength degradation diagram for an applied load of 350 MPa. At this temperature, the behavior of the yttria-doped material is found to be superior to that of magnesia-doped silicon nitride, in which creep results in the formation of microcracks that lead to strength degradation. By contrast, the yttria-doped material does not suffer from microcrack formation, or strength degradation at 1200°C. At higher temperatures strength degradation does occur, and as a consequence, an upper limit of 1200°C is recommended for yttria-doped, hot-pressed silicon nitride in structural applications.

NBSIR 83-2665. Baum, H. R.; Rockett, J. A. **An investigation of the forced ventilation in containership holds.** 1983 May. 175 p. Available from: NTIS; PB 83-209338.

Key words: cargo ships; fire hazardous materials; modeling; stratified flow; ventilation.

An analysis of the fluid flow and mass transfer induced by ventilation systems in containership holds was carried out. The work was performed in support of the U.S. position before a committee of the International Convention on Safety to Life at Sea. The analysis consists of a detailed calculation of the forced motion through an interconnected set of narrow, stably stratified vertical air passages which represent an idealized containership holds the results of this calculation are then used in a study of the concentration boundary layers formed by the pickup of spill material assumed to lie at the bottoms of the air passages. The result is a set of formulae which determine the rate of extraction of spill material as a function of hold geometry, ventilation parameters, and ambient stratification. The results are incorporated in a computer program which is described in detail. A variety of computed results are presented, together with a listing of the program. The results indicate the crucial importance of locating the extractor as close to the hold bottom as technically possible.

NBSIR 83-2666. Hillhouse, D. L. **Effects of high-voltage switching on the EPRI-NBS coupling capacitor voltage transformer (CCVT) calibration system standard divider.** 1983 March. 37 p. Available from: NTIS; PB 83-192682.

Key words: calibration; capacitive divider; CCVT; error sources; high-voltage measurements; high-voltage switching; ratio offset; trapped charge; Waltz Mill tests.

This report presents the results of tests of the effects of high-voltage switching on the EPRI-NBS CCVT calibration system's capacitive standard divider, completing an investigation stemming from the results of three calibrations at a Gulf States Utilities substation.

Initial tests consisted of full-scale (300 kV) switching operations at EPRI's Waltz Mill test facility, during which the divider exhibited significant ratio offsets (average = +0.2%, maximum = nearly +0.5%). Tests were continued at the National Bureau of Standards (NBS), where it was determined that operation of a grounding switch, installed to protect the divider low side during high-voltage switching, caused ratio offset by trapping charge on the divider's low side capacitor. This resulted in residual dc voltage which changed the value of the divider's low-side capacitance. The addition of a bleeder resistor eliminated the problem in the laboratory. With the bleeder resistor in place, the Waltz Mill tests were repeated. Fifty high-voltage switching operations indicated a negligible shot-to-shot variation (average = −1 ppm, σ = 80 ppm).

No obvious correlation was found between the ratio offsets described above and the results of CCVT calibrations performed while the effect may have been present in the divider. Experience indicates that a significant proportion of calibrated CCVTs is outside metering tolerance. Long-term simultaneous monitoring of a sizeable number of CCVTs is suggested.

NBSIR 83-2667. O'Brien, T. C. **NBS and industrial biotechnology: Instrumentation and associated measurement needs.** 1983 March. 63 p. Available from: NTIS; PB 83-191114.

Key words: biotechnology; market projections; measurements; monitoring and control technologies; National Bureau of Standards; scientific instruments; separation technologies.

Instrumentation developments in biotechnology are essential to maintaining the flow of research findings through commercial operations to the marketplace. This report identifies several measurement-related problems associated with industrial biotechnology instrument needs, and discusses appropriate research and service activities NBS should undertake in order to be responsive to some of this industry's infrastructure technology needs.

The report highlights several areas: (a) the highly competitive and rapidly evolving biotechnology instrumentation market; (b) biotechnology instrumentation market projections; (c) instrumentation developments (for example, monitoring and control technologies and separation technologies) considered essential for bioprocess optimization; (d) specific NBS scientific capabilities in bioanalysis, electrochemistry, etc. related to instrumentation measurement-related needs; and (e) steps NBS could take to begin to address these needs.

An extensive bibliography is provided.

NBSIR 83-2668. DeVoe, J. R.; Travis, J. C.; Turk, G. C.; Weeks, S. J. **Laser enhanced ionization in flames.** 1983 March. 36 p. Available from: NTIS; PB 83-193060.

Key words: laser enhanced ionization; laser spectroscopy; optogalvanic effect; spectroscopic analysis.

This report describes the discovery of laser enhanced ionization in flames along with a description of research on the mechanisms of signal production and collection. Early experiments on the method's use for complex sample analysis are described. Results of this research predict that two photon-two wavelength laser enhanced ionization will produce detection limits at the 10 parts per trillion level in solution for most elements. Laser excitation provides high selectivity so that the method can be predicted to have high accuracy.

NBSIR 83-2669. Ives, L.; Swartzendruber, L.; Boettinger, W.; Rosen, M.; Ridder, S.; Biancaniello, F.; Reno, R.; Ballard, D.; Mehrabian, R. **NBS: Processing/microstructure/property relationships in 2024 aluminum alloy plates.** 1983 April. 268 p. Available from: NTIS; PB 83-207696.

Key words: aging; aluminum alloy; eddy-current conductivity; hardness; heat flow; microstructure; nondestructive evaluation; precipitation; processing; segregation; solution heat treatment; ultrasonics.

Nondestructive evaluation (NDE) using eddy-current conductivity and hardness measurements form an essential part of the quality control of aluminum alloy plates used for aerospace vehicles. The relationships between the NDE measurements and the important mechanical properties are affected by a large number of variables including: chemical composition, cast structure, ingot scalping, solution heat treatment and quenching, mechanical working, and aging treatment. At the request of the National Aeronautics and Space Administration, a number of these relationships has been explored for 2024 aluminum alloy. This work is a continuation of our previous efforts on 2219 aluminum alloy and is motivated by a concern that a number of improperly treated plates with "soft spots" may have been incorporated into aerospace structures. A major result of our research has been a delineation of which alloy tempers and plate thicknesses are most likely to contain "soft spots" due to specific processing errors.

NBSIR 83-2670. Evans, D. D. **Calculating fire plume characteristics in a two layer environment.** 1983 September. 47 p. Available from: NTIS; PB 84-114578.

Key words: compartment fires; fire models; fire plumes; room fires; sprinkler systems.

Methods are developed to determine axial gas flow conditions within a weakly buoyant plume that passes from an ambient quiescent environment, in which the plume originates, to an upper layer at elevated temperatures. The methods are appropriate for inclusion in two layer analysis of enclosure fire. In particular, they are a first step in developing a prediction of actuation time for thermally activated automatic sprinklers exposed to an enclosure fire. Results obtained with various methods are compared with measurements in a 1.22 m diameter cylindrical enclosure.

NBSIR 83-2671. Stahl, F. I. **The Standards Interface for Computer-Aided Design.** 1983 March. 48 p. Available from: NTIS; PB 82-193094.

Key words: building codes and standards; building delivery process; building design process; computer-aided building design; computer-aided design; computer-integrated construction; engineering database management; structural engineering computer programs.

Building quality can be improved and building costs reduced through more effective computer utilization in design and construction. To accomplish these objectives improved interfaces are needed between building project databases and computer-based procedures for analysis and design, and between computer-based engineering procedures and applicable design standards. This latter task involves a set of problems termed the Standards Interface for Computer-Aided Design (SI/CAD). These problems comprise the focus of the current report. The SI/CAD is shown to be a critical determinant of computer-aided design (CAD) system effectiveness, particularly in the domain of structural engineering design. This report examines the hypotheses that: (1) the ability to easily maintain design standards data is fundamental to CAD system effectiveness; (2) the configuration of presently available computer-aided structural design (CASD) system software inhibits efficient design standards data modification, requiring costly maintenance to avoid software obsolescence and limiting the overall usefulness of these systems; and (3) methods to enhance the efficiency of criterion checking and standards data maintenance are required to increase the utilization of CAD technology. Support for hypotheses (1) and (2) is developed from anecdotal engineering experience and from the technical literature drawn principally from CASD. No evidence was found to support hypothesis (3).

NBSIR 83-2672. Saunders, P. B., ed. **Selected assessment strategies applied to short-term energy models.** 1983 April. 153 p. Available from: NTIS; PB 83-201418.

Key words: assessment; documentation; energy; information theory; mathematical models; sensitivity analysis.

This report is one in a series focusing on the evaluation of complex mathematical models. The basic approach pursued in this document is patterned after an earlier analysis of the Department of Energy's Midterm Oil and Gas Supply Model (MOGSM). Several extensions of the earlier methodology are presented which assist the analyst in defining the degree to which certain evaluation activities are model dependent. The Department of Energy's Short Term Integrated Forecasting System (STIFS) was used as a vehicle for exercising the revised methodology. The technical content of the report is divided into three parts, reflecting three basic issues of model form, sensitivity and forecast performance. The first issue addressed related to the structure of STIFS. It includes not only the mathematical assumptions implicit in the model but also data and software considerations. The approach to the second issue focuses on the measurement of climatological uncertainties and uses as its basis a Monte-Carlo experiment. The final issue deals with several techniques for evaluating the predictive performance of a model. Both classical statistical methods and an information theoretic approach are used to illustrate how such an analysis would be carried out in practice.

NBSIR 83-2673. Mills, K. L.; Moulton, J. **Proceedings of the first LAN-Transport Workshop (NBS).** 1983 February. 21 p. Available from: NTIS; PB 83-202549.

Key words: communication protocols; computer networks; local area networks; standards; transport protocol.

The National Bureau of Standards Institute for Computer Sciences and Technology (ICST) has prepared specifications for the International Organization for Standardization's (ISO) Class 4 Transport Protocol. At the request of a number of companies, ICST organized a workshop for local area network implementors of these specifications. The workshop focused on implementation techniques and strategies so that a multivendor demonstration of these protocols can occur at a major computer conference in the 1984 time frame. This report documents the workshop and records implementation choices and agreements made by the participants.

NBSIR 83-2674. Rennex, B. **Error analysis for the National Bureau of Standards 1016 mm guarded hot plate.** 1983 April. 47 p. Available from: NTIS; PB 83-202481.

Key words: apparent thermal conductivity; error analysis; guarded hot plate; thermal insulation; thermal resistance.

An error analysis is given for the 1-meter Guarded Hot Plate at the National Bureau of Standards. This apparatus is used to measure the thermal resistance of insulation materials. The individual contributions to uncertainty in thermal resistance are discussed in detail. The total uncertainty is estimated to be less than 0.5 percent at sample thicknesses up to 150 mm (6 inches) and less than 1 percent at a thickness of 300 mm (12 inches).

NBSIR 83-2675. Collins, B. L.; Lerner, N. D. **An evaluation of exit symbol visibility.** 1983 April. 52 p. Available from: NTIS; PB 83-202424.

Key words: exit symbols; fire safety; legibility; symbols; understandability; visibility; visual alerting.

The performance of exit symbols was assessed in a laboratory experiment using viewing conditions degraded to resemble smoke. Research participants were presented with color slides showing symbol signs designed to be used in buildings. For each slide the participant indicated if the symbol conveyed the message of "exit." A total of 108 symbol slides were used, of which 18 were exit symbols. Each of the 42 participants were familiarized with a random set of 9 of the 18 exit symbols, prior to data collection. During the experiment, the symbol of slides were presented under three levels of viewing difficulty. In general, errors increased as the viewing conditions became more degraded but the increase in errors became much more severe for some symbols than others. Fewer errors were made for some of the symbols that had been familiarized. The data suggested that increased errors under degraded viewing conditions were related to graphic features of the symbols. A number of specific symbol features that influence exit symbol effectiveness were identified along with features of nonexit symbols that produce confusions. Finally, recommendations for exit symbol design are presented that may lessen egress-related confusions during building emergencies.

NBSIR 83-2676. Chang, Y. M.; Grot, R. A. **Technique for tracking the effect of weatherization retrofits on low-income housing.** 1983 April. 51 p. Available from: NTIS; PB 83-203026.

Key words: balance point temperature; computer graphics; degree days; energy conservation; energy consumption; fuel usage records; tracking technique; weatherization retrofit.

This report presents a technique for analyzing the effect of energy saving retrofits installed in low-income housing under a nationwide weatherization demonstration program. This program was undertaken by the Community Services Administration (CSA) with the technical support of the National Bureau of Standards (NBS).

A tracking technique, based on the calculated balance-point temperature of each home prior to the weatherization, was developed to estimate the would-be fuel consumption over a period of time if the house had not been weatherized. The savings in fuel consumption for a home can be determined from the difference between the actual usage after retrofit and the calculated usage if it were not retrofitted. Besides the overall reduction, the saving in energy usage during different time periods while the house is being weatherized can be visualized from the graphical representation of the tracking technique.

Fuel reduction is reported for more than 100 homes using different fuels in seven cities across the nation, selected to represent various climate zones and geographical locations. It was found that the average saving in fuel consumption for dwellings in each city is about 30 percent.

NBSIR 83-2677. Gomberg, A.; Hall, J. R., Jr. **Analysis of electrical fire investigations in ten cities.** 1983 April. 57 p. Available from: NTIS; PB 83-200113.

Key words: electrical; electrical fires; fire cause; fire data; ignition.

This interim report describes the progress and conclusions to date on an analysis of electrical fire cases by the Center for Fire Research, National Bureau of Standards for the Consumer Products Safety Commission. The report describes the 110 detailed electrical fire investigation reports from 10 participating cities, and discusses preliminary findings resulting from analysis of the computerized data from those reports. These preliminary findings are being used to guide a follow on effort, to be reported on at a later date, to obtain, encode and analyze additional data from the original 110 cases, in order to better define and describe the most significant failure modes of electrical components and the sequences of events which lead to electrical fire ignition.

NBSIR 83-2678. Levin, B. C.; Paabo, M.; Birky, M. M. **An interlaboratory evaluation of the 1980 version of the National Bureau of Standards test method for assessing the acute inhalation toxicity of combustion products.** 1983 April. 88 p. Available from: NTIS; PB 83-198093.

Key words: carbon monoxide; carboxyhemoglobin; combustion; combustion products; hydrogen cyanide; inhalation; interlaboratory evaluation; LC_{50}; test methods; toxicity.

Seven laboratories selected from academia, industry, and government evaluated the 1980 version of the NBS test method for assessing the toxicity of combustion products to determine the operability of the procedure and the reproducibility of results across laboratories. The experimental design specified that each laboratory was responsible for testing Douglas fir and three other materials from a total of twelve natural and synthetic materials. All laboratories were required to use similar exposure and combustion systems, to measure the autoignition temperatures of their materials, to determine the toxicity of the gaseous products released by the materials under both flaming and non-flaming conditions, to monitor chamber environmental conditions (temperatures, and oxygen, carbon monoxide, and carbon dioxide concentrations), and to measure blood carboxyhemoglobin in the test animals (rats). In addition, a few laboratories measured hydrogen cyanide generated from nitrogen-containing materials. Toxicity was evaluated on the basis of incapacitation (hind-leg flexion behavioral avoidance response) during the 30 minute exposure and of lethality during the exposure and 14 day post-exposure observation period. The results of this interlaboratory evaluation were statistically analyzed and, in most cases, demonstrated reproducible results across laboratories. Possible reasons for any inconsistencies are discussed. Sensitive experimental factors are identified and modifications to the test method which resulted from the experimental data collected during the interlaboratory evaluation are described.

NBSIR 83-2680. Rudder, F. F., Jr. **Method for assessing benefits of airborne noise isolation requirements in residential and educational buildings.** 1983 April. 66 p. Available from: NTIS; PB 83-198556.

Key words: acoustical design; benefit analysis; building codes; model code; noise control; noise impact; outdoor-indoor noise isolation.

This report presents a method for estimating benefits accruing from implementing acoustical performance requirements for new buildings. The method can be applied to a wide range of environmental noise conditions and noise isolation requirements for building envelopes. Benefits are estimated based upon the distribution of population with outdoor noise level and the noise isolation provided by the building envelope. A method is described for estimating noise isolation performance of existing construction based upon local conditions.

NBSIR 83-2681. Debelius, J. R. **1982 GATT notification activities.** 1983 March. 24 p. Available from: NTIS; PB 83-203059.

Key words: GATT Standards Code; foreign regulations; notifications.

This report describes the GATT notification activities performed by the Standards Code and Information program, National Bureau of Standards, for calendar year 1982. The U.S. Department of Commerce designated NBS as the official U.S. inquiry point for information on standards and certification activities. NBS' responsibilities include notifying the GATT Secretariat of proposed U.S. Federal Government standards-based rules that may significantly affect trade; maintaining information on similar notifications made by other signatories; and responding to inquiries on both foreign and U.S. notifications.

NBSIR 83-2683. Russell, T. J. **Description of a CMOS test chip, NBS-39.** 1983 April. 36 p. Available from: NTIS; PB 83-200956.

Key words: CMOS; MOSFETs; p-well junction-isolated (JI) CMOS process; p-well local oxidation of silicon (LOCOS) CMOS process; scaling; short-channel; test chip; test structure.

Test chip NBS-39 was designed to analyze the scaling properties of short-channel metal-oxide-semiconductor field effect transistors (MOSFETs). This report is a guide for identifying and locating each test structure included on the test chip. There is a table with each test structure identified by name, number, parameter measured, and a reference of how to perform the measurement when appropriate. The test chip can be fabricated by a junction-isolated (JI) silicon complementary metal-oxide semiconductor (CMOS) p-well process and by a local oxidation of silicon (LOCOS) CMOS p-well process. The modifications required to go from a JI-CMOS fabrication process to a LOCOS-CMOS are discussed.

NBSIR 83-2684. Jones, W. W. **A review of compartment fire models.** 1983 April. 41 p. Available from: NTIS; PB 83-208173.

Key words: compartment fires; fire models; room fires; smoke movement; zone models.

We have examined the concept of zone modeling as it has been applied to fire problems. The existing models which embody the zone concept are compared in order to ascertain the state-of-the-art in understanding of fire growth and fire spread processes. This review is intended to be a starting point for future modeling efforts and thus the discussion centers around the use of the various submodels.

NBSIR 83-2686. Moore, E. F. **A numerical procedure for an inviscid stability analysis of an axisymmetric jet.** 1983 May. 11 p. Available from: NTIS; PB 83-224071.

Key words: axisymmetric jet; eigenvalue problem; mixing layer; numerical methods for eigenvalue problems; stability analysis.

Inviscid stability analysis has been applied to the mixing layer profile of an axisymmetric jet and a coflowing stream. A collection of computer subprograms has been developed to solve the resulting eigenvalue problem. The effect of changing the velocity profile and its parameters can be easily assessed. Results for Gaussian profiles are included.

NBSIR 83-2687. Gevarter, W. B. **An overview of computer-based natural language processing.** 1983 April. 81 p. Available from: NTIS; PB 83-200832.

Key words: artificial intelligence; computational linguistics; computer based; interfaces; natural language; translation.

Computer-based Natural Language processing and understanding is the key to enabling humans and their creations to interact with machines in natural language (in contrast to computer language). The doors that such an achievement can open has made this major research area in Artificial Intelligence and Computational Linguistics. Commercial natural languages interfaces to computers have recently entered the market and the future looks bright for other applications as well.

This report reviews the basic approaches to such systems, the techniques utilized, applications, the state-of-the-art of the technology, issues and research requirements, the major participants, and finally, future trends and expectations.

It is anticipated that this report will prove useful to engineering and research managers, potential users, and others who will be affected by this emerging field.

NBSIR 83-2688. Pielert, J. H.; Mathey, R. G. **Guidelines for assessment and abatement of asbestos-containing materials in buildings.** 1983 May. 75 p. Available from: NTIS; PB 83-208470.

Key words: abatement of asbestos; asbestos; buildings; fireproofing; insulation; regulations; structural steel.

This report presents guidelines for the assessment and abatement of asbestos-containing materials in buildings based on available information. Background information is given on the history and use of asbestos-containing products in buildings, and regulations pertaining to their use. Included are control measures for buildings containing asbestos materials, procedures for determining condition of the materials, and abatement techniques for containment and removal. A summary is presented of recent guide specifications and standards developed by industry, government agencies, and a standards organization which are related to asbestos-containing materials in existing buildings. These documents include guidance for the control, assessment, and abatement of such materials.

NBSIR 83-2689. Kashiwagi, T.; Ohlemiller, T. J.; Kashiwagi, T.; Jones, W. W. **Thermal radiative ignition of liquid fuels by a CO_2 laser.** 1983 May. 84 p. Available from: NTIS; PB 83-213470.

Key words: absorption; decanes; decenes; electromagnetic absorption; holographic interferometry; ignition; infrared radiation; vaporization.

This report summarizes progress in the study of the ignition mechanism of a liquid fuel by a CW CO_2 laser; the period covered is from October 1, 1979 to September 30, 1982. It describes (1) new observations of liquid fuel behavior near and at the liquid/air interface during the laser irradiation with incident fluxes from 260 to 2500 W/cm^2, (2) new time-resolved measurements of distributions of temperature and vapor concentration in the gas phase using a newly-developed, high speed, two-wavelength holographic interferometer and (3) the development of a technique to measure infrared absorption spectra of fuel vapors at elevated temperatures.

NBSIR 83-2690. Fatiadi, A. J. **Priority toxic pollutants in human urine: Their occurrence and analysis.** 1983 June. 63 p. Available from: NTIS; PB 83-225888.

Key words: chemicals; exposure; human; industrial; methodology; pollutants; survey; toxic; urine.

This survey reviews and discusses the occurrence of priority pesticides and industrial chemicals in human urine. An overview of some recent analytical methodology for determination of selected toxic pollutants and their metabolites as they are found in human urine is also presented. The review includes 427 references.

NBSIR 83-2691. Hunston, D. L. **Relationships between mechanical properties and performance of inks as the basis for quality control techniques.** 1983 May. 54 p. Available from: NTIS; PB 83-252387.

Key words: cure; drying; intaglio ink; linseed oil; printing; rheology; tung oil; viscoelasticity; viscosity.

Three different intaglio ink formulations have been examined to determine their mechanical properties. In all cases the properties share a strong shear rate and time dependence. In addition, the behaviors of the different formulations vary substantially at intermediate shear rates but are similar at the very high and very low shear rates that are seen on the printing press. Consequently, the shear behavior has importance for ink fabrication but does not explain the differences in printing performance that are seen for these formulations. The ink samples were then examined for the changes in mechanical properties that occur during drying (curing). Distinct differences in curing behavior are observed for the various formulations and it was determined that these differences can influence performance. It was also found that direct exposure to air (oxygen) will produce curing. The major implications of these results in terms of fabrication, quality control, and printing procedures are discussed.

NBSIR 83-2692. Early, J. **Evaluation criteria for comparing domestic and foreign material specifications.** 1983 May. 51 p. Available from: NTIS; PB 83-241653.

Key words: ASTM; comparison methodology; DIN; foreign specifications; JIS; metal specifications; tests.

Consistent decisions on the degree of equivalency between metal specifications of different national origins cannot be made only on the basis of chemical composition and direct comparison of mechanical property numbers. There are numerous additional factors, including metallurgical effects, product form effects, test acceptance criteria, and differences in specification philosophy, which if present, may influence the determination of equivalency because of their effect on property requirements. In order to remove the uncertainty in this decision-making process, these additional factors must be evaluated for each comparison.

Excerpts from actual comparisons have been used to illustrate the methodology followed which is based on the principles discussed in this report. The specific evaluation criteria identified are not meant to be totally inclusive, but rather represent those most often encountered. Some material specifications, especially application specifications, may include special requirements dictated by the application. Finally, material specifications are dynamic documents because revisions of test methods and test requirements are part of the specification writing process. Care must always be exercised to insure that the appropriate versions of specifications are being compared.

NBSIR 83-2693, Vol. I. Yokel, F. Y.; Stanevich, R. L. **Development of draft construction safety standards for excavations—Volume I.** 1983 April. 124 p. Available from: NTIS; PB 84-100569.

Key words: braced excavations; construction; Federal regulations; retaining structures; safety; shoring; slope stability; soil classification; soil pressures; standards; trenching.

A record of an interim stage in the development of revisions to existing Occupational Safety and Health Administration (OSHA) regulations governing excavations, trenching and shoring practices in the construction industry, Subpart P 29 CFR 1926, is presented. The National Bureau of Standards (NBS) prepared a working draft of recommended changes to the regulations based on previous NBS technical studies. Five regional industry workshops were held to discuss the proposed revisions. Included in the report is a copy of the recommended revisions, which were submitted to the workshops, and a record of industry's response in the form of suggestions, commentary and summaries of workshop activities. The key section of the report presents an analysis of industry response and resulting recommendations. The document is a record intended to aid OSHA during subsequent stages of the rule-making process.

NBSIR 83-2693, Vol. II. Yokel, F. Y.; Stanevich, R. L. **Development of draft construction safety standards for excavations—Volume I.** 1983 April. 314 p. Available from: NTIS; PB 83-233353.

Key words: braced excavations; construction; Federal regulations; retaining structures; safety; shoring; slope stability; soil classification; soil pressures; standards; trenching.

A record of an interim stage in the development of revisions to existing Occupational Safety and Health Administration (OSHA) regulations governing excavations, trenching and shoring practices in the construction industry, Subpart P 29 CFR 1926, is presented. The National Bureau of Standards (NBS) prepared a working draft of recommended changes to the regulations based on previous NBS technical studies. Five regional industry workshops were held to discuss the proposed revisions. Included in the report is a copy of the recommended revisions, which were submitted to the workshops, and a record of industry's response in the form of suggestions, commentary and summaries of workshop activities. The key section of the report presents an analysis of industry response and resulting recommendations. The document is a record intended to aid OSHA during subsequent stages of the rule-making process.

NBSIR 83-2694. Glass, R. A.; Howett, G. L.; Lister, K.; Collins, B. L. **Some criteria for colors and signs in workplaces.** 1983 April. 97 p. Available from: NTIS; PB 83-201442.

Key words: chromaticity; color; color appearance; energy-efficient lights; illumination; light source; safety; safety sign; safety symbols; visual acuity; visual sensitivity.

The use of safety-related visual displays such as signs and colors in workplaces is discussed. The discussion includes a review of relevant national and international standards for safety colors and signs. It also includes a review of measures of spatial resolution in human vision, as well as of color sensitivity and color appearance. In addition, research on the effectiveness of safety signs, symbols, and colors is reviewed. Based on the initial literature review, the appearance of safety colors under energy efficient light sources was identified as an area for detailed research. As a result, a laboratory study was conducted in which the color appearance of 45 different color samples under five light sources including energy efficient ones was determined for seven subjects. The color samples were contained in four color series: standard colors; experimental colors; retroreflective and retroreflective-fluorescent colors; and fluorescent-only colors. The results indicated the existence of a set of colors which was more identifiable under all light sources than the current standard safety colors. This set contains a number of fluorescent and retroreflective colors, unlike the current safety colors. Recommendations are made for further research, including field research, to determine the effectiveness of the suggested color set on safety signs under an even broader range of illuminants. The need to assess color appearance under mixed light sources is also addressed.

NBSIR 83-2696. Crissman, J. M.; Zapas, L. J.; Khoury, F. A. **NBS-BMD interagency agreement, task 80-01, Third annual report relationship between morphology and mechanical properties of ultra high molecular weight polyethylene.** 1983 May. 38 p. Available from: NTIS; PB 83-240960.

Key words: creep; morphology; polyethylene; recovery; ultra high molecular weight; x ray.

This report describes work done during FY 1982 under task 80-01, NBS-FDA/BMD (Bureau of Medical Devices) Interagency agreement. The report covers the third year of a four year project concerned with the study of the morphology and mechanical properties of ultra high molecular weight polyethylene (UHMWPE). During FY 1982, the two principle areas of investigation were (1) the examination by x-ray diffraction of morphological changes occurring in UHMWPE while under strain, and (2) the creep and recovery behavior of UHMWPE at small deformations. A new one dimensional constitutive equation is presented which describes very well the creep and recovery behavior of this material at small deformations.

NBSIR 83-2699. Cadoff, M. A. **Publications in 1980–1982 of the Mechanical Production Metrology Division.** 1983 May. 17 p. Available from: NTIS; PB 83-208082.

Key words: acoustic emission; acoustics; force; mass; micrometrology; surface topography; ultrasonics; vibration; wave optics.

This bibliography lists the publications of the personnel of the Mechanical Production Metrology Division from January 1980 through December 1982. Included in it are publications for which one or more authors were in the Division during this period, as well as a few publications that were written in support of Division programs, even though none of the authors were members of the Division.

NBSIR 83-2702. Fink, J. L.; Escalante, E. **Corrosion evaluation of underground telephone cable shielding materials.** 1983 April. 99 p. Available from: NTIS; PB 83-220038.

Key words: alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground.

Corrosion data are given on the performance of base and plastic-coated metals intended for use as cable shields for buried telephone cable. The materials investigated on specially prepared specimens were buried for periods up to six years in six different soil environments. Metals tested included homogeneous plastic-bonded and metallurgically bonded laminates. Some specimens were exposed bare (uncoated), while others had plastic coatings or other types of coatings on either one or both sides. Metals studied included aluminum, copper, low carbon steel, and stainless steel alloys.

NBSIR 83-2703. Vorburger, T. V. **FASTMENU: A set of FORTRAN programs for analyzing surface texture.** 1983 July. 123 p. Available from: NTIS; PB 83-240838.

Key words: amplitude density function; autocorrelation function; calibration; digitization; metrology; minicomputer; roughness; statistics; stylus; surface metrology; surface profile; surface texture.

A set of FORTRAN programs for surface texture analysis is described. These programs were developed for use with a minicomputer that is interfaced to stylus type instruments. The programs 1) perform data acquisition from the stylus instruments, 2) store the data on magnetic disk, and 3) perform statistical analyses for parameters such as the roughness average R_a, rms roughness R_q, and for the autocorrelation function and amplitude density function.

NBSIR 83-2704 (USAF). Smith, B.; Liewald, M. **Initial Graphics Exchange Specification test library, Version 1.3.** 1983 September. 223 p. Available from: NTIS; PB 84-102144.

Key words: ANSI Standard; computer aided design/computer aided manufacturing; computer graphics; interface standard.

This document contains a library of benchmark tests to be used to verify the interface capability possible with the Initial Graphics Exchange Specification (IGES) (Reference A). IGES provides a common data format to facilitate the exchange of data between different Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) systems.

The test cases outlined in this document provide data for software modules which translate IGES format to and from the format of a particular CAD/CAM system. The geometric and drafting entities contained in these parts comprise only a limited portion of all IGES entities and are intended to demonstrate some capabilities of an IGES translator on an individual entity basis. This set of tests does not

constitute a test of compliance with any existing or proposed standardization of IGES. Subsequent tests with more complex parts should be made to insure the suitability of the processors for a user's production environment.

NBSIR 83-2705. Hebner, R. E., ed. **Development of power system measurements—Quarterly report July 1, 1982 to September 30, 1982.** 1983 May. 26 p. Available from: NTIS; PB 83-210609.

Key words: cables; composite insulation; dc fields; high voltage; incipient fault; insulation; liquid breakdown; SF_6; space charge; transformer oil.

This report documents the progress on four technical investigations sponsored by the Department of Energy. Three were performed by the Electrosystems Division, the National Bureau of Standards and the fourth by the Department of Electrical Engineering of the University of Southern California. The work described covers the period from July 1, 1982 to September 30, 1982. The report emphasizes the calibration of instruments designed to measure the 60-Hz electric field in biological exposure facilities, the determination of the role of photodetachment of SF_6 corona discharges, the measurement of failure mechanisms in liquid/solid insulating systems, and the development and behavior of active insulators.

NBSIR 83-2706. Jason, N. H. **Fire research publications, 1982.** 1983 May. 18 p. Available from: NTIS; PB 83-238915.

Key words: bibliographies; building fires; combustion products; compartment fires; egress; fabric flammability; fire models; fire research; fire tests; flame research; human behavior; mattresses; smoke; toxicity.

"Fire Research Publications, 1982" is a supplement to the previous editions: 1969–72 NBSIR 73-246, NTIS Order No. COM-74-10989; 1973 NBSIR 74-511, NTIS Order No. COM-74-11448; 1974 NBSIR 75-736, NTIS Order No. COM-75-11018; 1975 NBSIR 76-1120, NTIS Order No. PB-257837; 1976 NBSIR 77-1277, NTIS Order No. PB-269965; 1977 NBSIR 78-1504, NTIS Order No. PB-284462; 1978 NBSIR 79-1745, NTIS Order No. PB-295395; 1979 NBSIR 80-2114, NTIS Order No. PB 80-103335; 1980 NBSIR 81-2272, NTIS Order No. PB 81-203317; 1981 NBSIR 82-2499, NTIS Order No. PB 82-220104.

Only publications prepared by members of the Center for Fire Research (CFR), by other National Bureau of Standards (NBS) personnel for CFR, or by external laboratories under contract or grant from the CFR are cited.

NBSIR 83-2708. Tordella, J.; Twilley, W. H. **Development of a calorimeter for simultaneously measuring heat release and mass loss rates.** 1983 June. 34 p. Available from: NTIS; PB 83-222711.

Key words: calorimeter; fire test; heat of combustion; heat release rate; mass loss rate.

A heat release rate calorimeter (designated as NBS II) was designed, built, and put into operation. Specimens may be burned vertically or horizontally without the use of reflectors to provide a uniform external radiant flux field. The flux range is 25 to 80 kW/m^2. Heat release rate, mass loss rate, smoke, and heat of combustion of the unburned gaseous decomposition products are measured. The heat release rate measurement involves the use of a substitution burner technique which provides fast response. The ratio of the heat release to mass loss rates, the apparent heat of combustion, is provided as a function of time. The calorimeter may also be operated in other modes, e.g., stack temperature increase and oxygen depletion, to obtain the heat release rate.

Representative data are reported for wood and a number of synthetic polymers burned horizontally at a flux of 50 kW/m^2. These specimens generate considerable heat and a significant amount of uncombusted fuel.

A program involving thorough characterization of the instrument, obtaining reference heat release data for numerous materials, and conducting research in heat release rate and other flammability characteristics is recommended.

NBSIR 83-2709. Pielert, J. H. **Status of safety net standards for construction and research needs.** 1983 September. 41 p. Available from: NTIS; PB 84-102045.

Key words: construction; construction safety; occupational safety; perimeter nets; safety nets.

This report represents the status of standards for safety nets used in construction and identifies areas of technical inconsistency. Typical applications of safety nets are reviewed including the results of literature and field surveys. Major technical sections of six standards are compared in a tabular format to highlight areas of agreement, as well as, requirements which vary and indicate lack of consensus. This information is analyzed and used to develop a prioritized research plan for safety nets.

NBSIR 83-2710. Blessing, G. V. **An assessment of ultrasonic reference block calibration methodology.** 1983 June. 23 p. Available from: NTIS; PB 83-225870.

Key words: ASTM E127; ASTM reference block calibrations; ultrasonic aluminum reference blocks; ultrasonic system calibration; ultrasonic transducer calibration.

The state of the art in aluminum ultrasonic reference block calibration practices is reviewed, especially as it has been guided by the recommended practices of ASTM for aluminum blocks. The principal system variables in the calibration procedure are identified, and recommendations for reducing their associated measurement errors are made. Quantitative evaluations of the limitations to improving measurement precision are made in light of present technology. Suggestions for improving present practices are made, and extensive reference to the relevant technical literature is made.

NBSIR 83-2711. Ledford, A. E.; Ryan, R. V.; Reilly, M. L.; Domalski, E. S.; Churney, K. L. **Trial combustions of kilogram-size samples of municipal solid waste.** 1983 June. 18 p. Available from: NTIS; PB 83-240580.

Key words: combustor; kilogram-size samples; municipal solid waste; oxygen flow combustion; refuse-derived fuel.

A new calorimeter is being developed at the National Bureau of Standards to determine the enthalpies of combustion of kilogram-size samples of municipal solid waste (MSW) in flowing oxygen near atmospheric pressure. Experiments were carried out to develop a prototype combustor in which pellets of relatively unprocessed MSW can be rapidly and completely burned with minimal scattering of ash. Pellets of up to 2.2 kg mass with ash content between 20 and 35 percent have been successfully burned at a rate of 15 minutes per kilogram initial mass with CO/CO_2 ratios not greater than 0.1 percent.

NBSIR 83-2712. Quintiere, J. G. **A simple correlation for predicting temperature in a room fire.** 1983 June. 48 p. Available from: NTIS; PB 83-237495.

Key words: compartment fires; energy release rate; modeling; prediction temperature; vent effects; wall effects.

The use of a simple formula for predicting upper compartment gas temperature in a fire is demonstrated. The formula is given in terms of energy release rate, vent geometry, and compartment lining material properties. It treats discrete fires within the room. Several examples are considered to show the versatility of the formula and its general level of accuracy.

NBSIR 83-2713. May, W. B., Jr. **Time of day control and duty cycling algorithms for building management and control systems.** 1983 July. 60 p. Available from: NTIS; PB 83-241919.

Key words: Building Management and Control Systems (EMCS, BMCS); computer control; control algorithms; control software; duty cycling; energy management; heating, ventilating and air conditioning (HVAC); scheduled start/stop; time of day control.

Software is an important component of building management and control systems (BMCS). Although much software is available in proprietary or system dependent form, public domain control software and algorithms are rare. This report describes concepts, algorithms, and software used in BMCS components developed in the NBS building systems and controls laboratory. The concepts and basic algorithms for time of day (scheduled start/stop) control and duty cycling of electrical equipment in building heating, ventilating,

and air conditioning systems are presented. Time of day control results in control events occurring at predetermined times of the day on selected days of the week. Duty cycling is the periodic turning off and on of loads, usually electrical, to reduce energy consumption under part heating and cooling load conditions. Considerations for use of duty cycling with other control strategies such as demand limiting, selection of duty cycling parameters, and dynamic adjustment of duty cycling, are discussed. All algorithms presented were implemented in software on a specific BMCS, and the actual computer programs used are presented as examples.

NBSIR 83-2714. Lyklema, J.; Parsons, R. **Electrical properties of interfaces. Compilation of data on the electrical double layer on mercury electrodes.** 1983 May. 841 p. Available from: NTIS; PB 83-222471.

Key words: critically evaluated data; data compilation; electrical double layer; interfacial tension; mercury electrode.

This paper contains data on the electrical double layer on a pure mercury electrode in contact with a solution which contains at least one electrolyte and, in some cases, a nonelectrolyte as well. The quantities covered are the double-layer capacity and the interfacial tension.

The search of the literature was carried through 1978. The tables have been made as complete as possible subject to certain criteria of reliability relating to the purity of substances used, the probability that equilibrium had been reached, the control of ambient conditions and geometrical and electrical conditions specific to the type of measurement. Estimates are given for the reliability of the data.

The classes of solutions covered are: solutions of single electrolytes, solutions containing mixture of electrolytes, electrolyte solutions containing nonionic organic additives, and solutions containing substances with ionic surfactant character. The data are presented in primary form with a minimum of subsequent processing. There is relatively little overlap between data sets.

NBSIR 83-2715. Klote, J. H. **Smoke control for elevators.** 1983 June. 60 p. Available from: NTIS; PB 84-118397.

Key words: building fires; egress; elevators (lifts); evacuation; handicapped; pressurization; smoke control; stairwells.

This paper is a second report on an ongoing project at NBS to investigate the use of elevators as a means of fire escape for the handicapped. The use of stairwells for fire evacuation poses a problem for people who cannot use stairs because of physical disabilities. This paper discusses some of the major problems associated with the use of elevators as a means of fire exit and proposes a conceptual solution to those problems. A report is made on field tests of six buildings with elevator protection systems.

A simple relationship is developed for the pressure differences across the elevator shaft and across the elevator lobby for one type of elevator pressurization system. Vertical pressure profiles of such systems are also discussed.

NBSIR 83-2716. Phillips, J. C. **Transport of acetic acid in polyethylene.** 1983 July. 23 p. Available from: NTIS; PB 83-244715.

Key words: acetic acid; desorption; diffusion; mass loss; polyethylene; sorption.

This report describes the mass loss and sorption/desorption of Acetic Acid (HAc) in polyethylene of different densities at various temperatures. Mass loss for a mixture of HAc and H_2O of three concentrations were also done at the highest temperature used.

Experimental data for mass loss were obtained at temperatures of approximately 40°C, 60°C, and 78°C for a low density bottle (LDPE, $\pi \sim .92$ g/cm^3) and a high density bottle (HDPE, $\pi \sim .94$ g/cm^3). At t=78°C a mixture of HAc/H_2O consisting of 100% HAc, 75% HAc, and 25% HAc by volume was used as permeant in the LDPE and HDPE bottles. From the mass loss data, the loss rate and diffusivity were determined.

Data for sorption/desorption were obtained at temperatures of approximately 30°C, 50°C, and 70°C at a vapor pressure of $\pi \sim 17$mm Hg. The polyethylene film had a density of $\pi \sim .906$ g/cm^3 and a thickness of 4 mil (10.16×10^{-3}cm). From the sorption and desorption measurements, diffusivity, solubility, and permeability were determined.

NBSIR 83-2717. Mills, K. L. **Proceedings of the Second LAN-Transport Workshop.** 1983 May. 22 p. Available from: NTIS; PB 83-222687.

Key words: communication protocols; computer networks; local area networks; transport protocols.

The National Bureau of Standards, Institute for Computer Sciences and Technology (ICST) has prepared specifications for the International Organization for Standardization's (ISO) Class 4 Transport Protocol. At the request of a number of companies, ICST organized a second workshop for local area network implementors of these specifications. The second workshop focused on 1) token bus local area networks and 2) file transfer applications to be run at a multi-vendor demonstration in the 1984 timeframe. This report documents the second workshop and records implementation choices and agreements made by the participants.

NBSIR 83-2718. Tanaka, T. **A model of multiroom fire spread.** 1983 July. 178 p. Available from: NTIS; PB 83-256099.

Key words: compartment fires; computer programs; fire models; fire plumes; fire spread; high rise buildings.

Some refinements have been made on a multi-room fire spread model. The primary improvements are: (a) that a model on excess fuel burning in arbitrary room has been introduced; (b) that a model for the prediction of gas concentrations has been added; (c) that subroutine ABSORB, which was created by Modak, has been introduced to predict the upper layer emissivity; (d) that a new fire plume model developed by McCaffrey has been included to remove the inaccuracy and inplausibility of a vertical point heat source plume model; and (e) that the code has been revised so that it can deal with tall buildings with somewhat less computer memory size.

Also, some sample calculation results with the new code and a documentation of the code have been included.

NBSIR 83-2719-1. Mayo-Wells, J. F. **Center for Electronics and Electrical Engineering Technical Progress Bulletin, Covering signals and systems program, October 1981-March 1982.** 1983 May. 15 p. Available from: NTIS; PB 83-244160.

Key words: antennas; electrical engineering; electrical power; electromagnetic interference; electronics; instrumentation; lasers; magnetics; microwave; optical fibers; semiconductors; superconductors.

This is the first issue of a new abstract bulletin to be issued quarterly by the Center for Electronics and Electrical Engineering, National Bureau of Standards. This issue covers the work of the Center's Signals and Systems Program for the first half of Federal fiscal year 1982. Abstracts are provided by technical area for both published papers and papers approved by NBS for publication.

NBSIR 83-2719-2. Mayo-Wells, J. F. **Center for Electronics and Electrical Engineering Technical Progress Bulletin. Covering signals and systems program, April 1982-September 1982.** 1983 May. 19 p. Available from: NTIS; PB 83-241158.

Key words: antennas; electrical engineering; electrical power; electromagnetic interference; electronics; instrumentation; lasers; magnetics; microwave; optical fibers; semiconductors; superconductors.

This is the second issue of an abstract bulletin to be issued quarterly by the Center for Electronics and Electrical Engineering, National Bureau of Standards. This issue covers the work of the Center's Signals and Systems Program for the second half of Federal fiscal year 1982. Abstracts are provided by technical area for both published papers and papers approved by NBS for publication.

NBSIR 83-2720. Park, C. **An optimum start/stop control algorithm for heating and cooling systems in buildings.** 1983 June. 69 p. Available from: NTIS; PB 83-242222.

Key words: digital control systems; energy conservation; energy management and control systems; heating and cooling systems optimum start/stop time; preheat time.

When a building structure is occupied intermittently, energy savings can be realized from the optimal start-up and shut-down of the heating or cooling system. This strategy, known as optimum start/stop control, reduces energy consumption by delaying the start-up of the space conditioning system until the last moment and then initiating shut-down as early as possible, while maintaining a preset level of comfort during the period of building occupancy.

Based on the bang-bang control theory, a simple optimum start/stop control algorithm is developed for computerized control systems in buildings. The optimum start time is obtained by finding the intersection of cool-down and heat-up curves that are approximated by exponential fitting of the previous and current day's data.

Information is presented in this report on the input and output variables, logic flow, and methodology employed in developing the algorithm. A computer program listing of the optimum start/stop control algorithm written in FORTRAN 77 and sample input and output data are included in the appendices.

NBSIR 83-2722. Senich, G. A.; Florin, R. E. **Radiation curing of inks and coatings.** 1983 June. 131 p. Available from: NTIS; PB 83-239566.

Key words: acrylates; crosslinking; electron beams; infrared; photocuring; photoinitiators; photopolymerization; polymerization by radiation; printing; reactive diluents; thermosetting resins; ultraviolet.

The science and technology of curing organic materials with radiation is reviewed. Electron beam, ultraviolet, infrared, microwave, and high frequency radiation sources and the resin systems suitable for use with these sources are considered. Equipment necessary to affect a radiation cure is discussed and some practical problems unique to each radiation method are indicated. The application of radiation curing to industrial processes which employ inks and coatings is covered, with particular emphasis given to printing with radiation curable formulations. Included are discussions of the advantages and disadvantages of radiation curing inks, some typical ink components and formulations, the specialized machinery required, and the influence of parameters unique to radiation curing methods on the printing process. Other nonprinting but related industrial operations utilizing radiation for treating thin films and coatings are also considered. Some costs, examples, and market statistics are given for these commercial procedures. New nonconventional, but also nonradiation, alternative curing methods are discussed briefly. A bibliography of recommended further reading and a list of over two hundred fifty references are included.

NBSIR 83-2723. Harris, J. E. **Performance of add-on type heat pump water heaters using two different test methods.** 1983 June. 30 p. Available from: NTIS; PB 83-222703.

Key words: appliances; energy; heat pump water heaters; testing; test procedures; water heaters.

Two different makes of add-on (without tank) heat pump water heaters (HPWH) were tested. Each of the HPWH's was subjected to a series of recovery tests similar to the Department of Energy (DOE) recovery test for conventional electric water heaters. The results of the tests (recovery efficiency, standby loss, input power, storage tank capacity and energy used) were used to compute an energy factor which could be used to calculate the estimated annual operating cost of such HPWH's. The energy factor was also determined by a series of simulated use tests consisting of four equal draws totaling 64.3 gallons of hot water per day. The average energy factor derived from the recovery tests was about 13 percent higher than that derived from the simulated use tests. Based upon the results of this limited test program it was recommended that a simulated use test be used to determine the energy factor for HPWH's without tank.

NBSIR 83-2724. Hastings, S. R.; Ruggli, R. **Swiss research in building heating conservation.** 1983 July. 153 p. Available from: NTIS; PB 83-241034.

Key words: energy conservation in buildings; European building research; field measurement of building energy use; passive solar heating; Switzerland; test method development.

Swiss research on heating energy conservation in buildings is presented to encourage communication among researchers. A background on Switzerland's climate, geography, construction industry, and energy situation is included to provide a context for the subsequent review of a sample of research projects. Each project is described with a statement of research objectives, technical approach taken, project status, brief findings, future work planned or recommended, and resulting publications. The sample of projects is taken from the subjects of community scale solar concepts, mathematical simulation, instrumented test cabins, instrumented buildings, and design tools and data bases. The final section discusses a structure for surveying research projects in a country in order to examine where efforts are now concentrated and what subjects are not addressed. Swiss research is examined using this structure and an assessment is presented.

NBSIR 83-2725. Rafelski, J.; Danos, M. **Perspectives in high energy nuclear collisions.** 1983 June. 83 p. Available from: NTIS; PB 83-223982.

Key words: elementary particles; gluon; hadron; nuclear collisions; nuclear plasma; quark.

This report has been prepared as a working document for the conception of a research facility devoted to the study of high energy nuclear collisions. Different aspects of hadronic physics to be studied in nuclear collisions are selected, with emphasis placed on the properties and nature of the quark-gluon plasma, the formation of the plasma state in the central region and its anticipated lifetime, and the observability and strangeness content of this new form of nuclear matter.

NBSIR 83-2726. Treado, S.; Gillette, G.; Kusuda, T. **Evaluation of the daylighting and energy performance of windows, skylights, and clerestories.** 1983 June. 26 p. Available from: NTIS; PB 83-240481.

Key words: building energy analysis; clerestories; daylighting; skylights; windows.

This paper examines the impact of several fenestration options on building space heating, cooling, and lighting loads. The use of skylights, windows, and clerestories is evaluated for a single floor commercial building, using the NBSLD-2 building energy analysis computer program, which possesses a fully integrated daylight model (DALITE). The evaluation focuses on: a) the impact of daylighting on heating and cooling energy and equipment sizing, b) the potential reduction in electric lighting energy requirements through daylight utilization, c) the relative daylighting/thermal performance of skylights, clerestories, and windows, and d) the effect of building orientation on fenestration optimization and selection.

The NBSLD-2 computer procedure performs a dynamic simulation of hour-by-hour building thermal performance and energy requirements for a one-year period. The thermal and daylighting characteristics of each fenestration aperature are modeled to enable evaluation of the trade-offs associated with the use of each fenestration type. The results are correlated in the form of design guidelines to enable the preliminary design decisions to be made regarding fenestration location, type, configuration, and size. The energy calculations are presented as functions of fenestration characteristics, so that the potential energy advantages can be estimated for different fenestration designs.

NBSIR 83-2727. Wu, S. T.; Leyendecker, E. V. **Lateral-torsional response of structures subjected to seismic waves.** 1983 June. 30 p. Available from: NTIS; PB 83-239582.

Key words: accidental eccentricity; building codes and standards; design eccentricity; dynamic eccentricity; parametric study; seismic waves; structural response.

The behavior of coupled lateral-torsional systems subjected to seismic waves is investigated analytically. The report presents the numerical results of a parametric study for structures subjected to S-H waves. Case studies are provided to show the contribution of each of the selected parameters to the rotational response of the systems. These parameters are: geometric eccentricity, aspect-ratio of the foundation mat, damping ratio, and the ratio of the rotational to translational frequencies. Dynamic eccentricity is selected as an index to represent the level of the response. The sensitivity due to the deviation of the input spectrum is investigated. Accidental

eccentricities due to seismic waves are also evaluated. Design concerns are given on how the design eccentricity should be considered based on this study.

NBSIR 83-2728. Treado, S. J. **Automated control of lighting and fenestration.** 1983 July. 18 p. Available from: NTIS; PB 83-250423.

Key words: automatic control; daylighting; lighting control; microprocessor; window management.

This paper describes an automatic system for controlling the lighting and window shading in a commercial building. The system utilizes a microcomputer to monitor solar radiation and illumination levels and interior and exterior air temperatures, processing the input parameters to determine the optimum lighting level, window area, and solar film position to minimize building heating and cooling loads due to windows and lighting. The control methodology and logical flow are presented, along with a sample control program written in FORTRAN. The response of the system to various combinations of weather conditions is examined.

NBSIR 83-2730. Cooper, L. Y. **On the significance of a wall effect in enclosures with growing fires.** 1983 June. 41 p. Available from: NTIS; PB 83-235671.

Key words: compartment fires; enclosure fires; fire growth; growing fires; mathematical modeling; smoke movement; two-layer phenomenon; wall flows.

This paper studies the significance of a wall effect that has been observed during the growth stage of enclosure fire experiments. Relative to the two-layer phenomenon which tends to develop during such experiments, the effect has to do with the near-wall downward injection of hot upper layer gases into the relatively cool uncontaminated lower layer. It is conjectured that these observed wall flows are buoyancy driven, and that they develop because of the relatively cool temperatures of the upper wall whose surfaces are in contact with the hot upper layer gases. For a growing fire (growth proportional to t^m; t being time and $m \geqslant 0$) in an enclosed compartment, the conjectured mechanism for the wall flow leads to a time-dependent solution for the ratio of wall layer mass ejection rate *from* the upper layer, $\dot{m}_w$, to the fire plume mass injection rate *to* the upper layer, $\dot{m}_p$. The solution indicates that in practical fire scenarios $\dot{m}_w/\dot{m}_p$ can be of the order of "several tenths" even prior to the time that the upper layer interface has dropped to an elevation midway between the ceiling and fire. In other words, the results of the analysis indicate the importance of taking the wall effect into account in two-layer zonal analyses of enclosure fire phenomena.

NBSIR 83-2731. Hastie, J. W.; Plante, E. R.; Bonnell, D. W. **Vaporization of simulated nuclear waste glass.** 1983 June. 69 p. Available from: NTIS; PB 84-102128.

Key words: boron; glass; nuclear waste; processing; radionuclide; silicon; thermodynamics; vaporization.

Industrial development of nuclear waste glass processing requires basic data on glass vaporization thermodynamics. Detailed mass spectrometric experiments and thermodynamic estimates have been made for vaporization of a nonradioactive borosilicate glass containing representative nuclear waste isotopes. Alkali metaborates were observed to be the dominant vapor species and their partial pressures indicate significant vapor transport under likely process conditions. The results indicate the following order of significance for vapor transport of radionuclide species, $Cs \sim Re(\sim Tc) > Ru >> Sr$.

NBSIR 83-2733. Blair, W. R.; Parks, E. J.; Brinckman, F. E. **Characterization of controlled release dynamics and identification of species from OMP impregnated wood pilings.** 1983 July. 28 p. Available from: NTIS; PB 83-252262.

Key words: atomic absorption spectrophotometry; cation exchange chromatography; high pressure liquid chromatography; *in situ* polymerization; leaching; organometallic polymers; size exclusion chromatography; tributyltin.

Organometallic polymers (OMP) are becoming an increasingly important class of compounds finding application in marine environments as anti-fouling and preservative agents. To provide accurate estimates of reliability in service and service life, new analytical methods are needed for the identification and measurement of the toxic species being delivered by the OMP. This report is concerned with the following: identification of parent tin species; identification of species leached from OMP impregnated wood pilings; and preliminary determination of the rate of tin release from OMP impregnated pilings. Additionally, the influence of microbiological activities on the leachate is considered in assessing the effectiveness and ultimate fate of the toxic species responsible for the anti-fouling and preservative properties of the OMP formulation. Data from leach rate measurement experiments are presented, along with chromatograms providing speciation data on parent and leachate tin compounds, discussion of areas for continued research are presented.

NBSIR 83-2734. Hanig, R. **An investigation of lyoluminescence techniques for application in radiation-protection dosimetry.** 1983 August. 58 p. Available from: NTIS; PB 83-263236.

Key words: chemiluminescence; liquid scintillation counter; luminol; lyoluminescence; lyoluminescence enhancement by radiation sensitization; lyoluminescence glow curve fitting; saccharides.

A cooled liquid scintillation system with single-photon counting photomultiplier tubes was employed to increase the sensitivity of luminol-enhanced lyoluminescence (LL). The problems of reagent purity and mechanical mixing were studied. For the disaccharide trehalose, the lowest dose significantly different from background was at the 1.2-rad level for ^{60}Co gamma rays, with a standard deviation of 33 percent. The system suffers from poor reproducibility in the mixing of the disaccharide with its solvent, and recommendations are made for improvements. Detector compounds of different hydrogen content were studied for possible application in neutron dosimetry and for their ability to retard free-radical recombination. The results were not conclusive. Enhancement of the LL effect was accomplished by radiation sensitization of solutions of trehalose with between 30 and 300 krad to water. The disaccharide was then recrystallized from solution, along with associated radiolysis products and, in some instances, with separately added chemical dopants. Preliminary intercomparison of these doped sugars with untreated materials at doses of 1, 5, and 10 rads indicates that they give a better signal-to-background ratio than the untreated disaccharide. A promising reaction model was tried which assumed a two-component exponential decay of light, multiplied by a first-order buildup term for the dissolving factor. The model seems to fit both the ordinary and luminol-enhanced LL glow-curves.

NBSIR 83-2736. Fraker, A. C.; Ruff, A. W.; Bundy, K. J.; Smith, J. D.; Penn, R. W.; Van Orden, A. C. **Studies of interface bondings on implant alloys.** 1983 September. 97 p. Available from: NTIS; PB 84-104181.

Key words: bone cement; interface strength; metals; poly(methyl methacrylate); prosthesis fixation; surfaces; surgical implants.

The work dealt primarily with testing metal/bone cement interface strength using the torsion test which was developed earlier in this project and described in NBSIR 82-2563. The test proved to be a good one and to be reasonably reproducible. The parameters studied to determine their influence on the metal/bone cement interface strength were material type, specimen surface roughness, sterilization and passivation treatments, cure time prior to testing and effects of ultra clean surfaces. Metals used were the alloys, Co-Cr-Mo, Ti-6Al-4V and 316L stainless steel. The bone cement used was Howmedica Surgical Simplex P which is a poly(methyl methacrylate) type. Seventy-seven tests were conducted. The description of these tests, analysis of the results and a discussion of related studies in the technical literature are given in the technical report entitled "An Experimental Investigation of the Torsional Strength of Metal/Bone Cement Interface."

NBSIR 83-2737. Klote, J. H.; Bodart, X. **Computer analysis of a pressurized stairwell.** 1983 August. 34 p. Available from: NTIS; PB 83-261503.

Key words: air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulation; smoke control; stairwells.

In recent years pressurized stairwells have been incorporated in buildings in an effort to provide smoke free exits during building fires. This paper compares the results of tests conducted in a pressurized stairwell at Champs Sur Marne, France, with computer analysis using a computer code developed at the National Bureau of Standards (NBS). A second paper is planned which will compare the NBS program with the Centre Scientifique et Technique du Batiment (CSTB) program for the same series of tests. Agreement between the NBS computer simulation and the test data was good for all tests analyzed. The appropriateness of using exclusively a flow exponent of 1/2 for smoke control design is reevaluated, and is found to have only a slight effect on the results of a computer simulation.

NBSIR 83-2740. Lamersdorf, W. **Specification and interpretation of data model semantics: An integration of two approaches.** 1983 July. 56 p. Available from: NTIS; PB 83-249714.

Key words: databases; data model processing; data model prototyping; data models; data model semantics; denotational semantics; formal semantic specification; relational database; relational data model; semantic model interpreter.

Two different approaches to database model description and evaluation are presented, compared, and integrated: a formal semantic specification method as originally developed for programming languages, and a computer-based data model processor to be used as a rapid prototyping system. Both ways to specify database model semantics are applied to a common example.

Two alternatives to combine the advantages of both methods are analyzed in detail. First, it is shown how the semantics of the data model processor can be precisely described in terms of the formal semantic specification method. Then, it is demonstrated how the abstract meta-language of the specification method can be mapped to the executable commands of the data model processor. Thus, database semantics can both be specified in an abstract and high-level way and still be analyzed and evaluated automatically.

NBSIR 83-2741. Mordfin, L. **NDE Publications: 1981.** 1983 July. 42 p. Available from: NTIS; PB 83-239574.

Key words: abstracts; acoustic emission; bibliography; eddy currents; index; leak testing; magnetic testing; National Bureau of Standards; nondestructive evaluation; publications; radiography; ultrasonics.

This is the fifth in a series of bibliographies of NBS publications on nondestructive evaluation (NDE). It provides bibliographic citations, with selected abstracts, for 172 publications that appeared in the open literature, primarily during calendar year 1981. A detailed subject index is included as well as information on how copies of many of the publications may be obtained.

NBSIR 83-2743. Passaglia, E.; Brown, D.; Dickens, B. **The preservation of the constitution of Puerto Rico.** 1983 July. 50 p. Available from: NTIS; PB 83-239590.

Key words: Constitution of Puerto Rico; construction; documents.

A general design for a display enclosure for the Constitution of Puerto Rico, and designs and methods of construction of hermetically sealed cases to contain the constitution documents are presented.

NBSIR 83-2745. Berman, E. B.; Chapman, R. E.; Hung, H. K. **Program documentation for the resource recovery planning model.** 1983 May. 143 p. Available from: NTIS; PB 83-244913.

Key words: economic analysis; facility location; fixed-charge problem; mathematical programming; optimization; resource recovery; solid waste management.

The Resource Recovery Planning (RRPLAN) model is designed with three purposes in mind. First and foremost, is the ability to generate a preferred (optimal) plan for resource recovery. Second, is the capability to evaluate a scenario specified by the decision maker for technical and economic feasibility. Third, is its use as a tool to facilitate the decision making process by providing answers to many what-if questions through an in-depth sensitivity analysis. In order to find the optimal solution, however, it is necessary to address three interdependent issues. The first two issues are concerned with the siting and sizing of solid waste management facilities, whereas the third concerns how to allocate commodities among the various facilities and potential markets. The existence of substantial economies of scale in the construction and operation of the types of facilities considered complicates the problem by introducing non-linearities into the objective function. RRPLAN uses a fixed-charge linear programming algorithm to deal with the two-parameter cost functions resulting from economies of scale. A heuristic post processor is also used to "force" the optimizer to systematically examine the solution domain in hopes of finding the true optimum. The model is written in FORTRAN and complies with the American National Standards Institute X3.9-1978 standard for that language.

NBSIR 83-2746. Kao, J. Y. **Strategies for energy conservation for a large office building.** 1983 July. 69 p. Available from: NTIS; PB 83-249722.

Key words: building control strategies; building energy conservation; building thermal performance; HVAC systems.

A comparative analysis is made of the thermal performance of selected HVAC systems and control strategies commonly employed in large office buildings. The comparisons are made for six geographical locations representing wide climatic variations within the continental United States.

Hour-by-hour simulations with the BLAST computer program are used to obtain the yearly heating, cooling, and fan energy consumption of a twelve-story large office building. The HVAC systems simulated are constant volume reheat, variable air volume, dual-duct, and fan-coil systems. The control strategies tested are dry bulb temperature economy cycles, enthalpy economy cycle, supply air temperature resetting, and the combinations of these strategies. The results of these simulations are presented and discussed. Substantial energy consumption differences are shown to exist.

NBSIR 83-2748. Cooper, L. Y. **Smoke movement in rooms of fire involvement and adjacent spaces.** 1983 July. 38 p. Available from: NTIS; PB 83-250951.

Key words: combustion products; compartment fires; egress; enclosure fires; fire detection; fire growth; fusible links; hazard analysis; mathematical models; room fires; smoke movement; tenability limits.

Key to the solution of fire safety design problems is the capability to predict the dynamics of enclosure fire environments. This paper presents a detailed qualitative description of the generic phenomena which occur during typical fire scenarios. The focus of attention is on the effects within building compartments of fire involvement, i.e., compartments made up of a single enclosed space or a space of two or more rooms interconnected by significant penetrations such as open doors or windows. Throughout the discussion reference is made to quantitative methods for predicting some of the most significant of these effects. Reference is also made to available mathematical/computer models which use these latter methods to quantitatively predict the overall fire environment. The basic topics that are covered are: fire growth in combustibles of fire origin; development of the fire plume and interaction of the plume with the ceiling surface; generation of ceiling jet flows which lead to actuation of detection/intervention hardware; interaction of ceiling jets and wall surfaces; growth of the smoke layer; development of wall flows which can be instrumental in drawing smoke down from the upper smoke layer into the relatively uncontaminated, shrinking lower ambient environment; downward radiation from the high temperature smoke layer and upper enclosure surfaces which can ultimately lead to flashover; onset of conditions which are untenable for human occupancy or property survivability. Topics related to fire generated environments in multiroom fire/smoke compartments include: dynamics of the smoke and fresh air exchange between the room of fire involvement and the adjacent spaces; dynamics of door/window plumes, ceiling jets, smoke filling and well flows within adjacent spaces; actuation of adjacent space fire detection/intervention hardware; and onset of adjacent space untenability.

NBSIR 83-2749. Chapman, R. E.; Hall, W. G. **Programmer's manual for the fire safety evaluation system cost minimizer computer program.** 1983 July. 98 p. Available from: NTIS; PB 83-251447.

Key words: building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; renovation.

The Fire Safety Evaluation System Cost Minimizer (FSESCM) computer program integrates engineering and economic considerations with a linear programming algorithm which permits the least-cost means of upgrading health care facilities to compliance with the Life Safety Code to be identified. A mathematical discussion of the application problem is used to introduce the basic philosophy behind the computer program. Each routine is described with emphasis on such topics as: (1) purpose; (2) calling sequence; (3) common blocks used; and (4) reports produced. A series of descriptive tables and a glossary are used to define all reports and variables. A discussion of test results and provisions for updating or modifying the source code are also given. The program is written in FORTRAN and complies with the ANSI X3.9-1978 software standard.

NBSIR 83-2750. Brown, D. W.; Lowry, R. E.; Smith, L. E. **Prediction of the long term stability of polyester-based recording media.** 1983 August. 27 p. Available from: NTIS; PB 83-261891.

Key words: degradation; hydrolysis; lifetime; magnetic tape; photographic film; poly(ethylene terephthalate); stability.

The stability of poly(ethylene terephthalate) is being studied in order to predict its long term behavior as the base for film and magnetic tape. This report contains results of the second year's work. Film base, photographic film, and electrographic film are being aged at several temperatures and relative humidities, RH. Acid contents, mechanical properties, and molecular weight have been measured at intervals. The rate of increase in acid content, k, provides a useful measure of the degradation rate. Data for films aged between 115 and 55 C at 100% RH obey the equation Ln k=39.3-(14000/T), where k is in %/day and T is the absolute temperature. The water content is included in k, which is approximately proportional to RH. Lifetimes of the films appear to be equal to 69.3/k days. Extrapolation to 25 and 20 C gives 400 and 900 years for the Lifetime at 100% RH. A more sensitive analytical method than now used will be required to make useful measurements of acid content at 35 C, even after samples have been aged for five years. Two films have always failed before the others. The short-lived films might well be stored with others, since failure of the former would warn of the approaching failure of the latter.

Magnetic tapes are also being aged, primarily to study the binder that holds the magnetic oxide to the substrate. Binder on five brands of tape that were aged at 50 C became crosslinked at RH of zero and 11%, changed little at 30% RH, but degraded at 100% RH. The binder on tapes aged at 85 C and 100% RH first degraded severely and then appeared to crosslink slightly. Badly degraded binder was not gummy but was easily detached from the substrate. Model binder aged at 85 C and 100% RH eventually became brittle.

NBSIR 83-2751. Carino, N. J., ed. **Proceedings of the international workshop on the performance of offshore concrete structures in the Arctic environment.** 1983 July. 72 p. Available from: NTIS; PB 84-121904.

Key words: arctic; concrete; construction; design; inspection; offshore structures; repair; research; structural engineering; technology assessment; workshop.

A workshop was held March 1 and 2, 1983 at the U.S. National Bureau of Standards. The objective was to bring together an international group of experts for the purpose of information exchange on the subject of the performance of Arctic offshore concrete structures. The workshop participants were divided into four working groups to discuss the following subjects related to Arctic offshore concrete structures: 1) design; 2) materials; 3) construction; and 4) inspection and repair. Each working group addressed the following topics within their subject: past experiences, current projects, and recommended research areas. The chairmen of each group prepared reports summarizing their group's deliberations. These reports are incorporated into this workshop summary.

NBSIR 83-2754. Hall, J. R., Jr.; Helzer, S. G. **Civilian residential fire fatality rates: Six high-rate states versus six low-rate states.** 1983 August. 35 p. Available from: NTIS; PB 84-102615.

Key words: fire data; fire deaths; fire statistics; residential fires.

The report presents results of an analysis of 1,600 fire fatalities occurring in six states with high fire-death rates and six states with low fire-death rates. Reasons for the differences in rates are explored, with special attention to victim age, sex, race, and condition at time of ignition. Fire cause patterns are touched on only lightly but are addressed more extensively in the companion piece to this report, "Rural and Non-Rural Civilian Residential Fire Fatalities in Twelve States," NBSIR 82-2519, by A. Gomberg and L. Clark, which also examines the rural/non-rural split.

NBSIR 83-2756. Mulroy, W. J.; Didion, D. A. **A laboratory investigation of refrigerant migration in a split unit air conditioner.** 1983 August. 47 p. Available from: NTIS; PB 83-262873.

Key words: central air conditioners; cyclic testing; heat pumps; refrigerant migration.

The relationship between cyclic refrigerant migration and cyclic loss for a residential, split-system air conditioner has been investigated. The cyclic refrigerant migration was measured at different points in the operating cycle by simultaneously shutting five pneumatic valves which isolated the refrigerant in the major system components. The refrigerant was then removed, weighed, and returned to the system. The unit tested was found to have a high initial capacity as migrated refrigerant was removed from the evaporator and then a low, slowly increasing capacity as trapped refrigerant was returned to the system from the accumulator. The unit performance was also compared to single and double time constant regressive approximations and to the time constant calculated from the evaporator mass and heat transfer coefficient. Although relationships between migrated refrigerant and cyclic capacity were observed, no practical refrigerant migration test method that would be less burdensome than the cyclic tests of ASHRAE Std. 116 appears possible at this time.

NBSIR 83-2757. Blanc, R. **Proceedings of the third LAN-Transport workshop.** 1983 July. 19 p. Available from: NTIS; PB 83-251348.

Key words: communication protocols; computer networks;file transfer protocol; local area networks.

The National Bureau of Standards' Institute for Computer Sciences and Technology (ICST) has prepared specifications for the International Organization for Standardization's (ISO) Class 4 Transport Protocol. At the request of a number of companies, ICST organized a workshop series for local area network implementors of these specifications. The first workshop focused on implementation techniques and strategies so that a multivendor demonstration of these protocols can occur at a major conference in 1984—targeted for the NCC 1984. Primarily, the details of CSMA/CD and Transport class 4 were discussed and parameters were selected. A second workshop focused on token bus LANs and file transfer application to be run at the targeted 1984 demonstration. This report covers the third in the series of LAN/Transport workshops, and reports agreements on the specifics of the transfer protocol.

NBSIR 83-2761. Hebner, R. E. **Development of power system measurements—Quarterly report January 1, 1983 to March 31, 1983.** 1983 September. 26 p. Available from: NTIS; PB 84-115104.

Key words: electric fields; gaseous insulation; interfaces; liquid insulation; magnetic fields; partial discharges; SF_6; solid insulation; transformer oil.

This report documents the progress on five technical investigations sponsored by the Department of Energy and performed by or under a grant from the Electrosystems Division, the National Bureau of Standards. The work described covers the period January 1, 1983 to March 31, 1983. This report emphasizes the errors associated with measurements of electric and magnetic fields, the characteristics of corona in compressed SF_6 gas, and the measurement of the space charge density in transformer oil, the development of active insulators, and interfacial phenomena.

NBSIR 83-2763. Gardner, T. J. **Artificial traffic generation of ISO transport class IV protocol data units on an IEEE 802.3 10 megabit CSMA/CD local area network.** 1983 August. 21 p. Available from: NTIS; PB 83-264432.

Key words: computer networks; CSMA/CE; local area networks; standards; traffic generation; transport protocols.

The National Bureau of Standards' Institute for Computer Sciences and Technology (ICST) is testing the International Organization for Standardization's (ISO) Transport Class IV protocol on an Institute of Electrical and Electronics Engineers (IEEE) 802.3 Local Area Network. Part of the test facility includes an artificial traffic generator that produces ISO Transport Class IV protocol data units encapsulated in IEEE 802.2 Type 1 Class 1 Logical Link frames. The traffic generator submits the frames to the network for transmission. This document describes the architecture and usage of the traffic generator for multi-host and multi-connection traffic.

NBSIR 83-2765. Steckler, K. D. **A calculation of wall fire spread in an enclosure.** 1983 November. 74 p. Available from: NTIS; PB 84-123165.

Key words: burning rate; fire models; flame spread; flashover; mathematical models; room fires; walls.

Mathematical models of fire growth in enclosures offer a potential for assessing the risk of materials with respect to a hazard such as flashover. The development of a model for fire spread over wall lining materials is presented. The work covers the development of a transient two-layer zone model, initially formulated for crib fires in a room, then adapted to simulate a spreading corner wall fire. The local wall flame spread rate and burning rate per unit area are expressed in the model as functions of the external radiation incident upon the burning surface and the oxygen concentration in the adjacent gas layer (zone). Flame spread is limited to the horizontal direction. Results for a fictitious wall lining material are presented. Major elements of the results are shown to be in qualitative agreement with experience. Finally, areas for improvement and the direction of future efforts are noted.

NBSIR 83-2768. Grot, R. A.; Chang, Y. M.; Persily, A. K.; Fang, J. B. **Interim report on NBS thermal integrity diagnostic tests on eight GSA Federal office buildings.** 1983 September. 50 p. Available from: NTIS; PB 84-104249.

Key words: air infiltration; building diagnostics; building thermal integrity; fan pressurization; field measurements; thermographic inspections; tracer gas technique; U-value tests.

This report summarizes preliminary results of diagnostic tests to evaluate the thermal integrity of eight Federal Office buildings located throughout the country. The test results include tracer gas measurements of air infiltration rates, pressurization tests of the air tightness of the building shell, and inspections of the envelope employing infrared thermography. In addition, the thermal U-values of exterior walls were measured with both heat flow meters and a portable calorimeter box. The data collected on these buildings are still undergoing analysis and therefore are to be considered preliminary.

NBSIR 83-2770 (GSA). Silberstein, S.; Grot, R. A.; Pruitt, D. O.; Engers, P.; Lane, P.; Schweinfurth, S. E. **Air exchange rate measurements in the National Archives Building.** 1983 September. 26 p. Available from: NTIS; PB 84-102110.

Key words: air exchange rate; archives; building envelope infiltration; pressurization; records storage; ventilation.

Air exchange measurements were carried out at the National Archives Building under various combinations of temperature and wind speed. The average air exchange rate under normal operation of the heating, ventilating, the air-conditioning system (HVAC) was 0.9 h^{-1} for an average temperature difference of 11.3°C and an average wind speed of 2.7 m/s. This rate is approximately twice those for new General Services Administration (GSA) office buildings. No clear dependence of air exchange rate on temperature differences up to 17°C or wind speeds up to 5 m/s was found.

With outdoor air dampers closed and fans operating, the average air exchange rate was 1.2 h^{-1} for an average temperature difference of 8.2°C and an average wind speed of 2.8 m/s.

A test of interzone air movement showed that air migrates rapidly from non-stack to stack areas with fans operating normally.

The building could not be pressurized beyond an indoor-outdoor pressure difference of 14 Pa. At this pressure difference, the air exchange rate was 1.5 h^{-1}. As in the case of normal operation of the HVAC system, this rate is also approximately twice those for new GSA office buildings.

NBSIR 83-2776. Magrab, E. B. **Determination of the viscoelastic shear modulus using forced torsional vibrations.** 1983 September. 61 p. Available from: NTIS; PB 84-119700.

Key words: shear modulus; torsion; vibrations; viscoelastic.

A forced torsional vibration system has been developed to measure the shear storage and loss moduli on right circular cylindrical specimens whose diameter can vary to 9 cm and whose length can vary from 2 to 15 cm. The method and apparatus are usable over the frequency range 80 to 550 Hz and a temperature range of -20°C to 80°C.

NBSIR 83-2778. Saylor, C. P. **Discovery of heavy hydrogen and heavy water.** 1983 October. 9 p. Available from: NTIS; PB 84-115039.

Key words: heavy hydrogen, discovery of; heavy water, discovery of; hydrogen, heavy, discovery of; water, heavy, discovery of.

Eleven significant references are listed at the end of the article. The role of Dr. H. C. Urey, F. G. Brickwedde, G. W. Murphy, E. W. Washburn, E. R. Smith, and M. Frandsen in the discovery of heavy hydrogen and heavy water is given.

NBSIR 83-2779. Mattis, R. L.; Zucker, R. **Release notes for STAT2 version 1.31: An addendum to NBS Special Publication 400-75.** 1983 November. 26 p. Available from: NTIS; PB 84-127455.

Key words: ATE; computer program; contour map; data base; outlier; process validation wafer; statistical analysis; two-dimensional map; wafer map.

This document describes the changes which have been made in the STAT2 computer program. The new version contains several new features which provide a more powerful data base capability, improved displays, and greater compatibility with the automatic tester. In going from the original version 1.01 to version 1.31, the DATA array has been redefined and new REA command formats have been added to be compatible with new data acquisition equipment. A new circular shaded map has been added which gives a more realistic representation of data variation over a wafer surface. New map and histogram scaling options allow greater flexibility in specifying the scale of data displays. A new format for two data base commands allows greater flexibility in selectively listing and correlating data base entries. The capability has been added for eliminating some unwanted printout, and for creating macro command files within a STAT2 run. Finally, a new method of specifying the directory containing the Help files makes STAT2 easier to install. Following the description of the changes is an annotated listing of new error messages.

NBSIR 83-2780. Woodward, K.; Rankin, F. **Behavior of concrete block masonry walls subjected to repeated cyclic displacements.** 1983 October. 178 p. Available from: NTIS; PB 84-122092.

Key words: cracking; cyclic; fatigue; masonry; shear; strain rate; walls.

An experimental investigation into the behavior of unreinforced, ungrouted concrete block masonry walls subjected to repeated in-plane cyclic displacements was undertaken. A total of 15 walls were tested of which 10 were 64 in×64 in planar walls and 5 were 64 in higher corner walls having equal leg lengths of 48 in. The primary parameter varied in the investigation was loading history. Monotonic tests at both slow and rapid strain rates were done. The cyclic tests included fully reversed displacement patterns and reversed displacement patterns superimposed on static displacement offsets. The cyclic tests included at least 100,000 repetitions. The test results indicated a pronounced effect of loading history on the wall performance, but only at load/displacements nearing the load capacity failure point.

NBSIR 83-2784-1. Rubin, A. I. **The automated office—An environment for productive work, or an information factory?: A report on the state-of-the-art.** 1983 November. 207 p. Available from: NTIS; PB

84-122530.

Key words: acoustic privacy; design criteria; ergonomics; lighting; office automation; office design criteria; quality-of-life; space planning; thermal comfort; VDT's (video display terminal); work station.

This study is a report of research findings and recommendations covering topics which influence automated office design. The subjects covered are: office design, office information systems, organizational factors, ergonomics, technology and communications. Advances in technology, coupled with the explosive growth of office-based work have resulted in the automation of many offices. To date, technology has provided the major impetus for automation, with mixed results. Systems frequently do not meet the needs of the end-user because of the lack of appropriate planning. Design issues are particularly neglected during planning, resulting in problems with the visual, thermal, and acoustic environment in many offices. These effects are particularly detrimental since many office automation, management, and design experts agree that the quality of the environment is especially important in the electronic office—to offset the impersonality of many office tasks, and changes in work procedures resulting in limited social interaction with colleagues. These issues are discussed as they relate to the development of design guidelines and criteria for automated offices. The report contains an extensive bibliography, dealing with the topics cited above.

NBSIR 83-2790. Kruger, J.; Ritter, J. J.; Long, G. G.; Kuriyama, M.; Goldman, A. I. **Passive films surface structure and stress corrosion and crevice corrosion susceptibility.** 1983 November. 46 p. Available from: NTIS; PB 84-136175.

Key words: cathodic delamination; chelating inhibitors; electrochemistry; ellipsometry; EXAFS; iron oxide films; organic coatings; passive films.

I. Iron K-absorption edge spectra were obtained from the passive films on iron for the dried films in air (*ex situ*) and for the films in the passivating solution (*in situ*). The *ex situ* results demonstrate that, while the structures of the films are more disordered than the spinel-like iron oxides (e.g., γ-Fe_2O_3), they are nevertheless closely related to these crystalline oxides. The *in situ* data shows evidence of a quite different structure, which may be due to the accommodation of hydrogen containing species into the structure.

II. Two sample-and-detector chambers for the study of surface films on metals using x-ray absorption spectroscopy are described. Results have been obtained using both a high intensity rotating anode x-ray generator and using the Cornell High Energy Synchrotron Source (CHESS).

III. The effects of chelating inhibitors on the cathodic delamination of an acrylic lacquer on iron have been studied by qualitative ellipsometry. The experiments indicate that both the chemical nature of the inhibitor and the mode of inhibitor introduction affect the rate of coating failure.

IV. Ellipsometric study of corrosion under paints advanced to 1) detect film dissolution, 2) separate surface roughening and film growth effects, 3) study anodes and cathodes.

5.14 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 Advisor, 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-81-341. Sabatiuk, P. A. **Statistical analysis of thermal performance predictions of passive solar heated residences.** 1982 January. 88 p. Available from: NTIS; PB 83-151308.

Key words: data base; energy; passive solar; solar contribution; solar fraction; storage capacity.

In support of the development of thermal performance criteria for residential passive solar buildings, a statistical and graphical analysis of design, climatic, and predicted performance data was performed for houses in the HUD Passive Residential Design Competition and the HUD Cycle 5 Residential Solar Demonstration Program. These passive residences are located in all regions of the United States requiring space heating, and they represent a variety of passive solar systems types including direct gain, indirect gain, and solarium (isolated gain) type systems. The results of these analyses are being used to develop proposed minimum acceptable levels of thermal performance for the residential passive performance criteria.

A large data base was compiled for the houses in these two HUD cycles, including parameters such as solar aperture area, January net solar contribution, and auxiliary energy use. Through the use of DATAPLOT, a statistical analysis computer program, relationships between these data base parameters were explored and the mean values and standard deviations of these parameters were calculated. The direct gain systems were found to perform slightly better than the indirect and solarium systems and storage capacity was found to vary greatly for all three system types. It appears that the annual depletable energy use of these houses will on the whole be less than the proposed BEPS annual heating and cooling levels.

NBS-GCR-82-381. Farrar, D. G.; Hileman, F. D.; Blank, T. L.; Pope, D. L. **Study on the sensitivity of the leg-flexion avoidance response to the sensory irritant component of Douglas fir combustion products.** 1982 March. 56 p. Available from: NTIS; PB 83-174425.

Key words: carbon monoxide; combustion products; experimental design; laboratory animals; rats; thermal degradation; toxic gases; toxicity; wood.

Experiments which were conducted to determine the effect of experimental conditions on the sensitivity of the leg-flexion avoidance response of the rat to combustion products, particularly sensory irritants e.g., acrolein. The experiments showed that there were ill-defined relationships between the strength of the electrical stimulus given to rats to train them to perform the response, and the sensitivity of the response to environmental contaminants. The value of the leg-flexion avoidance response as a model for the detection of the potential incapacitation due to the presence of sensory irritants in the environment is discussed.

NBS-GCR-82-410. Johnson, T. L.; Milligan, S. D.; Fortmann, T. E. **Hierarchical control system emulation applications guide.** 1982 October. 81 p. Available from: NTIS; PB 83-175075.

Key words: automated manufacturing; automatic control; computer-aided design; computer-aided manufacturing simulation; hierarchical control systems.

The Hierarchical Control System Emulation is a collection of computer programs written in the high-level Praxis language for use on a Digital Equipment Company VAX 11/780™ processor under the VMS™ operating system. These programs allow the user to write, debug, and concurrently emulate modules of a hierarchical control system and to simulate the physical plant which is controlled. The emulation executes in real time and interactive display and data logging capabilities are included. The emulation is intended as a computer-aided control system design tool for the NBS Automated Manufacturing Research Facility. The Applications Guide provides a case study of the Hierarchical Control System Emulation applied to an automated machining example, involving 14 modules.

NBS-GCR-82-411. Roussopoulos, N.; Yeh, R. T. **Database logical schema design.** 1981 December. 142 p. Available from: NTIS; PB 83-195743.

Key words: database design; database management; database modeling; logical database design; schema design; schema translation.

This report presents a methodology for logical database design. Included in this methodology are systems analysis and specification, conceptual modeling, application view modeling, conceptual schema design and mapping to the relational network and hierarchical models. The report concludes with a section on design maintenance, including maintenance of the logical database.

NBS-GCR-82-412. Peters, J. W. **Studies of dry-powder extinguishment of diffusion flames for condensed fuels.** 1982 November. 123 p. Available from: NTIS; PB 83-150656.

Key words: alumina; aluminum oxides; diffusion flames; extinction; heptanes; liquid fuels; particle sizes; powders.

A powder delivery system for the extinction of diffusion flames of condensed fuels is studied. The main component of the delivery system is a glass elutriation vessel containing a bed of powder.

The extinction experiments were conducted in counterflow flame geometry. A flat, laminar diffusion flame was produced in a stagnation-point boundary layer by directing an oxidizing gas stream downward onto the surface of a liquid fuel burning at atmospheric pressure. The flame could be extinguished by either decreasing the oxygen mass fraction in the oxidizer stream or increasing the velocity of the oxidizing gas stream. The mass ratio of powder to nitrogen plus powder was maintained at a number of different fixed values to generate extinction curves. The fundamental measurement taken was the oxygen mass fraction required for extinction as a function of the velocity of the gas stream. Studies were made primarily with the liquid fuel heptane, although the system can be used with other liquid fuels and with solid fuels. The powder tested was alumina, with 90% by weight of the alumina distribution concentrated in the diameter range of 1.8–5.8 mm. At a fixed value of the gas stream velocity, an increase in the powder loading caused an increase in the oxygen concentration at which extinction occurred. The extinction data can be used to extract overall activation energies and prefactors for the inhibition processes in one-step reaction rate approximations, perhaps ultimately leading to conclusions regarding chemical mechanisms for powder suppression.

NBS-GCR-82-415. Manola, F.; Pirotte, A. **CODASYL Query Language Flat (CQLF) specifications.** 1982 December. 142 p. Available from: NTIS; PB 83-164376.

Key words: CODASYL; computer software; database management systems; data definition languages; data manipulation languages; DBMS; language specifications; network data model; query languages.

CQLF is a high-level language for defining, accessing, and manipulating data in databases described using the 1981 ANSI dpANS version of the CODASYL Data Description Language.

CQLF has similarities to both the SQL and QUEL query languages, both of which have been widely discussed in the research literature on the relational data model. The CODASYL data model has traditionally been associated with batch-oriented, record-at-a-time data processing, but many of the same principles that have been developed for the relational model also apply to the CODASYL model. Database administrators can use CQLF to define ANSI-compliant schemas, and users can manipulate data with a sequence of CQLF statements. Implementation of this specification would dramatically enhance ad hoc access to CODASYL databases.

NBS-GCR-82-416. Harvard University and Factory Mutual Research Corporation. **Home Fire Project: 1972–1982.** 1982 November. 49 p. Available from: NTIS; PB 83-146878.

Key words: bibliographies; combustion; fire extinguishment; fire models; fire spread; fire suppression; full scale tests.

This report is a review of the accomplishments of a joint fire research effort between Harvard University and Factory Mutual Research Corporation. The summary applies to a ten year period—1972–1982. A catalogue of subjects is presented with a technical description of the work along with an annotated bibliography. The subjects include: spontaneous combustion, fire spread, vitiated combustion, radiation from flames, radiation scaling, vent flow, extinguishment, atmospheric modeling, pressure modeling, full-scale tests, and the computation of a fire.

NBS-GCR-82-417. Kisko, T. M.; Francis, R. L. **Network models of building evacuation: Development of software system.** 1982 December. 13 p. Available from: NTIS; PB 83-197509.

Key words: buildings; computer programs; egress; evacuation; fire safety.

This report summarizes the efforts of the first year of a two year project to develop user friendly software for the network modeling of building evacuation.

When the evacuation of a building involves the flow of people through well defined passageways, it is natural to consider the evacuation problem to be a network flow problem. EVACNET+ is a user friently interactive computer program that accepts a user defined network model of a building, converts that model to a time expanded dynamic "transshipment" network, and solves the dynamic network using a capacitated minimum cost network flow algorithms. The solved dynamic network gives a time-dependent plan to evacuate the building in a minimum time, and identifies building evacuation bottlenecks.

During year one, EVACNET+ was implemented to the point of preliminary testing.

NBS-GCR-82-418. Shahdad, B. M.; Libster, E. **Compiler features: A survey.** 1983 January. 64 p. Available from: NTIS; PB 83-164418.

Key words: COBOL; compilers; dynamic analysis; FORTRAN; programming aids; software development; software engineering; software tools; static analysis.

In essence, a compiler is a software tool that translates a high level programming language into a low level one. As compilers have evolved, additional support features have been incorporated into them. In this report, the results of a two-phased survey of FORTRAN and COBOL compilers are presented. The first phase of the survey was a literature search to determine features offered by current compilers. During the second phase, the results of the literature survey were verified by actually using a representative set of compilers.

NBS-GCR-82-419. Manola, F.; Pirotte, A.; Bloustein, B.; Ries, D. R. **A family of data model specifications for DBMS standards.** 1982 December. 390 p. Available from: NTIS; PB 83-163394.

Key words: database functions; database management; databases; data description languages; query languages; schemas; standards; system architecture; system components; systems data models.

This report describes the current status of a National Bureau of Standards project on architectures for Database Management Systems (DBMSs). Semiformal specifications for three major data models (relational, network, and hierarchical) are presented. A model that is a subset of operations and data objects common to all three models is identified. These models will be the basis of the development of a family of language specifications that are defined so that a user of a DBMS based on these specifications can use the common subset of operations and data objects without regard to the particular model that the DBMS implements.

NBS-GCR-82-420. Putnam, Hayes & Bartlett Inc. **Planning Report 13. The impact of private voluntary standards on industrial innovation.** 1983 January. 40 p. Available from: NTIS; PB 83-162354.

Key words: industrial competition; industrial growth; industrial growth policy; industrial innovation; standardization; voluntary standards.

A conceptual basis is developed for analyzing the impacts of industrial standards on innovation and subsequent diffusion. The framework relates the functions performed by standards to the investment decisions by firms with respect to innovation or the adoption of innovations. The four major functions performed by standards in technology-based industries are providing information, promoting compatibility, reducing product variety, and assuring certain quality or performance levels. For a more complete specification of the relevant economic relationships, investment behavior is also related to market structure characteristics.

Three case studies of technology-based areas of industrial activity are studied to determine the usefulness of the conceptual framework. The three areas are semiconductors, lubricating oils, and corrosion inhibitors.

The study finds that the proposed taxonomy is a useful approach to analyzing the impacts of standards. A second finding is that standards do, indeed, influence both the rate and direction of industrial innovation, and product as well as process innovations. Standards are also found to influence firms' choice of strategies and the choice and timing of investment projects. Another significant finding is that the influence of standards is not uniform across industries, being affected differentially by such factors as nature and maturity of the technology and the market structure. Finally, standards are clearly only one of many factors influencing technological innovation.

NBS-GCR-83-421. Fisher, F. L.; Williamson, R. B. **Intralaboratory evaluation of a room fire test method.** 1983 January. 120 p. Available from: NTIS; PB 83-163386.

Key words: fire tests; heat release rate; interior finish; oxygen consumption; room fires; smoke.

A series of experiments were conducted with the proposed ASTM standard room fire test. The combinations included (1) gypsum board walls and ceiling, (2) gypsum board walls and plywood ceiling, (3) plywood walls and gypsum board ceiling, and (4) plywood walls and ceiling. The total rates of production of heat, smoke, and carbon monoxide and the rates of air inflow to the room and enthalpy flow into the exhaust dust were measured during these tests. The maximum temperatures averaged over the top of the room were 400°C and 750°C for combination (1) and (2) respectively. In spite of the high temperature and the extention of the flame beyond the doorway, the total heat release rate for combination (2) was only 840 kW, the heat flux on the floor was less than 20 kW/m^2 which is the criterion for flashover, and the newspaper indicators did not ignite. The temperatures exceeded 750°C and the fire had to be extinguished before the maximum was reached for the other combinations. Their total heat release rates reached 3.6 MW at the time of extinguishment and exceeded 1 MW at the time of flashover.

NBS-GCR-83-422. Jeng, S. M.; Chen, L. D.; Faeth, G. M. **An investigation of axisymmetric buoyant turbulent diffusion flames: Turbulence properties and concentrations of major species.** 1983 February. 73 p. Available from: NTIS; PB 83-175612.

Key words: ceilings; diffusion flames; fire models; flame impingement; methane; propane; turbulence.

Earlier measurements of mean velocities and temperatures in buoyant, turbulent, axisymmetric methane diffusion flames burning in still air were extended to include measurements of fluctuating velocities and mean species concentrations (CH_4, N_2, O_2, CO_2, H_2O, CO and H_2). These measurements, as well as existing measurements in turbulent propane diffusion flames, were employed to evaluate

differential models of the process including: (1) a base k-ϵ-g model where effects of buoyancy are only considered in the governing equations for mean quantities; and (2) an extended k-ϵ-g model where buoyancy is also considered in the governing equations for turbulence quantities. Two methods for determining state relationships (the variation of scalar properties as a function of mixture fraction) used in these models were also evaluated: (1) the laminar flamelet approach, where scalar properties are found from measurements in laminar diffusion flames; and (2) the partial equilibrium approach, where scalar properties are found from chemical equilibrium calculations for fuel equivalence ratios less than a critical value, ϕ_c, and from frozen adiabatic mixing calculations for fuel equivalence ratios greater than this value. After choosing $\phi_c = 1.2$, all the models provided reasonably good predictions of mean velocities, temperatures and species concentrations in both methane and propane diffusion flames.

NBS-GCR-83-423. Tewarson, A.; Steciak, J. **Fire ventilation.** 1983 February. 29 p. Available from: NTIS; PB 83-183293.

Key words: air flows; combustion; fire tests; flame height; heat release rate; mass loss; oxygen consumption; ventilation.

A ventilation parameter is defined in terms of the availability of oxygen with respect to the stoichiometric combustion requirements. Pagni's normalized flame height for forced air flow conditions has been used to quantify the variations in the fire properties with ventilation. For the experimental conditions used, relationships have been established between Pagni's normalized flame height and ventilation parameter, oxygen consumption in the combustion process, combustion efficiency, and generation efficiencies of various chemical compounds.

NBS-GCR-83-424. Resource Recovery Subsection, Department of Environmental Regulation, State of Florida. **National directory of manufacturers utilizing recycled materials.** 1983 January. 217 p. Available from: NTIS; PB 83-198606.

Key words: directory; ferrous metals; glass; non-ferrous metals; paper; plastic; procurement; purchasing; recycling; resource recovery; rubber; textiles.

The directory focuses on manufacturers and/or distributors of products made from waste materials. Companies listed in the directory manufacture products which contain some recycled or recovered material. The directory consists of separate sections for the types of recycled materials used: glass, ferrous metals, nonferrous metals, paper, plastic, rubber, and textiles. The states are listed alphabetically within each subsection, and the companies are listed alphabetically under the state in which they are located.

This is an update of the January 1982 edition entitled "National Recycling Directory," Report No. NBS-GCR-82-366.

NBS-GCR-83-425. Bryan, J. L. **Implications for codes and behavior models from the analysis of behavior response patterns in fire situations as selected from the project people and project people II study programs.** 1983 March. 216 p. Available from: NTIS; PB 83-198507.

Key words: behavior models; computer models; doors; evacuation; exit signs; fire alarm systems; fire investigations; hospitals; NFPA 101; nursing homes; nursing staff; residential occupancies; smoke; smoke barriers.

The study described in this report involved an analysis of the previous Project People and the Project People II studies in relation to the identification of behavior response patterns. These response patterns are compared to the established and previously formulated models of behavior, and the provisions of the regional building codes and the NFPA Life Safety Code. This study evaluates the premodal concepts of Archea and Withey in relation to the identified behavioral response patterns of the participants in both the Project People study involved primarily with residential occupancies, and the Project People II study involved primarily with health care occupancies. In addition, the conceptual models of Bickman, Edelman, and McDaniel and Breaux, Canter and Sime are examined as well as the computer models of Stahl and Berlin. The identified behavioral response patterns are compared to the provisions in the three regional consensus-developed building codes: the 1981 edition of the Basic Building Code, the 1982 edition of the Uniform Building Code, and the 1979 edition of the Standard Building Code. The 1981 edition of the Code for Safety to Life from Fire in Buildings and Structures of the National Fire Protection Association, often referred to as the Life Safety Code, is also compared to the identified behavioral response patterns from the participants in both the Project People and the Project People II studies. Conclusions are derived regarding code provisions for exit sign marking, illumination, alarm systems, and smoke barrier doors.

NBS-GCR-83-426. Charles River Associates Inc. **Analysis of the role of the National Bureau of Standards in supporting industrial innovation and growth: Summary volume.** 1983 March. 53 p. Available from: NTIS; PB 83-235655.

Key words: government research; government research laboratories; industrial innovation; industrial policy; infrastructure; technological change.

This study was performed for the Planning Office at the National Bureau of Standards (NBS). The purpose of the study is to describe in economic and policy terms the philosophical and legislative missions of NBS that relate to industrial innovation and growth. A general conceptual framework is developed which identifies market failures or barriers to private innovation that are expected to be alleviated or removed most readily through the performance of research and development (R&D) or other technical activities by a government laboratory. The framework is applied to eight case studies of NBS research projects to assess their appropriateness from an economic perspective. In all cases it is determined that the roles played by NBS would not or could not have been performed by industry in a timely manner, if at all. Government conduct of R&D is found to be a particularly effective means of overcoming barriers to private research in the area of standards and measurement technology. It is also found that government conduct of R&D may be appropriate in certain cases in which industry underinvests in "generic technology research" and applied research.

NBS-GCR-83-427. Bush, K. E.; Bradley, H. L.; Hicks, H. D., Jr. **Users guide for the application of Table 1—Safety parameter values for the Fire Safety Evaluation System for National Park Service facilities.** 1983 May. 96 p. Available from: NTIS; PB 83-209320.

Key words: building contract; dormitories; fire safety; Fire Safety Evaluation System; hotels; interior finishes; Life Safety Code; NFPA 101; smoke detectors; sprinkler systems.

This guide is developed to provide definitions, explanations, and background information for the application of Table 1—Safety parameter values for both large overnight accommodations and dormitory facilities as defined in the accompanying worksheets and glossary. It also provides, through expanded text and illustrations, suggestions for the reasonable and intended uniform application of the evaluation system, and to clarify and describe terminology in fire safety parameters which may be unfamiliar to the user. The desired result of this guide is for the user to evaluate the parameters as described in the Fire Safety Evaluation System to existing park service accommodations.

NBS-GCR-83-428. Brauman, S. K.; Matzinger, D. P.; Berg, R. A. **Polymer degradation during combustion.** 1983 May. 38 p. Available from: NTIS; PB 83-216333.

Key words: combustion; heat flux; polymers; polypropylene; polystyrene; thermal degradation.

This is an extension of previous work on the degradation of polymers in fire-like conditions. A polymer rod (13.5 mm dia.) is made to gasify linearly at rates equal to those in candle-like burning by replacing the flame with a radiant heat flux. It was previously demonstrated that, under these conditions, polystyrene degrades in the same manner as it does in isothermal heating. In the present work, the radiant flux was varied and the resulting steady-state regession rate measured; from the results an effective heat of gasification (472 cal/g) is inferred. Polypropylene was also examined in the present study. In nitrogen its degradation mechanism appears unchanged from that in isothermal heating but in air the situation is less clear as oxygen is found to influence the rate of degradation substantially.

NBS-GCR-83-429. Pearson, R. G.; Joost, M. G. **Egress behavior response times of handicapped and elderly subjects to simulated residential fire situations.** 1983 May. 48 p. Available from: NTIS; PB 83-222695.

Key words: egress; elderly persons; ergonomics; evacuation; handicapped; human behavior; residential fires.

This study involved the measurement of the times required to perform actions that are typically performed in nighttime residential fire emergencies. These actions include: calling fire department, searching for young child (i.e., doll), and donning a robe.

The participants in the study included typical college students, elderly persons (including some with arthritic problems), blind people and young adults who use wheelchairs. While the college students generally performed the actions more quickly than the other groups, all groups were able to perform the actions in a timely fashion.

NBS-GCR-83-430. King, M. H. **Industrial access to NBS technology.** 1983 April. 77 p. Available from: NTIS; PB 83-259572.

Key words: Commercial Development Association; Federal R&D; Industrial Research Institute; industry/government relations; Office of Research and Technology Applications; technology policy; technology seekers; technology transfer.

Report on the results of a study during the period September 1982 to April 1983 initiated by the Office of Research and Technology Applications of the National Bureau of Standards (NBS) to determine ways to improve industrial access to R&D done by NBS. As a part of the study, a survey was sponsored by and distributed to 275 member companies of the Industrial Research Institute and 610 member companies of the Commercial Development Association to identify: Existence of industrial "technology seekers" and their attitudes toward Federal laboratories; Current means whereby industry receives information about Federal Laboratory R&D; Industry's attitude toward visit/tour programs at Federal laboratories; Type of general information about Federal laboratories most sought by industry; and Industry awareness of NBS programs.

The 350 industrial respondents (39.5% response rate) indicated a high level of interest in Federal R&D and a willingness to share information in order to improve the technology transfer between the public and private sectors.

The report documents and analyzes the findings of the survey.

NBS-GCR-83-431. Emmons, H. W.; Mitler, H. E. **Computer modeling of aircraft cabin fires.** 1983 June. 93 p. Available from: NTIS; PB 84-101153.

Key words: aircraft compartments; aircraft fires; aircraft fuel tanks; aircraft fuels; ceilings; computer models; crash landing; fire gases; gas flow.

Two aspects of the fire that can occur after an aircraft crash landing were considered. Often a crash opens a hole in the cabin. Frequently, the wing damage opens a fuel tank and fuel spread on the ground catches fire. If the fire occurs below the hole in the cabin, fire gases and flames may enter the cabin and set it afire. Furthermore, after the gases enter the cabin, those gases and any generated by fire in the cabin itself flow as a non-steady ceiling jet down the length of the cabin. Finally, the nature of the fire gas flow into the cabin is influenced by whether or not and where the occupants open a door to escape.

NBS-GCR-83-432. Alvord, D. M. **Status report of escape and rescue model.** 1983 June. 39 p. Available from: NTIS; PB 83-236182.

Key words: assistance; board and care homes; disability; escape and rescue evacuation time; fire drill; mode; movement speed; network; preparation time; rescue priority; simulation.

This report focuses on the Escape and Rescue Model, a deterministic discrete-event simulation model for the emergency evacuation of board and care homes. It is of an interim, introductory nature and not intended as a final report. Part A is an overview of the model, describing its capabilities, input requirements, basic framework, and permissible resident types, as well as some future directions the model may take. Part B contains a brief description of a recent survey of board and care homes in which many fire drills were performed, followed by a somewhat more detailed discussion of the utilization of the survey data to calibrate and validate the simulation model. Finally, two example simulation runs appear in order to illustrate the aforementioned validation as well as to provide representative simulation output.

NBS-GCR-83-433. Springer, G. S.; Do, M. H. **Degradation of mechanical properties of wood during fire.** 1983 October. 130 p. Available from: NTIS; PB 84-122274.

Key words: computer programs; degradation; fire models; fire tests; mechanical properties; wood.

The major objectives of this investigation were to evaluate the decrease in mechanical properties of wood exposed to fire, and to develop a method that can be used to predict the failure time of loaded wooden structural members during fire exposure. To achieve these objectives analytical models were developed which can be used to calculate a) the temperature distribution inside the wood, b) the mass loss, c) the changes in tensile, compressive, and shear strengths and moduli, d) the decrease in the safety factor and e) the time of failure. On the basis of these models, a "user friendly" computer code was written which is suitable for calculating these parameters for loaded wooden slabs exposed to elevated temperatures.

Tests were also conducted measuring the thermal and mechanical responses of southern pine and Douglas fir during exposure to temperatures in the range 100 to 800°C. In the tests the following parameters were measured as functions of exposure time: a) center point temperature, b) mass loss, c) tensile, compression, and shear strengths and moduli. In addition failure times of simply supported loaded beams were measured. The results of the model were compared to the data and reasonable agreements were found between calculated and measured values.

NBS-GCR-83-434. Schmitz, G. R.; Csizmadia, T. D. **Office structures and enclosures: Directions in innovative technology.** 1983 July. 71 p. Available from: NTIS; PB 83-250563.

Key words: building enclosure systems; building structural systems; innovative building technologies; office building enclosures; office building structures; structures.

Selected issues and innovative technological responses related to structures and enclosures of office buildings are presented. Innovations are based on a better use or improvement of existing technology, or a transfer of superior technology. Structural support system innovations are often concerned with economy, flexibility of use and human safety and comfort in highrise and long-span structures. Wind and seismic forces constitute major problems which can be solved through innovative structural systems and/or their new combinations, through mass reduction, structural damping devices, aerodynamic shapes, choice of materials and methods. Structural innovations are further related to specific elements such as roofs, floors, bearing walls, columns, bracings, and foundations. Enclosure system issues are concerned with the design, construction, maintenance and operation of the roof, the exterior wall and their components. New materials, products and design features are often used for the purposes of energy conservation and/or energy "gain." Solar access and systems (active and passive), water and air infiltration, adaptability to user requirements and change, issues of health and safety and visual aspects of the enclosure system are discussed.

NBS-GCR-83-435. Kahn, M. J. **Detection times to fire-related stimuli by sleeping subjects.** 1983 June. 97 p. Available from: NTIS; PB 83-227116.

Key words: auditory perception; fire alarm systems; fire detection; human behavior; human performance; odor discrimination; residential buildings; smoke; smoke detectors.

A laboratory study was conducted to determine human waking and response times to fire-related stimuli. Twenty-four college-age male subjects were tested with each subject being run for one night. Twelve subjects were exposed to smoke alarm warning signals of three intensities while a second set of twelve subjects was exposed to a smoke odor, a heat presentation, and one smoke alarm warning signal. Subjects were, without fail, awakened by alarms that reached their ears at a signal/noise ratio of 34 dB. They were considerably less effective in waking to the heat, the smoke odor, and alarm sounds that

reached their ears at a signal/noise ratio of 10 dB or less. Failure to detect these latter stimuli may have resulted from a lack of familiarization with the specific fire-related cues used in this research. Had training in detection of these cues been conducted, subjects might have been more responsive. Using similar logic an argument can be made that standardization of signals used for household smoke detectors would be beneficial.

NBS-GCR-83-436. Pitz, W. J. **Structure, inhibition and extinction of polymer diffusion flames.** 1983 July. 123 p. Available from: NTIS; PB 84-101336.

Key words: bromine; chlorine; diffusion flames; flame extinguishment; flame structure; halogens; inhibitors; polyethylene; polymers.

Composition and temperature profiles for combustion of high-purity polyethylene polymer in the opposed flow of a gaseous oxygen-nitrogen stream were obtained to examine the flame structure near extinction. As the oxygen concentration in the oxidizer flow was reduced, the flame moved toward the surface, the position of unity equivalence ratio moved away from the surface, and the maximum flame temperature decreased. Surface oxidation reactions were of minor importance. Halogenated inhibition effectiveness was assessed by evaluating its influence on extinction limits. The order of increasing effectiveness was found to be chlorine in the oxidizer flow, chlorine in the polymer, and bromine in the oxidizer flow. Predictions from a stagnation boundary-layer model with either a one-step, Arrhenius-rate expression or a flame-sheet representation were compared to the measured structure. Penetration of oxygen through the flame was accurately predicted by a finite-rate model. The temperature dependences of the global reaction rates at extinction were largely unaffected by addition of the halogen inhibitors.

NBS-GCR-83-437. Fernandez-Pello, A. C. **Fire propagation in concurrent flows.** 1983 July. 77 p. Available from: NTIS; PB 84-100155.

Key words: burning rate; flame spread; heat transfer; natural convection; polymethylmethacrylate; polyoxymethylene; pyrolysis.

A study has been performed of the process of fire spread in gaseous flows moving in the direction of flame propagation, i.e.: concurrent or flow assisted flame spread. The study includes two research efforts: 1) Natural convection, flow assisted, flame spread over enclosure's walls; 2) Flame spread over a flat surface in a concurrent forced flow. During this reporting period, a numerical analysis has been performed of the natural convection, steady burning of combustible surfaces of varied length and composition forming the walls of an enclosure. The results for the location and length of the flame agree well with experimental data. In a concurrent analytical effort, an analysis has been developed of the mixed convective burning of surface with arbitrary inclination. The analysis provides explicit expressions for the mass burning rate as a function of the mixed convection parameter $(Re_x^n+Gr_x^m)^{1/2n}$ and the mixed convection ratio $(Gr_x^m/Re_x^n)^{1/2}$. Experimentally, measurements of the rate of flame spread in a concurrent forced flow of varied velocity and oxygen concentration show that the spread process is controlled primarily by heat transfer from the flame to the fuel. The measured rate of spread of the pyrolysis front, V_p, can be correlated in terms of the free stream gas velocity μ_∞, and mass transfer number B, by using an expression of the form $V_p/B^2 \sim \mu_\infty$, which agrees with the predictions of thermal theories of the flow assisted mode of flame spread.

NBS-GCR-83-438. Johnson, W. B.; Lull, W. P.; Madson, C. A.; Turk, A.; Westlin, K. L.; Woods, J. E.; Banks, P. N. **Final report on January 19-20, 1983 NBS workshop: Environmental control for archival record storage.** 1983 July. 52 p. Available from: NTIS; PB 83-242230.

Key words: air quality; archival storage; criteria; design parameters; environmental conditions; environmental control; environmental conditioning systems.

A summary of the January 19-20, 1983 National Bureau of Standards Workshop on Environmental Conditions for Archival Records Storage is presented that proposes criteria and addresses control of environmental conditions in spaces used for storage of paper-based archival records. The objectives of the Workshop were to explore rationale for establishing levels of air quality for archival storage and to review equipment technology with regard to its capability to provide optimum environmental conditions for archival storage facilities.

The proposed criteria gives levels of air quality for different categories of archival storage for the four environmental variables, temperature, relative humidity, gaseous contaminants, and particulate contaminants, that primarily effect paper-based archival records. Other design parameters are addressed and recommendations made regarding factors to consider in the design of archival storage facilities. The types of environmental conditioning equipment, components, and systems for providing indoor air quality for preservation of paper-based archival records are reviewed and discussed with regard to environmental variables. Methods of thermal and air quality control are discussed and recommendations made for performance evaluation of environmental conditioning systems. Monitoring and assessment procedures to evaluate performance of environmental conditioning systems and components are addressed.

NBS-GCR-83-439. Nober, E. H.; Pierce, H.; Well, A. **Waking effectiveness of household smoke and fire detection devices.** 1983 July. 92 p. Available from: NTIS; PB 83-256511.

Key words: adults; alarm responses; auditory perception; children; decibel levels; developmentally disabled; elderly persons; fire departments; frequency distribution; frequency ranges; noise (sound); sleep; smoke detectors; wakefulness.

The present work consists of three experiments. Experiment A measured the frequency response and directionality of five typical home smoke alarms. In experiment B, normal-hearing young adults were subjected to alarm signals of 85, 70, and 55 dBA while asleep in their own bedrooms under both low and moderate background noise levels. Times required to awaken, turn off the alarm and phone the fire department ranged from 49–115 s at 55 dBA to 24–109 s at 85 dBA with low background noise. With moderate background noise, times increased to 45–137 s for the 55 dBA signal and 36–119 s for the 70 dBA signal. In experiment C, subjects included families with and without children, varying types of housing, elderly, and developmentally disabled populations. Times required to awaken and evacuate all subjects in the household were measured. Mean evacuation times for these groups were 48.5 s for the families, 65.8 s for the elderly, and 57.9 s for the developmentally disabled. The report concludes that college-aged subjects can be awakened and alerted with alarm levels as low as 55 dBA (even with moderate background noise) and that evacuation times for families, geriatric and developmentally disabled populations seem to be in a range of one to two minutes.

NBS-GCR-83-440. Kelly, J. C. **Capacity planning: A state of the art survey.** 1983 July. 46 p. Available from: NTIS; PB 83-252924.

Key words: capacity; capacity management; capacity measurement; capacity planning; modeling; performance standards; simulation; sizing; workload.

This report summarizes the results of a study performed by Datametrics Systems Corporation for the National Bureau of Standards to document the state of the art in computer capacity planning. The results of the study are based upon a review of the published literature, interviews with key industry and government leaders, and the experience of the author. Every attempt has been made to make an unbiased review of measures involved. None of the products discussed in this report are endorsed by Datametrics Systems Corporation or the National Bureau of Standards.

NBS-GCR-83-441. Chang, T. C. **The advances of computer-aided process planning.** 1983 August. 137 p. Available from: NTIS; PB 83-252254.

Key words: Automated Manufacturing Research Facility; computer-aided design; computer-aided processing planning; decision table/expert systems; group technology.

Modern industry is in need of the computer-aided process planning for two major reasons; the labor demand, and the technological demand. In the AMRF (Automated Manufacturing Research Facility) of the National Bureau of Standards, close interaction between

process planning and production planning and control is required—a computer-aided system is essential. In this report, current state-of-the-art process planning systems are reviewed. Approaches used in current systems are also discussed.

A modular system structure is proposed for AMRF. The structure is capable of accommodating all the necessary planning functions. The report also discusses the technical difficulties of implementing such a proposed process planning system. A glossary containing process planning terminologies is also included.

NBS-GCR-83-442. Murphy, R. B. **Molecular biophysics of olfaction—Progress report II.** 1983 August. 72 p. Available from: NTIS; PB 83-262667.

Key words: chemical analysis; electrochemistry; membranes; olfaction; protein separation.

This report summarizes the progress of the Olfactory Research Program at the Department of Chemistry, New York University, under Prof. Randall B. Murphy. The report presents two technical sections: experimental procedures and results. The experimental procedures describe in detail the method of olfactory epithelial extract, membrane formation, the system used to measure the electrical parameters of the bilayer system, and the measurement procedures. The results include membrane response to diethyl sulfide and the dependance of conductance upon homogenate concentration, ion selectivity, and specificity, and electrical field dependence as well as response to other odorants. The artificial membranes evidence a chemosensitive response, measured in terms of current flow at constant voltage, to very low concentrations in the nanomolar region of the odorant diethyl sulfide. A model system is described for the initial chemosensory events in the mammalian olfactory epithelium, based upon the functional reconstitution of membrane proteins from olfactory bipolar receptor cell cilia into artificial lipid bimolecular membranes.

NBS-GCR-83-443. Brown & Root Development, Inc. **State-of-the-art report of guyed tower platforms.** 1983. 126 p. Available from: NTIS; PB 83-253005.

Key words: compliant platforms; guyed towers; ocean engineering; offshore platforms; structure dynamics.

This state-of-the-art report reviews general concepts, design considerations, the modeling of dynamic and fatigue behavior, methods of analysis, and problems of fabrication and installation, pertaining to offshore guyed tower platforms. In addition, a list of references is provided, complemented by a bibliography on dynamic problems in platform design.

NBS-GCR-83-444. Pallett, D. S. **Workshop on standardization for speech I/O technology.** 1983 March. 239 p. Available from: NTIS; PB 83-262154.

Key words: speech input/output; speech performance standards; speech processing algorithms; speech recognition; speech standardization.

This Proceedings documents papers presented at the Workshop on Standardization for Speech I/O Technology held at the National Bureau of Standards in Gaithersburg, Maryland, on March 18-19, 1982. The key issue discussed at the Workshop was how to assess the performance of speech recognition and synthesis technology. A secondary issue dealt with the need for speech data bases used in performance assessment testing. The Proceedings volume contains the text of thirty-one papers presented on this topic.

NBS-GCR-83-448. Kanury, A. M. **Scaling correlations of flashover experiments.** 1983 October. 79 p. Available from: NTIS; PB 84-121581.

Key words: compartment fires; fire growth; fire tests; flashover; measurement; room fires; scale models.

The objective of research described here is to develop a correspondence between the measurements made on the fire growth process to flashover in compartments of different scales. Such a development is useful in predicting, from the necessarily limited existing experimental information, the conditions conducive to result in flashover and the time to flashover. Special consideration is given to the role of the room dimensions (absolute and relative), the lintel height, wall-linings, the character of the fire source, and others. Preliminary scaling rules are synthesized to relate the full-scale compartment fires with small-scale test fires; these rules are then applied to certain full-and quarter-scale model test data of the Bureau of Standards focusing on the issue of flashover as influenced by lintel height, partially successful. Data of all the tests in which flashover occurred within a finite time correlate in a reasonable fashion. However, test data in which flashover time is infinity do not obey the scaling hypothesis. The issue of whether or not flashover would occur, thus, seems to unsettled by this work.

NBS-GCR-ETIP 82-101. Mulkey, M.; Timpane, K. **An agenda for FCC telecommunications monitoring and analysis.** 1982 December. 54 p. Available from: NTIS; PB 83-140558.

Key words: administrative experiments; deregulation; ETIP; industry monitoring; innovation; telecommunications.

This is the final ETIP report on its experiment in communications deregulation. In this report of the last phase of that project an agenda for future monitoring of the effects of deregulation is suggested. Like most ETIP work it is based on the views of many, varied interests both inside and outside the Federal Communications Commission (FCC)—ETIP's partner in this project. The report contains, first, the views of those interviewed of the major issues facing the Commission, such as the effects on competition of deregulation. Secondly, the report suggests measures for monitoring and analyzing those issues. Finally, it recommends ongoing processes for the Commission to pursue in order to maintain a credible monitoring capability for the near future.

U.S. Patent 4,362,510. Brauer, G. M.; Argentar, H.; Stansbury, J. W. **Cementitious dental compositions which do not inhibit polymerization.** 7 December 1982. 11 p.

Key words: dental adhesive; dental cement; endodontic sealant; impression paste; insulating base; luting agent; pulp capping material; sedative base; tissue pack.

Cementitious dental compositions suitable for use as luting agents, sedative and insulating bases, temporary and long term restoratives, endodontic sealants, pulp capping materials, tissue packs, impression pastes and adhesives for dental composites and hard tissues comprising a solid phase which includes a metal oxide or hydroxide of tin or a Group II metal and a liquid phase which includes a chelating compound, the chelating compound being an ester of a vanillic acid moiety in which the ester is the product of a reaction of one of an alcohol, a polyhydric alcohol or a polyalkylene gylcol and at least one of either vanillic acid or its isomers or hololoynes. The compositions may additionally contain a second chelating compound, Al_2O_3, an hydrogenated rosin, polymeric materials and polymerizable monomeric materials.

U.S. Patent 4,374,171. McCarter, R. J. **Smolder and flame resistant insulation materials, composition and method.** 15 February 1983.

Key words: cellulosic insulation; cellulosic material; flame and smolder resistant.

A flame and smolder resistant cellulosic insulation material, method of treating loose-fill cellulosic material, and composition for imparting flame and smolder resistance to such materials are disclosed with the combination of from about 2 to 9% sulfur and from about 10 of 25% flame retardant uniformly distributed in the cellulosic insulation material based on the weight of cellulosic material.

U.S. Patent 4,377,751. Kronenberg, S.; Levine, H.; McLaughlin, W. L.; Siebentritt, C. R. **Optical waveguide dosimeter.** 22 May 1983. 4 p.

Key words: dosimetry; leuko dye; optical waveguide dosimeter.

An optical waveguide dosimeter for personnel dosimetry is provided including a liquid solution of leuko dye hermetically sealed in plastic tubing. Optical transport is improved by dipping the ends of the plastic tubing into clear epoxy, thus forming beads that serve as optical lenses. A layer of clear ultraviolet absorbing varnish coated on these beads and an opaque outer layer over the plastic tubing provides protection against ambient UV.

U.S. Patent 4,386,233. Smid, M. E.; Branstad, D. K. **Cryptographic key notarization methods and apparatus.** 31 May 1983.

Key words: cryptographic function; cryptographic keys; identifier; password designation.

Cryptographic keys for a cryptographic function are notarized by encrypting the keys with the cryptographic function using a notarizing cryptographic key derived from identifier designations associated with the encryptor and intended decryptor, respectively, and an interchange key which is accessible only to authorized users of the cryptographic function. Preferably, the identity of a user of the cryptographic function is authenticated as a condition to access to an interchange key. Advantageously, authentication is accomplished by comparing a password designation supplied by the user with a prestored version thereof which has been notarized by having been encrypted with the cryptographic function using a notarizing cryptographic key derived from the identifier designation of the corresponding authorized user and an interchange key. Signature properties similar to those provided by public key systems are provided for nonpublic keys by allowing a user to use a key for only encryption or decryption and not both. Preferably, this is attained through the use of user identifiers which are combined in predetermined combinations for data key notarization and notarized data key decryption in dependence on whether a key is to be used for encryption or decryption.

U.S. Patent 4,393,699. Seiler, J. F. N., Jr. **Pneumatic adhesion tester.** 19 July 1983. 5 p.

Key words: adhesion tester.

This tester comprises a fixture which is bonded to a coating or surface, and a plate and a membrane which are sealed together along their peripheries. A hole extends through the membrane and at least into the plate for receiving the fixture so that its bonding surface is flush with the membrane. The plate has a gas opening which is connectable with a source of pressurized gas.

U.S. Patent 4,398,293. Hall, J. L.; Baer, T. M.; Kowalski, F. V. **Frequency stabilization for two-mode laser.** 9 August 1983. 7 p.

Key words: correction control; error-correction signal; laser frequency; mode-pulling effect; two-mode laser.

Frequency stabilization is disclosed for a two-mode laser, such as a Zeeman laser. The emission frequency of the laser is servo-stabilized to the center of the atomic gain curve to provide a stable laser reference frequency that is independent of time and environmental operating conditions. Stabilization in a longitudinal-field Zeeman laser is achieved by utilizing the mode-pulling effect which makes the frequency difference between the two circular polarization components have a parabolic dependence on the optical frequency of the laser. The detected intermode beat frequency from the laser is subjected to digital phase-sensitive, drift-free integration, utilizing a reversible counter, to provide a cumulative count with a rate of increase corresponding to the displacement of the average wavelength from the atomic center wavelength and an analog error-correction signal is generated therefrom which is coupled to the laser. The error-correction signal is processed and coupled to the piezoelectric crystal which controls the emission frequency of the laser for fast laser frequency correction control, and may be also processed and coupled to the heater coil on the laser for thermally providing slow frequency correctional control.

U.S. Patent 4,402,606. Zalewski, E. F.; Keller, R. A.; Apel, C. T. **Optogalvanic intracavity quantitative detector and method for its use.** 6 September 1983. 11 p.

Key words: atoms; ions; light; molecules; optogalvanic intracavity detector.

The disclosure relates to an optogalvanic intracavity detector and method for its use. Measurement is made of the amount of light absorbed by atoms, small molecules and ions in a laser cavity utilizing laser-produced changes in plasmas containing the same atoms, molecules, or ions.

U.S. Patent 4,415,974. Laug, O. B.; Gordon, C. C.; Stone, R. O. **Airspeed display scale with integral trend indication.** 15 November 1983. 7 p.

Key words: aircraft; airspeed; digital-electronic circuitry; display scale.

A digitally activated display scale in association with digital-electronic circuitry, displays both the airspeed and airspeed trend of a landing aircraft. The digital/electronic circuitry process an analog voltage corresponding to an airspeed range of 80 to 179 knots to produce a digital number representative of the airspeed of the landing aircraft. The digital number is used to produce a continuous display of the airspeed and to indicate the trend of the airspeed as either increasing or decreasing.

6. TITLES AND ABSTRACTS OF PAPERS PUBLISHED IN NON-NBS MEDIA

21542. Reed, R. P.; Tobler, R. L. **Deformation of metastable austenitic steels at low temperatures,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 49-56 (Plenum Press, New York, 1982).

Key words: low temperatures; martensite; mechanical properties; plastic deformation; stainless steel; stress-strain curve.

The reaction of a solid to continuously increasing applied tensile load is portrayed using a stress-versus-strain curve. From stress-strain curves the Young's modulus, yield strength, ultimate tensile strength, percent elongation, and work hardening characteristics can be obtained. Typically, following the elastic deformation region, a metal or alloy work hardens at a decreasing rate until localized specimen necking initiates and the ultimate strength of the specimen has been reached.

The stress-strain characteristics at low temperatures of commercial grades of polycrystalline austenitic stainless steels containing about 18 wt.% Cr and 8 wt.% Ni are not conventional. The anomalous behavior is thought to be caused by the martensitic transformation of face-centered cubic austenite to body-centered cubic (α') and hexagonal close-packed phases. This paper suggests that the plastic deformation of metastable austenites is composed of three stages and uses a series of Fe-18Cr-8Ni-1-6Mn, 0.1–0.2N alloys, tested at 4 K, to demonstrate the usefulness of this characterization.

21543. Read, D. T.; Tobler, R. L. **Mechanical property measurements at low temperatures,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 17-28 (Plenum Press, New York, 1982).

Key words: elongation; fatigue crack growth rate; fracture toughness; J-integral; reduction of area; tensile property; ultimate strength; yield strength.

Mechanical test methods for the liquid helium temperature range are discussed. Fracture toughness testing and the use of toughness data will be emphasized. Facilities and test methods for fracture toughness, fatigue crack growth rate, tensile, and elastic properties at NBS/Boulder are described. Apparatus and techniques for temperature measurement and control during mechanical tests are discussed.

21544. Kasen, M. B. **Mechanical performance of graphite- and aramid-reinforced composites at cryogenic temperatures,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 165-178 (Plenum Press, New York, 1982).

Key words: aramid; compression; composites mechanical properties; cryogenics; graphite; shear; tensile.

The results of a program to determine the effect of cryogenic temperatures on the static mechanical properties of uniaxial and $\pm 45°$ laminates reinforced with high and medium modulus graphite and with aramid fiber are presented and discussed. Properties include tensile, compression and in-plane shear. The same commercial epoxy prepreg system was used for all laminates. Results indicate that cryogenic temperatures are not deleterious to the material performance.

21545. Goodrich, L. F.; Ekin, J. W.; Fickett, F. R. **Effect of twist pitch on short-sample V-I characteristics of multifilamentary superconductors,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 571-580 (Plenum Press, New York, 1982).

Key words: conductor; current transfer; multifilamentary superconductors; short-sample voltage-current characteristics; twist pitch; voltage tap.

The voltage tap location on short samples of twisted multifilamentary superconductors can result in anomalous V-I characteristics and significantly affect the determination of critical current. A phenomenological model of the effect has been developed based on the twist pitch of the wire and current-transfer theory. Extensive experimental data has ruled out other potential explanations for the observed behavior.

21546. Fickett, F. R. **Low-temperature materials research: A historical perspective,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 1-16 (Plenum Press, New York, 1982).

Key words: alloys; cryogenics; materials; metals; review; structure; superconductors.

The evolution of materials research at cryogenic temperatures is traced from its earliest beginnings to the present day. The emphasis is on developments in the United States. Nonsuperconducting components of cryogenic systems are the main topic, but practical superconductors are not neglected. An assessment of the data base as it now exists is presented as well as some projections for the future. A few mild-mannered comments are made regarding the modern tendency to first build large devices and then do the materials research.

21547. Ekin, J. W.; Pittman, E. S.; Superczynski, M. J.; Waltman, D. J. **Training studies of epoxy-impregnated superconductor windings,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 719-728 (Plenum Press, New York, 1982).

Key words: epoxy-impregnated magnets; fiberglass; NbTi; stability; superconductors; training.

A systematic study of training is being carried out in epoxy-impregnated NbTi superconductor windings. The effects of the following factors on training are reported: 1) coating the superconductor with an epoxy release agent, 2) adding a milled fiberglass filler to the epoxy impregnant, 3) prestressing the superconductor prior to winding, 4) room temperature cycling of a trained winding, and 5) vacuum impregnating superconductor windings with wax instead of epoxy. The results indicate that a major source of training in epoxy impregnated magnets is microfracture of the epoxy resin.

21548. Moody, J. R.; Beary, E. S. **Purified reagents for trace metal analysis,** *Talanta* **29,** 1003-1010 (1982).

Key words: clean laboratory; contamination control; fume control; purified reagents; safety; trace analysis.

Sub-boiling distillations have become a standard tool for the reduction of the inorganic analytical blank. More than 10 years of practical experience in the production of reagent acids is reviewed and a description is given of a new laboratory especially designed to permit trouble-free operation as well as ensure the continued high quality of the reagents produced.

21549. Sarbar, M.; Covington, A. K.; Nuttall, R. L.; Goldberg, R. N. **The activity and osmotic coefficients of aqueous sodium bicarbonate solutions,** *J. Chem. Thermodyn.* **14,** 967-976 (1982).

Key words: activity coefficient; electrolyte; excess Gibbs energy; isopiestic; mixtures; osmotic coefficient; sodium bicarbonate; sodium carbonate; solubility; solutions; thermodynamics.

We have used the isopiestic technique to measure the osmotic coefficients of mixed aqueous solutions of $NaHCO_3$ and Na_2CO_3 at 298.15 K. During the isopiestic equilibration, the systems were pressurized with $CO_2(g)$ to reduce the loss of CO_2 from the initially pure $NaHCO_3$ solutions and the consequent conversion of bicarbonate to carbonate. Following equilibration, a differential titration analysis was performed to determine the amounts of carbonate and bicarbonate in the solutions. We have calculated the osmotic and the activity coefficients of pure sodium bicarbonate solutions up to a molality of 1.3 $mol \cdot kg^{-1}$, using the experimentally determined osmotic coefficients for the mixtures, the osmotic coefficients for pure sodium carbonate solutions, and the equations of Reilly, Wood, and Robinson together with the assumption that the interaction coefficients are zero.

21550. Wang, G. C.; Celotta, R. J.; Pierce, D. T. **A constant momentum transfer average study of PLEED data from W(100),** *Surf. Sci.* **119,** 479-487 (1982).

Key words: constant momentum transfer average; polarized electron scattering; polarized LEED; surface structure.

We performed a constant momentum transfer averaging (CMTA) data reduction of PLEED data obtained from a W(100) surface. The results of averaging (00) beam intensity profiles, $I(E, \theta)$, difference profiles, $D(E, \theta)$, and strength of spin dependent scattering profiles, $S(E, \theta)$, are presented and discussed.

21551. Serbyn, M. R. **Interferometric phase calibration of vibration pickups,** (Proc. 1st Int. Modal Analysis Conf., Orlando, FL, Nov. 8-10, 1982), Paper in *ISA Trans.* pp. 223-229 (Instrument Society of America, 1982).

Key words: absolute calibration; automated testing; dynamic displacement; optical interferometry; phase measurement; transducer sensitivity; vibration pickups.

An absolute method for measuring the phase component of pickup sensitivity is described. The phase calibration is in terms of the time interval between zero crossings and can be performed along with magnitude calibration on an automated Michelson interferometer. The procedure is simplest when the peak vibrational displacement is between about 30 and 120 nm.

21552. Penn, D. R.; Rendell, R. W. **Surface photoeffect in small spheres,** *Phys. Rev. B* **26,** No. 6, 3047-3067 (Sept. 15, 1982).

Key words: spheres; surface photoeffect; photoabsorption; photoyield.

A new method is developed to calculate the photoabsorption and photoyield of small spheres. Numerical results are presented for the case of free-electron spheres for photon energies below the plasmon energies. It is found that the excitation of electron-hole pairs due to the presence of the surface results in enhancements in photoabsorption and photoyields that are typically $10–10^2$ relative to the classical results, which only include the excitation of transverse modes. Furthermore, enhancements of the order $10–10^2$ are found in the photoyield of small spheres relative to plane surfaces. These results are consistent with recent experimental results on a number of non-free-electron materials.

21553. Tobler, R. L.; Reed, R. P. **Tensile and fracture properties of manganese-modified AISI 304 type stainless steel,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 83-92 (Plenum Press, New York, 1982).

Key words: austenitic steels; cryogenic behavior; fracture toughness; mechanical properties of materials; stainless steels; tensile properties.

A series of ten low-carbon AISI-304-type austenitic stainless steels having 1 to 6% Mn (by weight) and 0.1 to 0.2% N were produced and tested to determine the effect of these elements on properties at 4 K. Tensile tests (at 295, 76, and 4 K) and J-integral fracture toughness tests (at 4 K) were conducted on developmental steels containing 18.25 to 19.50% Cr, 7.9 to 8.75% Ni, and 0.02 to 0.03% C. All steels were hot-rolled at 1450 K (2150°F) from ingots to 25.4-mm (1-inch) plates. The 4-K yield strengths ranged from 620 MPa (90 ksi) to 1068 MPa (155 ksi), increasing strongly with nitrogen content. Unacceptably low toughness was observed in the low manganese compositions, but the fracture toughnesses of alloys containing 6% Mn were equivalent to those of conventional AISI 304 stainless steels.

21554. Daney, D. E. **Cooling capacity of Stirling cryocoolers—The split cycle and nonideal gas effects,** *Cryogenics* **22,** No. 10, 531-535 (Oct. 1982).

Key words: cooling equipment; cryocoolers; nonideal gas effects; split cycle coolers; Stirling coolers; Stirling cycle.

The general expression for the cooling capacity of a Stirling cooler operating with nonideal gas is derived. The result demonstrates that thermodynamic regions of negative Joule-Thomson coefficient should be avoided. It is also shown that heat transfer to the expansion space occurs during three of the four steps of the ideal Stirling cycle.

21555. Kurylo, M. J.; Murphy, J. L.; Haller, G. S.; Cornett, K. D. **A flash photolysis resonance fluorescence investigation of the reaction $OH+H_2O_2 \rightarrow HO_2+H_2O$,** *Int. J. Chem. Kinet.* **14,** 1149-1161 (1982).

Key words: Arrhenius parameters; atmospheric; flash photolysis; hydrogen peroxide; hydrogen radicals; rate constant; resonance fluorescence.

The flash photolysis resonance fluorescence technique has been used to measure the rate constant for the reaction $OH+H_2O_2 \rightarrow HO_2+H_2O$ over the temperature range of 250–370 K. The present results are in excellent agreement with three very recent studies, and the combined data set can be used to derive the expression $k_1 = (2.91 \pm 0.30) \times 10^{-12} \exp[-(161 \pm 32)/T]$ cm^3/molecule s similar to that currently used in atmospheric modeling applications.

A summary of our computer simulation of this reaction system is presented. The results of the computations indicate the absence of secondary reaction complications in the present work while revealing significant problems in the earlier (pre-1980) studies of the title reaction.

21556. Melmed, A. J.; Graham, W. R. **Surface reconstruction of clean (001)W,** *Appl. Surf. Sci.* **11/12,** 470-478 (1982).

Key words: surface structure; reconstruction; surface science; (001) tungsten.

After more than a decade of experimental and theoretical research considerable controversy still remains regarding the surface structure of clean (001)W. This paper addresses primarily the conflicts associated with experimental aspects of the reconstruction problem and attempts to show that the majority of extant results are mutually compatible.

21557. Watson, R. E.; Bennett, L. H. **Volume effects in transition metal alloying,** *Acta Metall.* **30,** 1941-1955 (1982).

Key words: alloying; chemical bonds; d-band vacancies; electronegativity; magnetism; structural stability; transition metals; volume.

The relatively modest volume contractions (or expansions) occurring on alloying of transition metals do not correlate well with the heats of formation. In this work, a useful, numerically accurate, correlation is obtained for equiatomic alloys with an atomic scale, ϕ, that resembles a Gordy electronegativity. These volume effects display a trend in chemical bonding. Alloys involving manganese, due to its mangetism, and the light lanthanides, due to their special chemical bonding, deviate from the main trend. Alloys off 50/50 display strikingly similar effects, though they must be discussed with a somewhat different ϕ scale. Transition metal alloying with alkalis and alkaline earths show volume trends suggesting a smooth variation in chemical bonding from the alkalis to the noble metals. In contrast, transition metal alloying with Zn, Cd and Hg indicate a marked break in bonding behavior. The volume effects are strikingly independent of crystal structure. However, the structures assumed by various systems occupy well defined regions on a map, where the difference in ϕ is one coordinate and the average d-band electron vacancy is the other.

21558. Kong, R. C.; Lee, M. L.; Tominaga, Y.; Pratap, R.; Iwao, M.; Castle, R. N.; Wise, S. A. **Capillary column gas chromatographic resolution of isomeric polycyclic aromatic sulfur heterocycles in a coal liquid,** *J. Chromatogr. Sci.* **20,** 502-510 (Nov. 1982).

Key words: coal liquid; gas chromatography (GC); liquid chromatography (LC); liquid crystal stationary phases; mass spectrometry; polycyclic aromatic sulfur heterocycles.

Fused silica capillary columns coated with nonpolar (SE-52); polar (Superox 20M); and liquid crystal (BBBT, BMBT, and BHxBT) stationary phases and their mixtures were evaluated for the separation of isomeric polycyclic aromatic sulfur heterocycles containing three to five rings. Although columns containing Superox 20M or mixtures of Superox 20M in SE-52 were able to resolve all 3-ring isomers, no single column could resolve all of either the 4-ring or 5-ring isomers. Fortunately, the compounds that were unresolved on pure SE-52 could be resolved on a 50% mixture of BBBT in SE-52, making possible the positive identification of these compounds. Thus, the 3-, 4-, and 5-ring polycyclic aromatic sulfur heterocycles in a selected

coal liquid were determined using three columns coated with pure SE-52, 50% Superox 20M in SE-52, and 50% BBBT in SE-52.

21559. Mangum, B. W.; Furukawa, G. T. **Report on the Sixth International Symposium on Temperature,** *Metrologia* **18,** 161-168 (1982).

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

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

21560. Kaufman, V.; Sugar, J.; Cooper, D. N I **isoelectronic sequence: Observations of $2s^m2p^n$–$2s^{m-1}2p^{n+1}$ intersystem transitions and improved measurements for Cl XI, K XIII, Ca XIV, Sc XV, Ti XVI, and V XVII,** *Phys. Scr.* **26,** No. 3, 163-167 (1982).

Key words: Ca XV; Cl XII; energy levels; K XIV; Sc XIV; Ti XVII; V XVIII; wavelengths.

Spectra of Cl through V (excluding Ar) were produced with 1 GW (15 ns) pulses from a Nd-glass laser impinging on solid targets and observed with a 10.7-m grazing incidence spectrograph. Strong $2s^m2p^n$–$2s^{m-1}2p^{n+1}$ transition arrays in the N I isoelectronic sequence were recorded, from which intersystem lines were identified and improved wavelength measurements of allowed lines were made. Hartree-Fock calculations of the radial integrals were compared with values obtained from least squares fits of the energy levels of this sequence.

21561. Ederer, D. L. **The development of far UV spectrometers for synchrotron radiation facilities,** *Nucl. Instrum. Methods* **195,** 191-206 (1982).

Key words: instrumentation; monochromator; photon energy; spectrometers; synchrotron radiation.

In the early days of synchrotron radiation research conventional instruments were adapted for use with the radiation. While these instruments yielded fluxes that were adequate for simple experiments, such as absorption spectroscopy, and produced exciting results, stringent demands imposed by the higher flux requirements of photoelectron spectroscopy and fluorescence spectroscopy created a need for instruments that were designed and optimized for synchrotron radiation as a source. Furthermore, the fundamental challenge of developing designs that maintain a fixed exit slit position and exit beam direction has yielded over the years an evolving array of instrumentation that deliver higher and higher fluxes to the specimen with resolutions adequate for solid state and gas phase experiments of greater sophistication.

Since the last conference on Synchrotron Radiation Instrumentation instruments have been proposed, designed, and constructed for the synchrotron radiation facilities throughout the world, and in particular, in the United States at existing facilities and at the new laboratories under construction.

Monochromators that yield 10^{11} photons/s–100 mA–0.1 eV at a photon energy of 100 eV with 0.03 eV resolution are in operation. Monochromators have also been constructed that yield 10^{12} photons/s–100 mA–0.01 eV at photon energy of 10 eV. Designs that exploit the wavelength region below 100 Å with planned resolution of 0.02 Å and with expected throughputs of about 10^{11} photons/s–100 mA–0.1 eV are under construction.

These are exciting developments which provide dramatic evidence of the continuing progress in monochromator design for the exploitation of synchrotron radiation as an important tool for scientific research.

21562. Fried, A. **A study of measurement interference in the optoacoustic detection of NO_2 by Argon-ion laser excitation,** *Appl. Spectrosc.* **36,** No. 5, 562-565 (1982).

Key words: energy transfer; NO_2 measurement interference; optoacoustic detection of NO_2.

Optoacoustic measurements of NO_2 excited by an Ar^+ laser were performed in the presence of NO, N_2, H_2O, and O_2 matrix gases. Identical sensitivities were measured in all matrix gases except O_2 where energy transfer from NO_2 to the metastable $O_2(^1\Delta_g)$ state resulted in a dramatic decrease in sensitivity.

21563. Harris, R. E.; Wolf, P.; Moore, D. F. **Electronically adjustable delay for Josephson technology,** *IEEE Electron Device Lett.* **EDL-3,** No. 9, 261-263 (Sept. 1982).

Key words: high speed measurements; Josephson junctions; sampling.

An electronically adjustable time delay circuit for superconducting technology is reported. In conjunction with a superconducting sampler on the same chip, the delay circuit has allowed measurement of waveforms with an apparent resolution of 8.5 ps. The delay circuit permits flicker-free oscilloscope displays of fast waveforms, and provides the circuitry needed for further speed advances in superconducting sampling and other ultra-fast measurement techniques.

21564. Wlodawer, A.; Sjölin, L. **Improvement of the quality of the data collected using a position-sensitive detector,** *Nucl. Instrum. Methods* **201,** 117-122 (1982).

Key words: area detectors; diffraction data; films; linear detectors; neutrons; x rays.

A procedure for integrating the intensities of diffraction peaks which optimizes the signal-to-noise ratios and minimizes the possibility of introducing systematic errors has been extended to the data collected using a position-sensitive area detector. This technique, called "dynamic mask procedure," is capable of finding precise boundaries of the peaks on the basis of the variances in the signal. It can now be applied to X-ray and neutron data collected on films and using one- and two-dimensional position-sensitive detectors. A test using the neutron data collected with an area detector showed a significant decrease in the estimated standard deviations of the integrated peak intensities compared with the traditional techniques of peak summation.

21565. Cooper, J. W.; Saloman, E. B. **Stark effect on the oscillator-strength distribution of helium near the ionization limit,** *Phys. Rev. A* **26,** No. 3, 1452-1465 (Sept. 1982).

Key words: absorption; oscillator-strength; Stark effect.

The effect of electric fields of strengths up to 30 kV/cm on the absorption spectra of helium near the ionization limit has been investigated in detail with the use of synchrotron radiation from the SURF-II storage ring. In contrast to previous work on the heavier noble gases, the results show a strong dependence on the polarization of the source. A simple theoretical model is developed to explain the results. The relationship between the work reported here and previous theoretical and experimental studies is discussed.

21566. Chandler-Horowitz, D.; Candela, G. A. **Principal angle spectroscopic ellipsometry utilizing a rotating analyzer,** *Appl. Opt.* **21,** No. 16, 2972-2977 (Aug. 15, 1982).

Key words: accuracy of film index; accuracy of film thickness; principal angle of incidence; rotating analyzer; SiO_2 on silicon; Si_3N_4 on silicon; spectroscopic ellipsometer.

The variations of the intensity of the reflected light near null as a function of the angle of incidence are compared for three ellipsometric techniques. For films of either SiO_2 or Si_3N_4 on silicon, the highest accuracy of the film thickness measurement is always obtained when the angle of incidence is either equal or nearly equal to the principal angle for all thicknesses of the film layer. Based on these results, it is shown that a variable angle of incidence spectroscopic ellipsometer operated at the principal angle of incidence and using a rotating analyzer combines the advantage of versatility with near maximum accuracy and sensitivity.

21567. Dalder, E. N. C.; Seth, O. W.; Whipple, T. A. **Shielded metal-arc and flux-cored metal-arc stainless steel weldments: Magnet cases for 4-K service,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 839-

852 (Plenum Press, New York, 1982).

Key words: cryogenic properties; flux-cored metal arc; fracture toughness; shielded-metal-arc; superconducting magnet cases; welding consumables.

Load-bearing structures of superconducting magnet systems involve the manufacture of defect-free fusion welds in nitrogen-strengthened austenitic stainless steels in thicknesses up to 150 mm. These welds must be capable of fracture-safe operation at 4 K at stresses close to the yield strength and must resist failure caused by growth of fatigue cracks to critical sizes and rapid propagation to fracture. This paper presents an evaluation of shielded metal-arc and flux-cored metal-arc welding consumables designed to deposit ferrite-free 316L stainless-steel weld metal in the flat position at high-deposition rates. The significance of the results to design and manufacture of the Mirror Fusion Test Facility superconducting magnet set is discussed.

21568. Kasen, M. B.; Schramm, R. E. **Current status of standardized nonmetallic cryogenic laminates,** (Proc. Fourth Int. Cryogenic Materials Conf., San Diego, CA, Aug. 10-14, 1981), Paper in *Adv. Cryog. Eng.* **28,** 271-278 (Plenum Press, New York, 1982).

Key words: composites; cryogenics; epoxy; industrial laminates; nonmetallics; polyimide; radiation; standardization.

The MFE, MHD and rotating cryogenic machinery technologies are making increasingly severe demands on materials technology. This is particularly acute in nonmetallic structural and insulating materials required for superconducting magnet construction. Unlike metals technology, available nonmetallic materials have not been standardized, creating problems in reliability. This paper reviews efforts to meet current industrial needs for standardized nonmetallic laminates while laying the groundwork for systematic materials development to meet future needs.

21569. Ledbetter, H. M. **Single-crystal elastic constants in nondestructive evaluation of welds,** (Proc. 8th Air Force/Defense Advanced Research Projects Agency (AF/DARPA) Symp. Quantitative Nondestructive Evaluation, University of Colorado, Boulder, CO, Aug. 2-7, 1981), Paper in *Quantitative Nondestructive Evaluation* **1,** 619-624 (Plenum Press, New York, 1982).

Key words: elastic-compliance tensor; elastic constants; elastic-stiffness tensor; iron alloy; sound velocity; stainless steel; texture; weld.

For studying welds nondestructively using elastic waves, we describe the importance of knowing the material's single-crystal elastic constants, the C_{ij}'s. Where these are not known, we give some guidelines for estimating them from polycrystalline elastic constants such as Young's modulus and the shear modulus. We consider the important case of [100] texture. Being transversely isotropic, this case exhibits five macroscopic elastic constants, which we relate to the three cubic elastic constants: C_{11}, C_{12}, C_{44}. From these five constants we compute the angular variations of Young's modulus, the torsional modulus, and the sound velocities.

21570. Yen, D. **Electrical test methods for evaluating lithographic processes and equipment,** *SPIE* **342,** 73-81 (1982).

Key words: cross-bridge sheet resistor; electrical alignment test structure; integrated circuit; integrated circuit test structures; level-to-level registration; linewidth; linewidth uniformity; lithography; microelectronic devices; test chip.

A test structure is a microelectronic device that is fabricated by the same process used to fabricate integrated circuits (ICs) and can be tested electrically to determine important process parameters. Test structures can be used to evaluate semiconductor materials, evaluate and control process uniformity, measure device and circuit parameters, obtain input parameters for circuit simulation programs, and determine the performance of processing equipment. This paper reviews previous work at NBS on the design, measurement, and application of two types of test structures that have been used for evaluating lithographic processes and lithographic equipment performance. First, the cross-bridge sheet-resistor test structure is described. Test results from electrical measurements on this structure can be used to determine the electrical linewidth of a conducting layer. The use of test chips containing arrays of identical cross bridges for determining the uniformity of a lithographic process will be described. Analysis of test results from these arrays has been used to identify and separate the contribution to linewidth nonuniformities introduced by individual equipment and processes. The precision to which linewidth can be determined using this structure is discussed. Also, an electrical alignment test structure for determining the misalignment between two photomask steps is described and an example of its use presented. Finally, an automated dc parametric test system used for measuring these structures is described.

21571. Unassigned.

21572. Simiu, E.; Filliben, J. J.; Shaver, J. R. **Short-term records and extreme wind speeds,** *ASCE* **108,** No. ST11, 2571-2576 (Nov. 1982).

Key words: climatology; extreme values; short-term records; statistics; structural engineering; wind forces.

An empirical study was conducted to determine whether design wind speeds can be estimated confidently from short records, i.e., records extending over periods of a few years. The study was based upon the analysis of records of daily, weekly, and monthly largest wind speeds taken at 36 United States weather stations over periods ranging from three to 10 years and upon largest yearly wind speeds recorded at these stations over periods ranging from approximately 25–45 years. Investigations were presented into the type of probability distributions that best fit sets of largest daily, weekly, and monthly wind speeds and into the relationship between extreme winds estimated from short records of largest daily and weekly wind speeds on the one hand, and from 25-year to 45-year records of largest yearly wind speeds on the other hand. The main effort in the paper was focused on the relationship between estimates of 50-year wind speeds based on three-year records of largest monthly speeds and on 25-year to 45-year records of largest yearly speeds. It was found that 50-year speeds can be estimated confidently from 3-year records of the largest monthly speeds.

21573. Nyyssonen, D. **Design of an optical linewidth standard reference material for wafers,** *SPIE* **342,** 27-34 (1982).

Key words: coherence; edge detection; linewidth measurements; microlithography; microscopy; optical metrology.

Optical linewidth measurements on patterned wafers are complicated by the wide variety of materials and correspondingly wide variation in optical parameters, complex refractive index and thickness, used in the manufacture of integrated circuits. It has been shown that in addition to linewidth, two key parameters, the normalized local reflectance R and the optical phase difference ϕ at the line edge, determine the characteristics of the optical image and, therefore, affect the accuracy and precision of linewidth measurements. Both of these parameters, R and ϕ, are dependent upon the illuminating wavelength or spectral bandpass and the coherence parameter of the optical system. To achieve the measurement precision and accuracy required for VLSI dimensions (e.g., 10% tolerance for 1-μm linewidths), it is necessary to control coherence, spectral bandpass, and image integrity as well as to achieve reproducible edge detection and focus criteria. When a system can be operated without further operator intervention despite changes in the materials being measured, it is possible to calibrate the linewidth measurement system using a standard fabricated from only a few materials representing a range of image characteristics. The desirable characteristics of such a standard are discussed with respect to durability, edge definition, and equivalence of the image characteristics to materials used in the manufacture of ICs. A prototype design consisting of combinations of SiO_2 and chromium layers on a silicon substrate is presented.

21574. Clark, F. O.; Troland, T. H.; Johnson, D. R. **Polarization properties of the 86 GHz SiO maser emission from R Cassiopeiae,** *Astrophys. J.* **261,** 569-575 (Oct. 15, 1982).

Key words: masers; polarization; stars, circumstellar shells; stars, individual; stars, long-period variables.

We have measured the polarization properties of the $J=2\rightarrow1$, $v=1$ SiO circumstellar maser emission from R Cas over a period of nearly 2 years. Velocity profiles for both the Stokes parameter I and the total linear polarization change relatively smoothly but not periodically with time indicating that radiative pumping mechanisms

are probably not dominant in this source. Superposed on these smoothly varying profiles, we have detected a phase dependent effect at $\phi \sim 0.96$ for two successive optical maxima. This phase dependent effect, most readily observed in polarized radiation, places the SiO just above the stellar photosphere and allows the radial thickness of the line formation region to be estimated. We report the detection of a "superbroad" spectral feature of width ~ 18 km s^{-1}.

21575. Dermann, K.; Rupp, N. W.; Brauer, G. M. **Effect of hydrophilic diluents on the properties of cured composites,** *J. Dent. Res.* **61,** No. 11, 1250-1254 (Nov. 1982).

Key words: composite restorative resin; dental restorative; hydrophilic diluent; hydrophilic monomer; marginal adaptation of composites; properties of composite resins; water sorption of composites.

Hydrophilic diluents in composite formulations slightly increase water sorption of cured resin. This increased water uptake does not result in a significant improvement in the marginal adaptation, although other properties of the resulting composites are very satisfactory.

21576. Burrows, J. H. **Commentary on** *computers and standards, Comput. Stand.* **1,** No. 1, 5-8 (Jan. 1982).

Key words: ADP; computers; ICST; NBS; network standards; standards.

It is becoming increasingly important that users' needs be considered in the development of computer standards. Future standards development activities should focus on areas such as terminal, computer system and network interconnections; data and media exchange; and work environments to help the user make more effective use of computers and improve productivity. Current efforts to develop network protocol standards by NBS, national, and international voluntary groups are important steps toward establishing user-oriented standards.

21577. Clark, F. O.; Johnson, D. R. **The velocity gradient of B361,** *Astrophys. J.* **263,** 160-165 (Dec. 1, 1982).

Key words: B361; galactic gas cloud; magnetic braking; radio astronomy; velocity gradient.

Observations of a well-ordered velocity gradient that decreases with decreasing cloud radius are reported for the galactic dark cloud B361. The source also exhibits systematic changes in spectral line width. Current observations confirm the suggestion of rotation in this source reported earlier and imply the presence of an effective mechanism for redistributing angular momentum. Magnetic braking is invoked to explain the observed effects.

21578. Moody, J. R. **NBS clean laboratories for trace element analysis,** *Analyt. Chem.* **54,** No. 13, 1358A-1376A (Nov. 1982).

Key words: analytical blank; clean lab; clean room; contamination control; corrosion; hepa filter; plastics.

Clean rooms have been in use for more than 30 years, yet only in the last 10 years has clean air technology been applied to the chemistry laboratory. This report details the successful design and application of a NBS designed clean laboratory specifically for trace element analysis when low elemental contamination levels are necessary for successful analytical work. Details of construction are given where they are critical to the adequate long term performance of the laboratory. Other analytical applications of clean air technology are described.

21579. Levin, B. C. **Fire deaths and toxic gases,** *Nature* **300,** p. 18 (Nov. 4, 1982).

Key words: acute inhalation toxicity; carbon monoxide; test methods; toxic combustion products; toxic hazard analysis.

Eighty percent of the deaths in fires are attributed to inhalation of smoke and hot gases rather than to burns. Recently, the fire research community has become more acutely aware of the problems of the toxicity of combustion products and the possibility that toxic gases other than carbon monoxide may play an important role. This current awareness has resulted in the development of a number of test methods to measure combustion product toxicity. These test methods are all performed under slightly different laboratory conditions and do not address the problem of total toxic hazard to which a product can contribute under "real fire" conditions. Many scientists are now turning their efforts to toxic hazard analysis.

21580. Younger, S. M. **Distorted-wave electron-impact ionization cross sections for the argon isoelectronic sequence,** *Phys. Rev. A* **26,** No. 6, 3177-3186 (Dec. 1982).

Key words: argon isoelectronic sequence; electron impact ionization.

Electron-impact ionization cross sections have been calculated in a distorted-wave exchange approximation for seven ions in the argon isoelectronic sequence. For neutral argon, target configuration interaction and term dependence in the ejected-electron continuum were found to be significant influences on the cross section. Similarities of electron ionization and photoionization are discussed. An analytic fit is given which accurately reproduces the distorted-wave cross sections and rate coefficients of argonlike ions with $Z \geqslant 20$.

21581. Ellingwood, B.; Galambos, T. V. **Probability-based criteria for structural design,** *Struct. Safety* **1,** 15-26 (1982).

Key words: buildings (codes); design (buildings); limit states; loads (forces); masonry; probability theory; reinforced concrete; reliability; safety; specifications; standards; steel; structural engineering.

Probability-based loading and resistance criteria are presented that are suitable for routine safety checking in design. The criteria are based on a comprehensive analysis of statistical data on structural loads and resistances and an examination of levels of reliability implied by the use of current design standards and specifications. The criteria are intended to be used in specifications that are oriented towards limit states design.

21582. Pierce, D. T.; Celotta, R. J.; Unguris, J.; Siegmann, H. C. **Spin-dependent elastic scattering of electrons from a ferromagnetic glass, $Ni_{40}Fe_{40}B_{20}$,** *Phys. Rev. B* **26,** No. 5, 2566-2574 (Sept. 1, 1982).

Key words: ferromagnetic glass; polarized electron scattering; surface magnetism.

The dependence of the elastic scattering of electrons on the relative direction of the spin of the incident electron with respect to the magnetization of the ferromagnetic glass $Ni_{40}Fe_{40}B_{20}$ was measured at various energies, angles, and temperatures. We show that this scattering is liquidlike, i.e., effects of crystal diffraction are negligible. Also, multiple scattering of electrons contributes less than 30% to the intensity in the backward scattering direction. Under these conditions, and with correction for electron attenuation, the scattering is atomlike. This yields a first insight into the spin dependence of electron scattering from single magnetic atoms in a metallic environment. The surface magnetization was found to decrease with temperature with the same power law as the bulk magnetization at low temperature in agreement with theoretical predictions by Mills and Maradudin.

21583. Hust, J. G.; Lankford, A. B. **Comments on the measurement of thermal conductivity and presentation of a thermal conductivity integral method,** *Int. J. Thermophys.* **3,** No. 1, 67-77 (1982).

Key words: thermal conductance; thermal conductivity; thermal conductivity integral.

A discussion is presented regarding the significance of the spatial temperature gradient approximation normally used in thermal conductivity measurement. Examples are presented illustrating the magnitude of temperature differences allowed for conductivity integral (TCI) method of analysis is presented as an alternative method which totally eliminates the need to impose temperature difference restrictions on the measurement process, so long as other errors, such as radiative heat losses, do not become excessive.

21584. McCarty, R. D. **Mathematical models for the prediction of liquefied-natural-gas densities,** *J. Chem. Thermodyn.* **14,** No. 9, 837-854 (1982).

Key words: comparison; density; equation of state; LNG; mathematical models; mixtures.

Three mathematical models of the equation of state for liquid mixtures simulating liquefied natural gas (LNG) are discussed and compared. The adjustable parameters for each model have been optimized using the same set of experimental data, consisting of over 280 new (p, V, T, x) points taken at the National Bureau of Standards in Boulder, Colorado. It is estimated that each of the models will predict LNG densities over its range of validity to within 0.1 per cent of the true values, given the pressure, temperature, and composition of the mixture. Deviation plots and a detailed performance evaluation are given for each model. The range of validity varies slightly among the models but in general the range of the study included the saturated liquid from 90 to 135 K.

21585. Marx, E.; Maystre, D. **Dyadic Green functions for the time-dependent wave equation,** *J. Math. Phys.* **23,** No. 6, 1047-1056 (June 1982).

Key words: distributions; dyadic Green functions; electromagnetic scattering; elementary solution; transient electromagnetic waves; vector wave equation.

The theory of dyadic Green functions for a transient electromagnetic field, which obeys the vector wave equation, is presented within the framework of the theory of distributions. First, the elementary solution of the scalar wave equation is derived, and then it is used to find the general solution of that equation. After establishing the equivalence between Maxwell's equations and the time-dependent vector wave equation, the dyadic elementary solution is derived and applied to solve the equation. Further properties of dyadic Green functions for the wave equation are derived within the heuristic approach to the theory of Green's functions. The paper includes a collection of formulas from the theory of distributions intended to help readers who are not familiar with the subject.

21586. Mountain, R. D. **Molecular-dynamics study of liquid rubidium,** *Phys. Rev. A* **26,** No. 5, 2859-2868 (Nov. 1982).

Key words: Lennard-Jones liquid; liquid rubidium; liquid state; molecular dynamics; pair correlation function; self-diffusion coefficient; supercooled liquid; transverse current correlations.

Molecular dynamics has been used to investigate the properties of supercooled liquid states for a model of liquid rubidium. The energy-temperature relation for the reduced density $n^*=0.95$ for liquid, amorphous solid, and bcc crystal phases is presented along with the pair-correlation function, the self-diffusion coefficient, and the transverse-current correlation as functions of temperature for the liquid. The self-diffusion coefficient is found to vary with temperature in a way which correlates with the temperature evolution of the pair-correlation function. The power spectra of the transverse-current correlation function are used to determine the minimum length required for the decay of fluctuations to be describable by linearized hydrodynamics. This length grows rapidly as the amount of supercooling increases and becomes significantly larger than the dimensions of the cube to which periodic boundary conditions are applied.

21587. Pararas, A.; Ceyer, S. T.; Yates, J. T., Jr. **An o-ring-sealed rotary feedthrough for UHV applications,** *J. Vac. Sci. Technol.* **21,** No. 4, 1031 (Nov/Dec. 1982).

Key words: rotary feedthrough; ultrahigh vacuum.

A differentially pumped o-ring-sealed rotary feedthrough for ultrahigh vacuum applications is described. Its simplified design results in a significant reduction of machining requirements, compared to previous designs.

21588. Wu, W.; McKinney, J. E. **Influence of chemicals on wear of dental composites,** *J. Dent. Res.* **61,** No. 10, 1180-1183 (Oct. 1982).

Key words: chemical softening; dental composites; surface hardness; swelling; wear.

The wear resistance of a commercial dental restorative composite exposed to different chemicals was measured with a pin-disc apparatus. The initial wear rate increased dramatically once the composite had been immersed in chemicals known to soften the cross-linked matrix material, which is a copolymer derived from BIS-GMA and diluent monomer. The increase of wear rate in a chemically softened composite was found to persist over a depth beyond 160 μm for specimens immersed over two wk prior to wear testing.

21589. D'Antonio, P.; Konnert, J. H.; Rhyne, J. J.; Hubbard, C. R. **Structural ordering in amorphous $TbFe_2$ and YFe_2,** *J. Appl. Cryst.* **15,** 452-460 (1982).

Key words: amorphous solid; amorphous structure; metal glass; neutron diffraction; radial distribution function; x-ray structure.

Total neutron scattering data were collected on sputtered YFe_2 at 298 K and $TbFe_2$ at 423 K with a wavelength of 0·7 A°. The $TbFe_2$ data were collected above the magnetic ordering temperature of 383 K. In addition, the elastic neutron scattering of $TbFe_2$ was measured with the use of a pyrolytic graphite analyzer at a wavelength of 1·5 Å, and its total X-ray scattering was measured with Mo radiation and a silicon-lithium drifted detector. Experimental radial distribution functions, with statistical error limits, were calculated. Errors due to an incorrect background, scaling of the data and termination effects were minimized. The scale and shape of the experimental background and the coordination numbers, internuclear distances and disorder parameters, for the first six coordination spheres, have been determined. The contribution of paramagnetic inelastic scattering from $TbFe_2$ to the total neutron scattering is quite appreciable. The shape of the background scattering, which goes through a maximum, is indicative of residual coherence and suggests shortrange magnetic ordering where neighboring atom spins are aligned. These effects are not observed in YFe_2, nor in the elastic $TbFe_2$ data. The metallic glasses have a structural topology which is quite different from that found in their crystalline analogues. The transition-metal substructure, consisting of corner-sharing tetrahedra, is the only aspect of the crystalline topology preserved in the amorphous phase. The structural parameters suggest a tendency of the rare-earth atoms to cluster, thereby decreasing the number of Fe nearest neighbors relative to the crystalline structure.

21590. Julienne, P. S. **Nonadiabatic theory of collision-broadened atomic line profiles,** *Phys. Rev. A* **26,** No. 6, 3299-3317 (Dec. 1982).

Key words: atomic line broadening; Born-Oppenheimer breakdown; close coupled scattering; laser-switched collisions.

The close-coupled theory of atomic scattering in a radiation field can be used to calculate nonadiabatic effects on collision-broadened atomic line profiles. When the strength of the radiation field is not too large, reduced free-free dipole matrix elements, which are independent of the field strength and are analogous to the free-free Franck-Condon factors of line profile theory, can be defined in terms of the S-matrix elements for light-induced atomic scattering. The profile can then be calculated even when the molecular states are mixed by off-diagonal terms in the molecular Hamiltonian due to the breakdown of the Born-Oppenheimer approximation. Numerical close-coupled scattering calculations are used to calculate the profile for the asymptotically forbidden, collision-induced radiative transition $O^1S+Ar \rightarrow O^1D+Ar+h\nu$. The profile was calculated in two ways: (1) with the use of the normal Born-Oppenheimer approximation for the final states and (2) with the use of the new technique to treat the nonadiabatic mixing among the $^1\Sigma$, $^1\Pi$, and $^1\Delta$ final states. The Coriolis interaction mixes the Hund's case-(a) Λ states asymptotically to give Hund's case-(e) states. The central and red-wing parts of the profile which originate primarily from large internuclear separations are strongly affected by this mixing. The calculated profile which takes this mixing into account agrees well with the experimental profile but differs significantly from the Born-Oppenheimer profile. The differences are explained in terms of intensity borrowing and Hund's case-(e) selection rules.

21591. Ellingwood, B.; Galambos, T. V.; MacGregor, J. G.; Cornell, C. A. **A probability-based load criterion for structural design,** *Civ. Eng.,* pp. 74-76 (July 1981).

Key words: buildings (codes); design (buildings); limit states; loads (forces); probability theory; reliability; specifications; standards; structural engineering.

Recommended load factors and load combinations are presented which are compatible with the loads recommended in the proposed 1980 version of American National Standards 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 incorporates state-of-the-art load and resistance models and available statistical information. The load factors are intended to apply to all types of structural materials used in building construction.

21592. Coxon, B.; Reynolds, R. C. **Synthesis of nitrogen-15-labeled amino sugar derivatives by addition of phthalimide-^{15}N to a carbohydrate epoxide,** *Carbohydr. Res.* **110,** 43-54 (1982).

Key words: benzylidene acetals; carbon-13-nitrogen-15 coupling constants; carbon-13 NMR; conformations; epoxide reactions; nitrogen-15 labeled amino sugars; nitrogen-15-proton coupling constants; phthalimido amino sugars; proton NMR spectroscopy; proton-proton coupling constants; 2-amino-altrose derivatives; 3-amino-glucose derivatives.

Derivatives of methyl 2-amino-2-deoxy-α-D-altropranoside-*2*-^{15}N and methyl 3-amino-3-deoxy-α-D-glucopyranoside-*3*-^{15}N have been synthesized by addition of phthalimide-^{15}N to methyl 2,3-anhydro-4,6-*O*-benzylidene-α-D-allopyranoside. The structures of the phthalimido derivatives that resulted have been proved chemically, by conversion into known aminodeoxy derivatives, and spectroscopically, by ^{1}H- and ^{13}C-n.m.r. spectroscopy. ^{1}H-N.m.r. spectroscopy at 360 MHz also allowed definition of the configurations and conformations of the labeled and unlabeled phthalimide derivatives, and the measurement of vicinal ^{1}H-^{15}N coupling-constants that are characteristic of ^{1}H-^{15}N dihedral angles of $\sim 60°$.

21593. Thurber, W. R.; Forman, R. A.; Phillips, W. E. **A novel method to detect nonexponential transients in deep level transient spectroscopy,** *J. Appl. Phys.* **53,** No. 11, 7397-7400 (Nov. 1982).

Key words: deep levels; defect characterization; defects; DLTS; electrical properties; impurities; instrumentation; platinum-doped silicon; semiconductors; silicon; transient spectroscopy.

In conventional Deep Level Transient Spectroscopy (DLTS) measurements, the analysis of the results is based upon the assumption of an exponential current or capacitance transient. We present experimental and computational results on a novel experimental method for determining when the assumption of exponentiality is not satisfied by the sample under study. The measurement may be performed without any changes in the conventional double-boxcar DLTS system.

21594. Janev, R. K.; Belic, D. S. **Quasi-resonant charge exchange collisions between multiply charged ions,** *J. Phys. B: At. Mol. Phys.* **15,** 3479-3487 (1982).

Key words: charge exchange; ion-ion charge transfer; ion-ion collisions; multiply charged ions; quasi-resonant reactions; tokamak-plasma impurities.

Cross section calculations of the quasi-resonant ion-ion charge exchange reaction $A^{Z+}+B^{(Z+1)+}\rightarrow A^{(Z+1)+}+B^{Z+}+\Delta\epsilon$ ($1\leqslant Z\leqslant 5$, $\Delta\epsilon\ll 1$ au) are performed for some tokamak plasma impurity ions. It is demonstrated that, in the 10–50keV energy range, the rate of production of $A^{(Z+1)+}$ by the above reaction may become comparable with the electron-A^{Z+} ionisation rate when the ratio of the concentrations of the $B^{(Z+1)+}$ ions and the plasma electrons is of the order of 10^{-1}–10^{-2}.

21595. Bernheim, R. A.; Gold, L. P.; Tipton, T. **Rydberg states of Li_2 and molecular constants of Li_2^+,** *Chem. Phys. Lett.* **92,** No. 1, 13-15 (Oct. 8, 1982).

Key words: ionization; laser spectroscopy; lithium dimer; lithium dimer ion; Li_2; Li_2^+; molecular spectroscopy; Rydberg states.

A Rydberg series of excited electronic states of $^{7}Li_2$ has been characterized by pulsed optical-optical double resonance spectroscopy. Molecular constants of these states have been extrapolated to give the ionization potential of $^{7}Li_2$ and molecular constants of the $X^2\Sigma_g^+$ state of $^{7}Li_2^+$.

21596. Cohen, E. R.; Frommhold, L.; Birnbaum, G. **Analysis of the far infrared H_2–He spectrum,** *J. Chem. Phys.* **77,** No. 10, 4933-4941 (Nov. 15, 1982).

Key words: band shape analysis; collision induced absorption; far infrared; helium; hydrogen; induced dipole models; model line shapes; planetary atmospheres.

Previous measurements of the far infrared absorption due to H_2–He collisions at the temperatures of 77, 195, and 292 K are analyzed. The spectra are fitted by a semiempirical line shape representing the isotropic induced overlap component and combined anisotropic quadrupolar and overlap components. The experimental spectral moments are evaluated and compared with theory for several induced-dipole and potential models. From the isotropic contribution, the range and strength of the induced dipole is evaluated and compared with the results of *ab initio* calculations. fitting parameters are obtained with physically plausible temperature dependences which allow simple and accurate representation of the spectra and of their moments at temperatures different from those of the measurements.

21597. Agarwal, G. S.; Jha, S. S. **Surface-enhanced Raman scattering in a two-oscillator electromagnetic model,** *Phys. Rev. B* **26,** No. 8, 4013-4021 (Oct. 15, 1982).

Key words: Raman scattering; surface enhanced Raman scattering; two-oscillator model.

A two-oscillator model is considered to investigate the effect of a metal substrate of dielectric function $\epsilon(\omega)$ on the Raman scattering from a molecule absorbed on the metal surface. In the presence of the metal and an external electric field, the linear motion of the electronic and ionic oscillators in the molecule get coupled, in general. For obtaining Raman scattering at the Stokes frequency, a phenomenological nonlinear force term, which is bilinear in the oscillator amplitudes, is introduced in the equation of motion. The whole problem is considerably simplified when we use the fact that the ionic mass is much larger than the electronic mass and the ionic vibration frequency is much smaller than the electronic and optical frequencies. It is shown that because of different renormalization factors the frequency dependence of the enhancement factor F, taken to be the ratio of Raman intensity with an without the metal, is quite different from that calculated by using the familiar polarizability-derivative theory. Applying the well-known fluctuation-dissipation theorem, the new Raman line shape is also calculated to contrast it with the corresponding line shape in the absence of the metal.

21598. Agarwal, G. S.; Haan, S. L.; Burnett, K.; Cooper, J. **Photoemission spectra in intense laser field induced autoionization,** *Phys. Rev. A* **26,** No. 4, 2277-2280 (Oct. 1982).

Key words: autoionization; photoemission.

Photoemission spectra from autoionizing states in the presence of a strong laser field are calculated. Such spectra have very sharp features near "confluence" (at the Fano minimum) and are very similar, in structure, to photoelectron spectra. The total intensity, as a function of laser intensity or detuning, has a peak near confluence, which can be used, among other things, for the accurate determination of Fano asymmetry parameter q.

21599. Zumberge, M. A.; Rinker, R. L.; Faller, J. E. **A portable apparatus for absolute measurements of the Earth's gravity,** *Metrologia* **18,** 145-152 (1982).

Key words: absolute gravity; acceleration of gravity; constants; geophysics; gravity.

We have developed a new and portable apparatus for making absolute measurements of the acceleration due to the Earth's gravity. We use the method of free fall, and interferometrically determine the acceleration of a freely falling cube corner. In the design and development of this instrument, particular attention was paid to those aspects which would affect its performance in the field. The resulting instrument, we believe, provides a viable new tool for the study of tectonic motions. The system is very small; it can be transported in a small van and requires only two hours for assembly. A high rate of data acquisition is available; if necessary, a single measurement can be made every two seconds. Further, we have made a concerted effort

to detect and (we hope) eliminate systematic errors. The results of extensive tests indicate that the achievable accuracy for g is about six parts in 10^9. This instrument therefore provides a sensitivity to vertical motions (e.g., of the Earth's crust) as small as 2 cm.

21600. Bryant, G. W.; Glick, A. J. **Impurity states in doped *trans*-polyacetylene,** *Phys. Rev. B* **26,** No. 10, 5855-5866 (Nov. 15, 1982).

Key words: doped; impurity states; kink; one-dimensional; optical absorption; polaron; polyacetylene.

We assess the importance of the impurity states of a doped *trans*-polyacetylene chain. The impurity potential is modeled by a point charge that is located off the chain and is screened phenomenologically. The common assumption that the dopant levels of a dimerized chain closely approximate the hydrogenic levels of a point charge is invalid if the impurity is not on the chain, even if the dopant is screened by the bulk dielectric constant. Additional nonhydrogenic states occur well into the gap. The formation energies for charged kink and polaron lattice distortions are found by solving the Su-Schrieffer-Heeger model for polyacetylene with an impurity added. The impurity states severely alter the structure and states of kink and polaron distortions. Moreover, the modifications depend sensitively on the form of the dopant potential. For the dopant screened isotropically by the bulk dielectric constant, the kink distortion has gap states inconsistent with the observed midgap optical absorption. In contrast, the polaron distortion is both stable and predicts a consistent optical threshold. The nature of doping polyacetylene will remain unclear until a realistic model for the dopant and its interaction with polyacetylene has been developed.

21601. Girvin, S. M.; Jonson, M. **Inversion layer thermopower in high magnetic field,** *J. Phys. C: Solid State Phys.* **15,** L1147-L1151 (1982).

Key words: inversion layer; Landau level; quantum Hall effect; thermoelectric effect.

We calculate the thermopower of an ideal two-dimensional electron gas (inversion layer) in a quantising magnetic field. We find that the thermopower is a universal function of the reduced temperature ($k_B T/\hbar\omega_c$) which has a novel dependence on the chemical potential.

21602. Kessler, E. G., Jr.; Deslattes, R. D.; Girard, D.; Schwitz, W.; Jacobs, L.; Renner, O. **Mid-to-high-Z precision x-ray measurements,** *Phys. Rev. A* **26,** No. 5, 2696-2706 (Nov. 1982).

Key words: crystal diffraction; high atomic number; line widths; theoretical calculations; wavelengths; x ray.

New x-ray wavelength (energy) and width measurements are reported for a number of elements from $47 \leqslant Z \leqslant 92$. The x rays were produced with the use of an electron Van de Graaff, and the measurements were made with a two-axis flat-crystal transmission spectrometer equipped with angle-mesuring interferometers. The new measurements reported here, combined with other high-precision x-ray wavelengths, form a moderately extensive data base for comparison with theoretical calculations. Comparison with recent revisions of a previously available all-Z calculation reveals improved patterns of general agreement with, however, important exceptions. The newly measured linewidths are in agreement with widths calculated via relativistic wave functions used for the term estimates.

21603. Marx, E. **Single integral equation for wave scattering,** *J. Math. Phys.* **23,** No. 6, 1057-1065 (June 1982).

Key words: distributions; Green's functions; integral equations; Maxwell's equations; scalar wave equation; wave scattering.

When a wave interacts with an obstacle, the scattered and transmitted fields can be found by solving a system of integral equations for two unknown fields defined on the surface of the body. By choosing a more appropriate unknown function, the system of equations is reduced to a single singular integral equation of the first kind. This reduction is done here for transient and monochromatic waves, for a scalar field that obeys the wave equation, and for electromagnetic fields that obey Maxwell's equations.

21604. Burnett, E. D.; Corliss, E. L. R.; Nedzelnitsky, V. **Research problems in coupler and *in situ* measurements on hearing aids,** Paper in *The Vanderbilt Hearing-Aid Report,* pp. 67-73 (Monographs in Contemporary Audiology, 6796 Market Street, Upper Darby, PA, 19082, Dec. 1982).

Key words: amplification, hearing aid; coherence; compression, hearing aids; cross-spectrum; diffraction, head; directional hearing aids; effective signal-to-noise ratio; feedback acoustic; hearing aid measurements; insertion gain; nonlinear distortion.

In conventional tests of hearing aids, the primary measurement is gain in sound-pressure level, measured as the difference between the sound level in an earphone coupler at the output of the hearing aid and the sound level originally present in the sound field. More recent methods determine the "insertion gain" as the difference between the sound level actually produced at a specified point in the ear of a reference manikin fitted with the hearing aid and the sound pressure that would be present at the same location if the hearing aid were absent. Although this gain is taken as the fundamental measurement and represents a significant improvement over earlier methods, it is somewhat idealized. In general, the variations in this gain due to differences between a user's ear and the manikin simulator used in testing as well as the effect of incipient feedback are known only roughly. The clinical significance of these variations due to differences between test and use conditions is at best only partially understood. Moreover, the incident sound field is a considerable simplification of the conditions in which the listener will want to use his hearing aid. Most tests are made with steady-state sinusoidal signals in the free field, although the listener needs his hearing aid to understand speech, usually in semi-reverberant environments. This paper discusses experimental developments, partially achieved, to make the objective measurements on hearing aids more closely resemble the conditions under which hearing aids are used.

21605. Pontius, P. E.; Mitchell, R. A. **Inherent problems in force measurement,** *Exp. Mech.* **22,** No. 3, 81-88 (Mar. 1982).

Key words: creep; deadweight machine; force; force calibration; force measurement; hysteresis; load cell; machine-sensor interaction; proving ring; thermoelastic effect.

A force sensor is ordinarily used as a part of a larger system such as a testing machine, test stand, weighing system or process-control system. When a force sensor is calibrated in a standards laboratory and then installed and used in a different system, there may be a significant shift in sensor response due to differences in many factors such as machine-sensor mechanical interaction, loading sequence, loading rate and environmental conditions. NBS research is directed toward establishing the magnitude of the errors due to these factors and developing methods for controlling these errors. Some initial results in the study of machine-sensor interaction, hysteresis, thermoelastic effect and creep are discussed here. A long range objective is to enable users to make informed judgments about the adequacy of their own force measurements, based on an understanding of their own measurement process rather than a routine calibration at a standards laboratory.

21606. Birnbaum, G. **The study of atomic and molecular interactions from collision-induced spectra.** *Proc. Eighth Symp. Thermophysical Properties, National Bureau of Standards, Washington, DC, June 15-18, 1981,* pp. 8-17 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1982).

Key words: atomic and molecular interactions; collision-induced spectra; infrared; Rayleigh scattering; thermophysical properties.

It is shown how the analysis of collision-induced phenomena, in particular, far infrared absorption and depolarized light scattering, may be used to obtain information about intermolecular interactions. The basic analytical methods use spectral moments and molecular band shapes, and accurate quantum mechanical calculations of translational bands. These methods may be used tc evaluate multipole moments, estimate diffusion coefficients and test potential functions.

21607. Giarratano, P. J.; Lloyd, F. L.; Mullen, L. O.; Chen, G. B. **A thin platinum film for transient heat transfer studies,** (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry,* J. F. Schooley, ed., V, 859-863 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: platinum thermometer-heater; thin film sensor; transient measurements.

This paper describes the construction and performance of a platinum film (37 mm×8 mm×18 nm) which is used simultaneously as a heater surface and thermometer for transient heat transfer studies. Nominal resistance ranges from 25 Ω at room temperature to 10 Ω at liquid nitrogen temperature. Typical resistance versus temperature from 75.7 to 293 K, stability, and time response of the film are presented. A description of a transient method for determining the thermal conductivity of the quartz substrate is also included in the discussion.

21608. Linenberger, D.; Spellicy, E.; Radebaugh, R. **Thermal response times of some cryogenic thermometers,** (Proc. Sixth Int. Symp. Temperature, Washington, DC, Mar. 15-18, 1982), Paper in *Temperature—Its Measurement and Control in Science and Industry,* J. F. Schooley, ed., V, 1367-1372 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: carbon resistance thermometers; germanium thermomneters; low temperature thermometry; response times; silicon diode thermometry; silicon-on-sapphire thermometry.

The measurement of time-varying temperatures requires sensors with sufficiently fast response times. As an aid to the selection of a satisfactory thermometer, this paper describes the measurement of the thermal time constants of several cryogenic thermometers. The thermal time constants were measured by observing the response of the thermometers to self-heating induced by the injection of a constant current step. Temperatures studied were 4, 77, and 295 K. Measurements were made in both the gas and liquid phases of helium and nitrogen in order to determine the upper and lower limits of the time constants. Specific thermometers investigated include a germanium resistance thermometer, carbon resistors, diodes, and a silicon-on-sapphire resistance device (area $\sim$0.35 mm^2). In several cases the measurements are compared with the calculated values of the time constants.

21609. Hamilton, C. A. **High-speed, low-crosstalk chip holder for Josephson integrated circuits,** *IEEE Trans. Instrum. Meas.* **IM-31,** No. 2, 129-131 (June 1982).

Key words: chip holder; contact array; cryogenic; Josephson integrated circuit.

This paper describes the construction and performance of a compact chip mount for making multiple, high-speed, low-crosstalk contacts to a Josephson integrated circuit. The mount has a rise time of about 32 ps and worst case crosstalk between lines of -33 dB.

21610. Bowen, R. L.; Cobb, E. N.; Setz, L. E. **Adhesive bonding to dentin and enamel,** *Dentistry* **82,** 11-13 (Dec. 1982).

Key words: adhesion; bonding; composites; coupling agent; dentin; enamel; polymer; resin.

A new method for preparing dentin and enamel surfaces to bond to hardening composite resins resulted in average tensile bond strengths of about one ton (2,000 pounds) per square inch. Fractures occurred not only in the interfacial region but also in the composite material and occasionally in the dentin of the extracted tooth.

21611. Yeh, T. T.; Robertson, B.; Mattar, W. M. **LDV measurements near a vortex shedding strut mounted in a pipe,** (Proc. Winter Annu. Meet. Am. Soc. Mechanical Engineers, Phoenix, AZ, Nov. 14-19, 1982), Paper in *Engineering Applications of Laser Velocimetry,* pp. 193-202 (The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, Nov. 1982).

Key words: fluid velocity; laser Doppler velocimeter; vortex shedding; wake.

The velocity field around a vortex shedding strut mounted in a circular pipe has been measured in detail with a laser Doppler velocimeter (LDV) at a pipe Reynolds number equal to 90,000. The instantaneous velocity is decomposed into mean, periodic, and random components. Only the first two harmonics are large enough to be detected; the large-scale structure can be characterized by just these two terms and the mean. Profiles of the different velocity terms are given upstream of, downstream of, and close to the strut. The two-dimensional velocity vector field of the mean flow on the transverse diametral plane of symmetry is presented along with its streamlines. Finally, profiles of the ratio of the energy of a periodic component to the total kinetic energy in a narrow frequency band are given.

21612. Drullinger, R. E. **Increased gain through identification and alleviation of dye self absorption in laser pumped dye lasers,** *Opt. Commun.* **39,** No. 4, 263-264 (Oct. 15, 1981).

Key words: dye lasers; laser pumping; lasing dye; self absorption; tuning curves.

The effect of overlapping absorption and emission spectra is to shift the gain curve of a dye to the red side of its fluorescence curve and reduce its gain. It is shown how simple binary mixtures of "adjacent" dyes can be used to produce a new gain maximum in the regions between the gain maximum of the single dyes.

21613. Proctor, T. M., Jr. **Some details on the NBS conical transducer,** *J. Acoust. Emiss.* **1,** No. 3, 173-178 (1982).

Key words: acoustic emission; calibration; nondestructive evaluation; secondary standard; sensor; transducer.

We have developed a piezoelectric transducer that responds with a high degree of accuracy to normal surface displacement over the frequency range of 50 kHz to 1 MHz. Although it does have some drawbacks (size and durability), this transducer design has high sensitivity over this band and relative ease of use. If care is taken, the fragility is not a problem. Recent developments on this transducer indicate that the backing size can be reduced to as much as 1/4 of the volume of the backing discussed in this paper without appreciable loss of response quality. We have also found it extremely useful for the purpose of investigating transfer functions in AE work. Its faithful time wave response opens many new avenues for investigation.

21614. Hamilton, C. A.; Lloyd, F. L. **100 GHz binary counter based on DC SQUID's,** *IEEE Electron Device Lett.* **EDL-3,** No. 11, 335-338 (Nov. 1982).

Key words: counter; flux quantum logic; scalar; SQUID.

A binary counter using bistable dc SQUID's as flip flop circuits is demonstrated. All of the functions: LOAD, COUNT, STORE, READ, and CLEAR can be performed. The use of single flux quantum logic results in high sensitivity (10^{-18} J input pulse energy), high speed (100 GHz count rate) and low power (10^{-7} W at 100 GHz count rate).

21615. Mies, F. H.; Julienne, P. S. **The thermodynamic properties of diatomic molecules at elevated temperatures: Role of continuum and metastable states,** *J. Chem. Phys.* **77,** No. 12, 6162-6167 (Dec. 15, 1982).

Key words: continuum states; equation of state; equilibrium constant; Li_2; metastable states; Na_2; phase shifts; predissociation; scattering theory; thermochemistry; virial coefficient.

A complete quantum formulation of diatomic partition functions uses the energy variation of the elastic scattering phase shift to represent the phase space associated with the molecular continuum states. The resonance structure in the phase shift, due to tunneling through rotational barriers, gives a rigorous interpretation of the metastable states which lie behind the barrier, and we can justify the need to include such states in the evaluation of thermodynamic properties. However, we also find that it is inconsistent merely to include the metastable phase space without considering the remaining contributions from the continuum. If either component is ignored in treating the dimer, then, of necessity, their presence will appear as the virial coefficients which cause nonideal behavior for the atomic fragments of the molecule. Both approaches are consistent and yield a proper equation of state for the vapor. We will show quantitative agreement between the exact quantal results and the approximate classical expressions for the partition function at high temperatures. Since the classical theory automatically includes all the effects of the molecular continuum, we suggest that this is both the simplest and most unambiguous procedure for extending thermodynamic tables to elevated temperatures. Explicit calculations are presented for Li_2 and

Na_2.

21616. Bernheim, R. A.; Gold, L. P.; Tipton, T. **Pulsed optical-optical double resonance spectroscopy of the *gerade* excited states of $^7Li_2$,** *Proc. Int. Conf. Lasers '81, New Orleans, LA, Dec. 14-18, 1981,* pp. 193-198 (Society of Optical and Quantum Electronics, McLean, VA, 1982).

Key words: laser spectroscopy; lithium dimer; molecular spectroscopy; multiphoton spectroscopy; optical-optical double resonance.

The technique of pulsed optical-optical double resonance spectroscopy is described. The results of studies on the $E^1\Sigma_g^+$, $F^1\Sigma_g^+$ and $G^1\Pi_g$ states are reviewed. The spectroscopic studies yield good descriptions of the lower 60% of the potential wells for the F and G states, and there is evidence for a double minimum in the E state. A $^1\Pi_g$ Rydberg series was studied which gives a value of 41496 ± 4 cm^{-1} for the ionization potential of $^7Li_2$ and molecular constants of $D_e=10463\pm23$ cm^{-1}, $\omega_e=261.6$ cm^{-1}, $B_e=0.493$ cm^{-1}, and $\omega_e x_e=1.6$ cm^{-1} for the $X^2\Sigma_g^+$ state of $^7Li_2^+$.

21617. Lew, H. S.; Carino, N. J.; Fattal, S. G. **Cause of the condominium collapse in Cocoa Beach, Florida,** *Concr. Int.* **4,** No. 8, 64-73 (Aug. 1982).

Key words: buildings; concrete construction; failure; flat concrete plates; punching shear; shear strength; strength analysis; structural analysis.

This paper gives the results of an investigation into the collapse of a five-story, flat-plate condominium building in Cocoa Beach, Fla. The collapse occurred on March 27, 1981, while the casting of the roof slab was in progress. Eleven workers were killed and 23 were injured. The investigators conducted on-site inspections, made laboratory tests, and made analytical studies. It was concluded that the most probable cause of the collapse was inadequate punching shear capacity in the fifth-floor slab to resist the imposed construction loads. The analysis indicated that punching shear stresses at many slab/column connections were close to the ultimate capacity specified by the Code, (ACI 318-77). Consequently, it was concluded that a punching shear failure at a heavily stressed location triggered a succession of failures at other locations, resulting in the downward collapse of the entire structure.

21618. Ellingwood, B. **Safety checking formats for limit states design,** *J. Struct. Div. Soc. Am. Civ. Eng. Tech. Note* **108,** No. ST7, 1481-1493 (July 1982).

Key words: buildings (codes); design (structures); concrete; limit states; loads; masonry; probability theory; reliability; specifications; standards; steel; strength designs; structural engineering; timber.

The growing need for a unified approach to structural design for different construction materials and technologies is met by the limit states design approach. Several standards-writing committees currently are considering how best to implement practical limit states design criteria. This paper examines the relative advantages of several approaches proposed for this purpose, with regard to their ability to provide desired levels of reliability for all probable design situations. The choice of an appropriate approach is found to depend on fundamental characteristics of structural behavior, and thus might not be the same for different construction materials.

21619. Beers, J. S.; Lee, K. B. **Interferometric measurement of length scales at the National Bureau of Standards,** *Precis. Eng.* **4,** No. 4, 205-214 (Oct. 1982).

Key words: automation; calibration; interferometry; length scales; measurement assurance; measurement uncertainty.

The interferometric comparator for calibrating graduated length scales at the National Bureau of Standards is described. Its origins and early development are traced, and recent modernization and automation are detailed. A measurement assurance program is used to evaluate precision, accuracy and long term performance.

21620. Carino, N. J. **Application of maturity concept to form removal and reshoring schedule,** *Proc. Int. Conf. Forming Economical Concrete Buildings, Lincolnshire (Chicago), IL, Nov. 8-10, 1982,* pp. 8.1-8.19 (Portland Cement Association, Skokie, IL, 1982).

Key words: concrete; compressive strength; curing temperature; formwork; hydration; maturity; mortar; scheduling; temperature effects.

A brief account of the historical development of the maturity concept is presented. This is followed by a derivation to illustrate the basis of the maturity concept. It is shown that the commonly used Saul-maturity function is, at best, an approximation of the combined effects of temperature and time on strength development of concrete. However, the accuracy can be improved by using the correct value of the datum temperature. Finally, examples are presented to illustrate the application of the maturity concept in construction practice.

21621. Ellingwood, B. **Wind and snow load statistics for probabilistic design,** *J. Struct. Div. Soc. Am. Civ. Eng. Tech. Notes* **107,** No. ST7, 1345-1350 (July 1981).

Key words: buildings (codes); design (buildings); loads (forces); probability theory; reliability; standards; statistical analysis; structural engineering.

Structural reliability analyses and probability-based limit states design require statistical descriptions of structural load and load effect variables. Frequently, data are only available for the basic variables (e.g., wind speed, ground snow load, etc.) from which the loads are calculated through mathematical relationships. While early first-order, second-moment reliability analyses required only estimates of means and variances in the basic variables, more recent methods utilize the probability distributions also. In this note, suitable probability distributions and statistical parameters for wind and snow loads are derived using recent statistical data. These distributions have been used to develop a set of tentative load factors for possible use in a future edition of the A58 Standard.

21622. Ellingwood, B. **Analysis of reliability for masonry structures,** *J. Struct. Div. Soc. Am. Civ. Eng. Tech. Notes* **107,** No. ST5, 757-773 (May 1981).

Key words: brick masonry; buildings (codes); concrete masonry; design; limit states design; loads (forces); probability theory; reliability; statistical analysis; structural engineering.

Strength design and the use of loading criteria based on probabilistic limit states design principles are relatively new concepts in the masonry area. However, these procedures afford a number of advantages for design. Implementation of these concepts requires an assessment of statistical data on masonry strength, the establishment of appropriate measures of reliability for design, and the development of safety factors to be applied to material and load variables. Available strength data on brick and concrete masonry construction are summarized and a few reliability calculations are made to show how masonry compares with other engineered construction materials.

21623. Ellingwood, B. **Reliability of wood structural elements,** *J. Struct. Div. Am. Soc. Civ. Eng. Tech. Notes* **107,** No. ST1, 73-87 (Jan. 1981).

Key words: buildings (codes); limit states design; probability theory; reliability; standards; statistical analysis; structural engineering; timber construction.

Recent trends in development of standards for design have been toward the use of probabilistic limit states concepts. The development of such criteria requires that a large amount of data be examined by the appropriate standards writing organizations. This paper describes basic statistical information that currently is available for developing probability based limit states design criteria for timber structures. A number of problem areas are discussed where additional study appears necessary or desirable prior to implementing such criteria practice.

21624. Ellingwood, B.; MacGregor, J. G.; Galambos, T. V.; Cornell, C. A. **Probability based load criteria: Load factors and load combinations,** *J. Struct. Div. Am. Soc. Civ. Eng. Tech. Notes* **108,** No. ST5, 978-997 (May 1982).

Key words: buildings (codes); design (buildings); limit states; loads (forces); probability theory; reliability; safety; specifications; standards; structural engineering.

This is the second of two papers that describe a study conducted to develop probability-based load factors and load combinations suitable for use with common construction materials and technologies. In the second phase of the study, described in this paper, the checking equation format for the proposed load criteria was selected, and the load factors and load combinations were computed using a constrained optimization procedure. Comparisons of reliabilities obtained using the proposed procedure with existing criteria are made. Guidance is provided for material specification-writing groups to enable them to select compatible resistance criteria without further numerical computations.

21625. Carino, N. J. **Maturity functions for concrete,** *Proc. Int. Conf. Concrete at Early Ages, Paris, France, Apr. 6-8, 1982,* pp. 123-128 (Ecole Nationale Des Ponts et Chaussees, Paris, France, 1982).

Key words: concrete; curing temperature; hydration; inplace testing; maturity; mortar; strength.

This paper deals with the characteristics of a temperature-time function to account for the combined effects of temperature and time on the strength development of concrete. Starting with a differential equation to describe the rate of strength gain under isothermal curing conditions, it is shown that the product of age and the rate constant is the sought after function. Assuming a linear variation of the rate constant with temperature results in a temperature-time function identical to the traditional Saul-maturity-function. By using the Arrhenius equation to represent the variation of rate constant with temperature, a function, called "effective age," is proposed which better describes the effects of temperature and time on strength development for isothermal curing.

21626. Behrens, J. W. **Inferred ^{238}Pu(n,f) cross section in the MeV range,** *Trans. Am. Nucl. Soc.* **43,** 722-723 (Nov. 1982).

Key words: inference method; MeV energy range; neutron-induced reaction; ^{238}Pu(n,f) cross section.

During the past decade, considerable effort has been spent in extending the measurements of fission cross sections of the transactinides in the MeV range. Accurately measured data now exist for 14 nuclides (^{232}Th, ^{233,234,235,236,238}U, ^{237}Np, ^{239,240,241,242,244}Pu, and ^{241,243}Am). These data form a basis set that is sufficiently large to justify an attempt to infer fission cross sections for unmeasured nuclei from the systematics of the fission cross sections of neighboring nuclei. This approach is particularly useful in obtaining fission cross sections for the many short-lived nuclides ($t_{1/2}<90$ years) that are currently difficult, if not impossible, to measure.

21627. Ellingwood, B. R.; Reinhold, T. A. **Reliability analysis of steel beam-columns,** *J. Struct. Div. Am. Soc. Civ. Eng. Tech. Notes* **106,** No. ST12, 2560-2564 (Dec. 1980).

Key words: beams; buildings (codes); columns; limit states design; probability theory; reliability; steels; structural engineering.

Probabilistic analyses of the safety of structural members frequently have relied on a formulation of the ultimate limit state equation in which load carrying capacity (resistance) is measured by a single variable R, such as the fully plastic moment for a beam (1,3,5). Safety or reliability is defined by the condition where the effects of the applied loads do not exceed resistance R. However, there is a feeling that alternate formulations in terms of the basic variables that determine resistance, e.g., yield stress, section modulus, etc., may be more desirable in certain instances. This note compares measures of reliability calculated from the R-variable and basic variables formulations of the safety problem for hot-rolled steel beam-columns subjected to dead and live loads and considers some of the implications for reliability based design.

21628. Nyyssonen, D. **Calibration of optical systems for linewidth measurements on wafers,** *Opt. Eng.* **21,** No. 5, 882-887 (Sept./Oct. 1982).

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 dependent, 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.

21629. Salomone, L. A. **Improving geotechnical investigations for underground transmission lines,** (Proc. Symp. Underground Cable Thermal Backfill, Toronto, Ontario, Canada, Sept. 17-18, 1981), Chapter 3 in *Underground Cable Thermal Backfill,* pp. 57-71 (Pergamon Press Canada Ltd., Suite 104, 150 Consumers Rd., Willowdale, Ontario, Canada M2J1P9, 1982).

Key words: design; soil mechanics; thermal conductivity; thermal resistivity; transmission lines.

An evaluation of the thermal properties of the soils that surround underground transmission lines is an important part of existing design procedures for underground power cables. Geotechnical investigations consisting of in-situ and laboratory thermal probe tests, soil sampling and determinations of moisture and density are frequently performed to evaluate the thermal resistivity of soils encountered along proposed transmission line routes. These investigations often are based on routine procedures adopted over the years but not necessarily reflecting all the information and techniques now available in the fields of agronomy and geotechnical engineering.

The paper demonstrates how information and techniques used by agronomists and geotechnical engineers can be correlated and then used to improve our capability of predicting in-situ thermal soil properties. Also, suggestions for improving existing procedures for evaluating the thermal resistivity of soils are provided.

21630. Dehmer, J. L.; Parr, A. C.; Wallace, S.; Dill, D. **Photoelectron branching ratios and angular distributions for the valence levels of SF_6 in the range $16 \leqslant h\nu \leqslant 30$ eV,** *Phys. Rev. A* **26,** No. 6, 3283-3292 (Dec. 1982).

Key words: angular distribution; branching ratios; photoelectron spectra; photoionization; resonance.

Photoelectron branching ratios and angular distributions have been measured for the six outermost levels of SF_6 in the range $16 \leqslant h\nu \leqslant 30$ eV with the use of synchrotron radiation. These results are discussed in the framework of the large variety of experimental and theoretical studies of SF_6 with the dual objective of resolving the long-standing problem of the ordering of the valence shells and of gaining some insight into the role of shape-resonant behavior in the low-energy photoionization continua of SF_6. These objectives are met with partial success in that we tentatively conclude the valence configuration $5a_{1g}^2$ $4t_{1u}^6$ $1t_{2g}^6$ $3e_g^4$ $(t_{2u}^6+5t_{1u}^6)$ $1t_{1g}^6$ $^1A_{1g}$ is most consistent with the available body of evidence and that it is plausible to invoke channel interaction near the strong resonant feature at $h\nu \sim 23$–24 eV to help account for some of the apparently contradictory evidence. Further experimental and theoretical work is suggested to clarify these issues.

21631. Rhyne, J. J.; Koon, N. C. **Ground state spin excitations in $HoAl_2$,** *J. Appl. Phys.* **53,** No. 11, 8354-8356 (Nov. 1982).

Key words: crystal fields; Laves-phase compounds; magnetism; neutron scattering; rare earth compounds; spin waves.

Inelastic neutron scattering has been used to examine the spin waves in a single crystal of the cubic Laves-phase compound $HoAl_2$, which orders at a $T_c=28$ K. Three pairs of acoustic (in-phase spin precession) and optic (out-of-phase precession) modes were observed in their respective Brillouin zones centered at (220) and (002). Due to

the weak Ho–Ho exchange all modes show relatively little dispersion (e.g., the lowest acoustic mode which exhibits a band width of 1.5 meV and a q=0 gap of 1.4 meV). Measurements were made at 4 K for spin waves propagating in three directions [q,q,0], [q,0,0], and [q,q,q]. The spectra showed significant anisotropy in the second half of each zone. The observed inelastic scattering modes have been analyzed using an RPA pseudo-boson formalism with crystal field and exchange parameters consistent with those found for other RAl_2 compounds.

21632. Hecht, H.; Houghton, R. C., Jr. **The current status of software tool usage,** *Proc. COMPSAC 82, Chicago, IL, Nov. 8-12, 1982,* pp. 1-8 (IEEE Computer Society, P.O. Box 80452, Worldway Postal Center, Los Angeles, CA 90009, Nov. 1982).

Key words: software development; software management; software productivity; software quality; software tools.

As part of its efforts to improve productivity and quality of software procured by the Government, the National Bureau of Standards initiated a survey of software development organizations on their use of tools. Partial findings reported here indicate that (1) tool usage increases with the size of the organization, (2) software tool developers, regardless of size, are intense users of tools, not just their own, and (3) there is no pronounced difference in tool usage between organizations of similar size in the private sector, in Government support organizations, and Government agencies. Tool features utilized, and user reaction to tools, are also described.

21633. Rust, B. W.; Kirk, B. L. **Modulation of fossil fuel production by global temperature variations,** *Environ. Int.* **7,** No. 6, 419-422 (1982).

Key words: atmospheric pollution; carbon dioxide problem; fossil fuel production; global temperature.

An analysis of the fossil fuel production record since 1860 shows that the exponential growth in production is modulated in the inverse sense by variations in global average temperature. Taking this modulation into account shows that the underlying rate of increase is about 25% less than the widely quoted 4.3% annual rate. This modulation may also produce a partially ameliorating feedback if the often predicted carbon dioxide greenhouse effect actually materializes.

21634. Ayres, T. R.; Simon, T.; Linsky, J. L. **Evolution of chromospheres and coronae in solar mass stars: A far ultraviolet and soft x-ray comparison of Arcturus (K2 III) and alpha Centauri A (G2 V),** *Astrophys. J.* **263,** No. 2, 791-802 (Dec. 15, 1982).

Key words: late-type stars; stellar chromospheres; stellar coronae; stellar evolution; ultraviolet spectra; x-ray sources.

We compare *IUE* far-ultraviolet and *Einstein* soft X-ray observations of the red giant Arcturus (α Boötis, K2 III) and the nearby yellow dwarf α Centauri A (G2 V), which are archetypes of solar mass stars in very different stages of evolution. We find no evidence for coronal ($T \approx 10^6$ K) soft X-ray emission from the red giant at surface flux levels of only 0.0006 (3σ) that detected previously for α Cen A, and no evidence for C IV λλ1548, 1551 ($T \approx 10^5$ K) or C II λλ1335, 1336 ($T \approx 2 \times 10^4$ K) resonance line emission at surface flux levels of only 0.02 (3σ) those of the yellow dwarf. Instead of a solar-like hot corona and warm ($T \approx 10^5$ K) transition region, the resonance line upper limits and previous detections of the C II *intersystem* UV multiplet 0.01 near 2325 Å provide evidence that the outer atmosphere of Arcturus is geometrically extended ($\Delta h \sim R_*$), tenuous ($n_e \approx 3 \times 10^8$ cm^{-3}), and cool ($T \lesssim 10^4$ K).

A second important difference between Arcturus and α Cen A is the prominent cool stellar wind of the red giant. The terminal velocity inferred from the blueshifted absorption components in the O I and Mg II resonance lines is $v_\infty = 40$–50 km s^{-1}, the estimated mass loss rate is $\gtrsim 3 \times 10^{-10}\ M_\odot$ yr^{-1}, and the angular momentum loss is at least four orders of magnitude larger than that of the weak coronal wind of the Sun. The rapid spin-down of a post-main-sequence solar mass star, owing initially to evolutionary expansion and later to the development of a strong wind, is likely to severely inhibit the generation and amplification of magnetic fields by the dynamo mechanism. The decline in magnetic activity with evolution into the giant branch may account for the extraordinary weakness of Arcturus in X-rays compared with α Cen A, since hot coronae are likely to be associated with strong surface magnetic fields.

Finally, we provide an extensive tabulation of line identifications, widths, and fluxes for the *IUE* far-ultraviolet echelle spectra of the two stars; we discuss the two competing explanations for the Wilson-Bappu effect; and we illustrate the "missing line" phenomenon in the Arcturus high-dispersion spectrum, which quite likely is produced by fluoresced carbon monoxide bands.

21635. Bartel, T. W.; Yaniv, S. L. **Curvature of sound decays in partially reverberant rooms,** *J. Acoust. Soc. Am.* **72,** No. 6, 1838-1844 (Dec. 1982).

Key words: architectural acoustics; decay rate; ensemble averaging; reverberant sound field; reverberation room; sound absorption.

Measurements were conducted to investigate the departure from linearity of sound decays in partially reverberant rooms—that is, rooms, such as are found in office buildings and residences, that are less reverberant than laboratory reverberation chambers. The extent to which the nonlinearities in the decay curves could be reduced by means of an ensemble-averaging procedure was determined. Decay curves for five partially reverberant rooms, ranging in size from 45 to 425 m^3, were tape recorded and played back at reduced speed into a real-time analyzer. Decay measurements were also performed in the NBS 425-m^3 reverberation chamber. It was found that "smooth" decay curves, displaying a curvature characterized by a monotonically decreasing decay rate, could be obtained provided that the ensemble averages included decays recorded at several source and receiver locations. Thus, the rate of decay at any point in time for partially reverberant rooms could be precisely and unambiguously determined. The magnitude of the curvature was such that the percentage difference between the early decay rate and the decay rate averaged over a 25-dB range varied from approximately 2% to 40%, with the greatest differences occurring in rooms containing an absorptive ceiling and floor or an opening connecting them to other rooms.

21636. Bennett, L. H.; Watson, R. E. **Atomic volumes in transition metal-metalloid crystalline and glassy alloys,** *Scr. Metall.* **16,** 1379-1382 (1982).

Key words: amorphous metals; atomic volumes; glassy alloys; metalloids; transition metals.

The metalloid volume in transition metal rich-metalloid compounds is found to be roughly constant with a value close to that which can be inferred from the 12-fold bonding radii. This holds for "proper"-sized elements such as P and for the small interstitials B, C, and N. Volume contractions associated with charge transfer occur when elements from the Sc and Ti columns are involved and a break in bonding behavior, hence in volume effects, occur on going from the transition to the noble metals.

21637. Gaigalas, A. K.; Robertson, B. **Time dependence of pressure in a bubbler tube,** *AIChE J.* **28,** No. 6, 922-929 (Nov. 1982).

Key words: accuracy of pressure measurement; bubble growth and shape effects; bubbler tube; pressure measurement; pressure oscillations; virtual mass.

An experimental and theoretical study is presented of the time dependence of air pressure in a bubbler tube used to measure the liquid level in a tank. The observed time dependence of the air pressure is a superposition of two components. The first component is a repeated slow rise and sudden fall in the air pressure that is associated with bubble growth and breakoff. It is the sudden breakoff that generates the second component consisting of damped oscillations associated with sound waves in the air interacting with an oscillating flow of the liquid. The air pressure during bubble growth is described theoretically. This result is combined with the gas law to predict the functional form of the slow pressure rise; this prediction agrees with experiment. An equation for the oscillation frequencies is derived, solved, and compared with experiment; agreement is within the measurement accuracy of 5%.

21638. Gary, D. E.; Linsky, J. L.; Dulk, G. A. **An unusual microwave flare with 56 second oscillations on the M dwarf L726-8 A,** *Astrophys. J.* **263,** No. 2, L79-L83 (Dec. 15, 1982).

Key words: radio sources, variable; stars, coronae; stars, flare; stars, late-type; stars, radio radiation; Sun, radio radiation.

Using the VLA, we have observed an unusual flare event on L726-8 A (dM5.5e), the primary star in the M dwarf system containing the prototype flare star UV Cet. This flare had a peak flux of 8 mJy at 6 cm and a corresponding brightness temperature $\gtrsim 10^{10}$ K, was almost entirely right-hand circularly polarized, showed large flux variations on the 10 s time resolution of the VLA, and exhibited quasi-periodic oscillations with a period of about 56 ± 5 s. While periodic flux variations have been detected during solar flares and RS CVn type stellar flares, this is the first detection to our knowledge of periodicity in microwaves from M dwarf stars. We propose that the observed radiation was due to maser action, probably an electron-cyclotron maser, and that the energy release mechanism was modulated.

21639. Halbritter, J. **On conditioning: Reduction of secondary- and rf-field emission by electron, photon, or helium impact,** *J. Appl. Phys.* **53,** No. 9, 6475-6478 (Sept. 1982).

Key words: electron damage; electron impact; field-electron emission; rf conditioning; secondary electron emission.

Rf conditioning is a well known procedure by which the electron emission in rf cavities is reduced, thereby permitting the attainment of higher field strengths. The reduction of electron emission in rf conditioning is explained by electron, photon, or He impact, which causes hydrocarbon adsorption and dehydrogenation and polymerization of adsorbed hydrocarbons. These newly formed radiation-resistant compounds show strong inelastic scattering for slow electrons, which greatly reduces the secondary emission and field emission out of excited states (rf-field emission).

21640. Thomson, R. M.; Fuller, E. R., Jr. **Dislocation shielding of a crack in a quasi continuum approximation,** *Proc. Symp. Micro and Macro Mechanics of Crack Growth, Louisville, KY, Oct. 13-15, 1981,* K. Sadananda, B. B. Rath, and D. J. Michel, eds., pp. 49-59 (The Metallurgical Society of AIME, 1982).

Key words: brittle crack; dislocation shielding; elastic enclave; fracture.

Earlier predictions of toughness by Thomson and Weertman are reviewed. The differing predictions of the two authors are shown to be due to different interpretations of the functional dependence of the size of the elastic region on intrinsic surface energy. An analysis of the quasi continuum model in terms of dislocation rearrangements is given, and the nature of the boundary condition on the elastic enclave boundary is discussed.

21641. Davidson, R. M.; Margolis, S. A.; White V, E.; Coxon, B.; Oppenheimer, N. J. **A new, facile synthesis of 2-amino-(pento- and hexo-furano)oxazoline derivatives,** *Carbohydr. Res.* **111,** C16-C19 (1983).

Key words: derivatives; glycofuranosyl; synthesis; 2″-amino oxazoline; ^{15}N-n.m.r.

We have developed a new, facile synthesis of pento- and hexo-furanosyl 2″-amino oxazoline derivatives including examples in the *D*-ribose, *D*-arabinose, *D*-xylose, *D*-glucose, and *L*-sorbose series. This new procedure has been used to introduce ^{15}N-labels into these derivatives. Our results show a quantitative incorporation of *both* ^{15}N-labels from cyanamide-$^{15}N_2$ into the glycofuranosyl 2″-amino oxazoline derivatives. The retention of both lables from the cyanamide-$^{15}N_2$ indicates that the original nitrogen atom of the glycosylamine was lost. These doubly $^{15}N_2$-labeled derivatives have all been studied by proton, ^{13}C- and ^{15}N-n.m.r. at 400 MHz and also by mass spectrometry.

21642. Stockbauer, R.; Hanson, D. M.; Flodström, S. A.; Bertel, E.; Madey, T. E. **Photon stimulated desorption of ions: A new probe of surface bonding and structure,** *Int. J. Mass Spectrom. Ion Phys.* **47,** 51-54 (1983).

Key words: carbon monoxide; cyclohexane; electron stimulated desorption; methanol; niobium; photon stimulated desorption; ruthenium; time-of-flight mass spectrometry; titanium; tungsten; water.

A brief review is given of some of the work at the National Bureau of Standards using photon stimulated desorption of ions from adsorbed molecules. Ion desorption mechanisms for ionically and covalently bonded absorbates are discussed. Selected results are presented for 0 on Ti(001), Nb(001) and W(111), CO on Ru(001), and H_2O, CH_3OH and C_6H_{12} on Ti(001).

21643. Robertson, A. F. **Development of an improved radiant heat source for fire testing,** *Fire Mater.* **6,** No. 2, 68-71 (1982).

Key words: burners; fire tests; heat source.

The development, construction, and testing of a gas-fired radiant heat source for use as part of a fire test method is described. The unit has been shown capable of operation over extended periods at surface temperatures yielding radiance corresponding to that of a black body at 935°C. This permits a 60% increase of specimen irradiance over that possible with a burner previously used, without modifying the specimen-burner configuration factor. One such application of this burner allows operation with specimen irradiance levels at 5 W cm^{-2} or for short periods at levels approaching 7 W cm^{-2} at higher temperatures. This performance is achieved while maintaining effective spatial separation between specimen and heat source. This assists in avoiding imposition of vitiated air near the surface of a burning specimen. Some performance data are provided on its behavior when supplied with natural gas. The unit can burn propane but only with a significant reduction of thermal output.

21644. Gajewski, E.; Dizdaroglu, M.; Simic, M. G. **Kováts' indices of trimethylsilylated amino acids on fused-silica capillary columns,** *J. Chromatogr.* **249,** 41-55 (1982).

Key words: lysozyme; n-paraffins; protein amino acids; repeatability; retention indices; standard deviations.

Trimethylsilyl derivatives of protein amino acids were separated by high-resolution gas chromatography on three fused-silica capillary columns, coated with SE-54, SP-2100 and Carbowax 20M, respectively. Kováts' retention indices were also calculated by using *n*-alkanes as standards and tabulated. Excellent reproducibility of the index values were obtained. The usefulness of the method in actual amino acid analysis of peptides and proteins was demonstrated by analyzing the HCl-hydrolyzate of lysozyme.

21645. Stein, S.; Glaze, D.; Levine, J.; Gray, J.; Hilliard, D.; Howe, D.; Erb, L. **Performance of an automated high accuracy phase measurement system,** *Proc. 36th Annu. Symp. Frequency Control, Philadelphia, PA, June 2-4, 1982,* pp. 314-320 (U.S. Army Research & Development Command, Electronics Technology and Devices Laboratory, Fort Monmouth, NJ, 1982).

Key words: dual mixer; frequency measurements; phase; time; time comparison.

A fully automated measurement system has been developed that combines many properties previously realized with separate techniques. This system is an extension of the dual mixer time difference technique, and maintains its important features: zero dead time, absolute phase difference measurement, very high precision, the ability to measure oscillators of equal frequency and the ability to make measurements at the time of the operator's choice. For one set of design parameters, the theoretical resolution is 0.2 ps, the measurement noise is 2 ps rms and measurements may be made within 0.1 s of any selected time. The dual mixer technique has been extended by adding scalers which remove the cycle ambiguity experienced in previous realizations. In this respect, the system functions like a divider plus clock, storing the epoch of each device under test in hardward.

The automation is based on the ANSI/IEEE-583 (CAMAC) interface standard. Each measurement channel consists of a mixer, zero-crossing detector, scaler and time interval counter. Four channels fit in a double width CAMAC module which in turn is installed in a standard CAMAC crate. Controllers are available to interface with a wide variety of computers as well as any IEEE-488 compatible device. Two systems have been in operation for several months. One operates 24 hours a day, taking data from 15 clocks for the NBS time scale, and the other is used for short duration laboratory experiments.

21646. May, W. E.; Chesler, S. N.; Hertz, H. S.; Wise, S. A. **Analytical standards and methods for the determination of polynuclear aromatic hydrocarbons in environmental samples,** *Int. J. Environ. Anal. Chem.* **12,** 259-275 (1982).

Key words: gas chromatography/mass spectrometry; generator columns; high performance liquid chromatography; polynuclear aromatic hydrocarbons; priority pollutants; shale oil; standard reference materials; urban particulate matter.

Standard reference materials (SRM's) have been produced, certified, and issued by the United States National Bureau of Standards (NBS) since 1905. NBS currently issues more than 1000 SRM's of various types, including nuclear materials, rubber, clinical and environmental trace metal standards. The most recent addition to this group is a series of environmental trace organic materials with certified concentrations of selected polynuclear aromatic hydrocarbons (PAH), phenols, and N-heterocyclic compounds. Until recently, trace organic SRM's were non-existent due to the lack of analytical methodology necessary for certification. Details concerning the analytical methods developed and used for certification of the concentrations of several PAH in SRM's 1580 (Organics in Shale Oil), 1644 (Generator Columns for PAH in water), 1647 (PAH in Acetonitrile), and 1649 (Urban Particulate Matter) are given along with some suggested uses for these SRM's.

21647. Travis, J. C.; Turk, G. C.; Green, R. B. **Laser-enhanced ionization spectrometry,** *Anal. Chem.* **54,** No. 10, 1006A-1018A (Aug. 1982).

Key words: analytical flame spectrometry; atomic spectrometry; flame ionization; ion collection; ion production; laser enhanced ionization; laser excitation; optogalvanic effect.

An overview is given of the five-year old analytical method of laser enhanced ionization (LEI) in flames. The photo-assisted collisional ionization process by which analyte atoms are selectively ionized is examined, with special attention to the conditions for achieving 100% ionization. A discussion of signal collection includes the motion of electrons and ions in an electric field, the electric field distribution in a flame under the influence of an applied potential, and considerations in electrode design. Sensitivity, selectivity, and ionization interference are described on the basis of experimental data with both simple and complex matrices. Speculations are given as to the ultimate potential of LEI and related methods.

21648. Unassigned.

21649. Galambos, T. V.; Ellingwood, B.; MacGregor, J. G.; Cornell, C. A. **Probability based load criteria: Assessment of current design practice,** *J. Struct. Div. Am. Soc. Civ. Eng., Tech. Notes* **108,** No. ST5, 959-976 (May 1982).

Key words: buildings (codes); design (buildings); loads (forces); probability theory; reliability; safety; specifications; standards; structural engineering.

This is the first of two papers that describe a study conducted to develop probability-based load factors and load combinations suitable for use with the loads specified in American National Standard A58 on design loads and with all common construction materials and technologies. The first part of the study, described in this paper, involved the selection of a probabilistic methodology for performing the necessary reliability analyses and the collection and examination of statistical data on structural resistance and loads. Levels of reliability implied by the use of current design standards and specifications for common design situations in which performance generally is felt to be satisfactory were then estimated.

21650. Sternheimer, R. M.; Seltzer, S. M.; Berger, M. J. **Density effect for the ionization loss of charged particles in various substances,** *Phys. Rev. B* **26,** No. 11, 6067-6076 (Dec. 1, 1982).

Key words: charged particles; compounds; density effect; elements; mean excitation energies; stopping power.

The density-effect correction $\delta(\beta)$ for the ionization energy loss of charged particles has been evaluated for 72 substances (34 metallic elements, 26 compounds, 11 gases, and liquid hydrogen), using up-to-date values of the mean excitation potential I and of the atomic absorption edges $h\nu_p$ which were employed as input data for the general equations for $\delta(\beta)$ previously derived by Sternheimer.

21651. Goldfarb, R. B.; Fickett, F. R.; Rao, K. V.; Chen, H. S. **Spin-freezing below the ferromagnetic transition determined by the imaginary component of ac magnetic susceptibility,** *J. Appl. Phys.* **53,** No. 11, 7687-7689 (Nov. 1982).

Key words: amorphous; ferromagnetism; magnetic phase transitions; magnetic susceptibility; paramagnetism; spin glasses.

The temperature dependences of the real and imaginary components of ac magnetic susceptibility have been measured for a number of amorphous Fe-Mn and Fe-Ni alloys. The alloys have paramagnetic, ferromagnetic, and spin-glass intervals as a function of decreasing temperature. The spin-freezing temperatures T_{fg} are identified by examining the imaginary susceptibility χ''. With decreasing temperature, χ'', representative of losses, begins to increase at the Curie temperature T_C, and reaches a peak at a temperature identified as T_{fg}. No peak is seen at T_C. The real susceptibility χ' increases rapidly at T_C but decreases before reaching T_{fg}. For frequencies of 10 and 20 Hz, the peak magnitude of χ'' is about half that of χ'. The results suggest that T_{fg} may be unambiguously defined by a peak in χ'' in the case of spin glasses with intervening ferromagnetic states.

21652. Debelius, J. R. **Information exchange—The operation of the U.S. inquiry point for standards and certification information,** *Proc. 31st Annu. Conf. 1982 Standards Engineering Society, Ottawa, Ontario, Canada, Sept. 20-22, 1982,* pp. 42-45 (Standards Engineering Society, 6700 Penn Avenue South, Minneapolis, MN 55423, 1982).

Key words: GATT Standards Code; proposed regulations; standards information; technical barriers to trade; U.S. inquiry point.

The National Bureau of Standards (NBS) was designated by the Department of Commerce as the U.S. inquiry point under the Trade Agreements Act of 1979, which implemented the Agreement on Technical Barriers to Trade (Standards Code) in the U.S. NBS has established several programs to disseminate information about and encourage comments on proposed foreign government regulations and certification systems which may create trade barriers. Since 1965, NBS has maintained a standards reference collection containing over 240,000 documents. Information on standards, test methods, specifications, and analytical methods can be obtained from the collection. In addition, standards-related periodicals and reference books as well as a visual search microfilm file are available. A computerized information system containing the titles and other relevant data of 30,000 U.S. voluntary standards allows the staff prompt access to this information. Because of this activity, NBS is well-suited to provide inquiry point services. NBS' responsibilities as inquiry point include: reporting trade-significant proposed U.S. regulations to the GATT Secretariat; receiving and disseminating notifications of proposed foreign technical regulations; providing copies of the full text of the regulations upon request; transmitting comments by U.S. organizations on proposed regulations to the appropriate foreign government; and maintaining a 'hotline' on foreign notifications.

21653. Greenberg, R. R.; Kingston, H. M. **Simultaneous determination of twelve trace elements in estuarine and sea water using pre-irradiation chromatography,** *J. Radioanal. Chem.* **71,** No. 1-2, 147-167 (1982).

Key words: chromatography; high-salinity; neutron activation analysis; prechemistry; seawater; transition metals; ultra-trace analysis; water.

A procedure is described for the preconcentration of 100 ml of estuarine and seawater into a solid sample using Chelex-100 resin. This solid sample weighs less than half a gram and contains the transition metals and many other elements of interest, but is essentially free from the alkali metals, the alkaline earth metals, and the halogens. The concentrations of Co, Cr, Cu, Fe, Mn, Mo, Ni, Sc, Th, U, V and Zn have been determined in seawater when this procedure was coupled to neutron activation analysis.

21654. Baum, H. R.; Rehm, R. G. **Numerical computation of large-scale fire-induced flows,** *Proc. Eighth Int. Conf. Numerical Methods in Fluid Dynamics, Aachen, West Germany, June 28-July 2, 1982,* 14 pages (Springer-Verlag Publisher, 1982).

Key words: buoyant convection; computations-finite difference; Euler equations; finite difference equations; fire-enclosure; fluid flow; heat source-volumetric; partial differential equations.

Large-scale fire-induced flows are calculated using a filtered set of inviscid equations driven by a volumetric heat source prescribed as a function of space and time. All phenomena with length and time scales too small to be resolved by direct computation are removed by the assumptions of the model: rapid time scales associated with acoustic and shock waves are removed by analytical filtering; combustion phenomena are replaced by a grid-resolvable heat source; and Grashof number limitations and boundary layers are removed by the inviscid approximation. No "turbulence model" is used. The finite difference method used for the computation is second order accurate in space and time, and is dispersive rather than diffusive to avoid numerical viscosity damping. Evolution equations for density and two velocity components (in the two-dimensional case reported here) are integrated on a staggered grid, and a nonseparable elliptic equation for pressure is solved at each time step. Results of a sample computation are presented and shown to be able to predict the two dimensional buoyant plume front velocity in experiments performed by releasing dyed salt water into a fresh water tank.

21655. Donaldson, J. L. U.S. **Government certification activities—Implementing the Standards Code,** *Proc. 31st Annu. Conf. 1982 World Standards—Tools Trade Development, Ottawa, Ontario, Canada, Sept. 20-22, 1982,* pp. 67-72 (Standards Engineering Society, Inc., 6700 Penn Avenue South, Minneapolis, MN, Nov. 1982).

Key words: certification; coordination; GATT; harmonization; information; inquiries; participation; representation; standards.

The Standards Code negotiated under the auspices of the General Agreement on Tariffs and Trade became effective on January 1, 1980. Its purpose is to eliminate the use of standards and certification rules as impediments to trade. Properly operated, certification systems attesting to the conformity of products to specified standards can facilitate the flow of the certified goods in commerce. To enhance its world trading position, the United States has passed legislation implementing the Code and authorizing the Department of Commerce to carry out certain functions required by the Code. The Department has assigned the technical and information functions to the Office of Product Standards Policy (OPSP) at the National Bureau of Standards. This paper examines those aspects of the Code and the law bearing on certification and discusses OPSP's response to its assigned responsibilities.

21656. Bender, P. L.; Larden, D. R. **TOPEX orbit determination using GPS signals plus a sidetone ranging system,** *Proc. Third Int. Geodetic Symp. Satellite Doppler Positioning, Las Cruces, NM, Feb. 8-12, 1982,* **2,** 1253-1258 (Physical Science Laboratory, New Mexico State University Las Cruces, NM, Dec. 1982).

Key words: altimetry; geodesy; ocean currents; oceanography; orbit determination; space.

One reason for carrying out our GPS orbit determination study was to see how well the radial coordinate for altimeter satellites such as TOPEX could be found by on-board measurements of GPS signals, including the reconstructed carrier phase. Preliminary results are very encouraging. However, the inclusion on altimeter satellites of an additional high accuracy tracking system seems desirable. A suggestion is made for using a sidetone ranging system in conjunction with TRANET 2 beacons.

21657. Olver, F. W. J. **Further developments of Rp and Ap error analysis,** *IMA J. Num. Anal.* **2,** 249-274 (1982).

Key words: absolute error; compensating factor; error bounds; floating-point arithmetic; inner products; input; interval analysis; output; relative error; sums.

Extensions are made of a recently developed theory of floating-point error analysis to facilitate the construction and computation of strict error bounds of a *posteriori* type. *Inter alia*, these extensions obviate the need for specially-directed rounding procedures in computer hardware or software, and reduce computational cost by enabling error bounds to be computed to a low working precision.

Applications are made to the evaluation of products, quotients, powers, sums and inner products, and also to the processes of input and output.

21658. Coriell, S. R.; Turnbull, D. **Relative roles of heat transport and interface rearrangement rates in the rapid growth of crystals in undercooled melts,** *Acta Metall.* **30,** 2135-2139 (1982).

Key words: crystal growth; dendritic growth; heat flow; interface kinetics; nickel dendrites; stability.

Perhaps, the highest measured crystal growth velocities (50 m/s) are those of Ni dendrites growing into pure undercooled melts as reported by Walker and Colligan and Bayles. Recent theoretical (Langer and Muller-Krumbhaar) and experimental (Glicksman *et al.*) advances in our understanding of dendritic growth allow accurate calculation of the heat transport limited rate of dendritic growth. We use previous results on the effect of interface kinetics on the morphological stability of a sphere to calculate the effect of interface kinetics on dendritic growth. An interface kinetic coefficient based on the estimated velocity of sound in molten nickel provides a good fit to the dendritic growth data at high velocities.

21659. Travis, J. C. **Limits to sensitivity in laser enhanced ionization,** *J. Chem. Educ.* **59,** No. 11, 909-914 (Nov. 1982).

Key words: atomic spectrometry; flame analysis; ionization; laser enhanced ionization; laser spectrometry; trace metal analysis.

Laser enhanced ionization (LEI) occurs when a tunable dye laser is used to resonantly excite a specific atomic population in a flame. Using LEI with analytical burners which spray fine mists of liquid samples into high temperature flames, we are able to detect 1 pg of Li per mL of water, and <5 ng/mL for some 24 elements.

The process of ion production and collection may both be shown to approach 100% efficiency under optimum circumstances in LEI. The ultimate theoretical sensitivity may thus be derived from a knowledge of the limiting noise source. Assuming this source to be statistical fluctuation in the background current (shot noise) yields a theoretical sensitivity limit in good agreement with the best experimental value.

21660. Hodeau, J. L.; Marezio, M.; Santoro, A.; Roth, R. S. **Neutron profile refinement of the structures of Li_2SnO_3 and Li_2ZrO_3,** *J. Solid State Chem.* **45,** 170-179 (1982).

Key words: lithium stanate; lithium zirconate; neutron diffraction; powder method; profile refinement; Rietveld method.

The crystal structures of the compounds Li_2SnO_3 and Li_2ZrO_3 have been refined with the Rietveld method [H. M. Rietveld, *J. Appl. Crystallogr.* **2,** 65 (1969)] using neutron powder diffraction data collected at room temperature. Both compounds crystallize with the symmetry of space group $C2/c$. For Li_2SnO_3, $Z=8$, and the lattice parameters obtained from the refinement are $a=5.2889(2)$, $b=9.1872(3)$, $c=10.0260(3)$ Å, and $\beta=100.348(2)°$. For Li_2ZrO_3, $Z=4$, and $a=5.4218(2)$, $b=9.0216(4)$, $c=5.4187(2)$ Å, and $\beta=112.709(2)°$. Both compounds have NaCl-type structures in which the oxygen anions, as well as the cations, form a distorted cubic close-packed network. The order among the lithium and the tetravalent cations is different in the two compounds. In Li_2SnO_3, there are two types of layers perpendicular to c^*, one with Li^+ only and one with Li^+ and Sn^{4+} in the ratio 1:2. In Li_2ZrO_3, the layers perpendicular to c^* are all the same with Li^+ and Zr^{4+} ions in the ratio 2:1. The different arrangement of the cations in the two structures can be explained in terms of the difference in size of Sn^{4+} and Zr^{4+}.

21661. Krasny, J. F.; Singleton, R. W.; Pettengill, J. **Performance evaluation of fabrics used in fire fighters' turnout coats,** *Fire Technol.* **18,** No. 4, 309-318 (Nov. 1982).

Key words: abrasion resistance; burn injury; clothing; fabrics; fire fighting; heat protection; insulation; physical properties; tensile strength; turnout coats.

Several fabrics commonly used in the outer shells of structural fire fighters' turnout coats were subjected to a variety of laboratory tests. These included breaking and tearing strength tests as well as several

kinds of abrasion tests.

21662. Ekin, J. W.; Gavaler, J. R.; Gregg, J. **Effect of strain on the critical current and critical field of B1 structure NbN superconductors,** *Appl. Phys. Lett.* **41,** No. 10, 996-998 (Nov. 15, 1982).

Key words: B1 crystal structure; critical current; critical current degradation; critical field; irreversible strain limit; NbN; strain effect; superconductors.

The effect of uniaxial strain on the critical current of NbN superconductors has been measured at 4.2 K in magnetic fields from 6 to 22 T. Unlike A15 superconductors, the critical current of B1 structure NbN shows no measurable dependence on elastic strain, even at fields as high as 22 T. Furthermore, the bulk upper critical field determined from the high-field critical current data is independent of uniaxial strain within experimental error (±0.5%). The irreversible strain limit ϵ_{irrev} where the superconductor is permanently damaged was measured to be greater than 0.7% (0.5% intrinsic strain) in 0.2-μm-thick film samples. Values of ϵ_{irrev} were observed to correlate with the microstructure of the NbN films as well as with the onset of substrate yielding.

21663. Chandler-Horowitz, D. **Ellipsometric accuracy and the principal angle of incidence,** *Proc. SPIE Int. Soc. Photo-Opt. Instrum. Eng., Integrated Circuit Metrology, Arlington, VA, May 4-5, 1982,* **342,** 121-130 (SPIE, P.O. Box 10, Bellingham, WA, 1982).

Key words: angle of incidence accuracy; ellipsometric accuracy; ellipsometric angles, Δ and ψ; principal angle of incidence; refractive index; thickness thin films.

The effects of improving the accuracy of the angle of incidence on the ellipsometric determination of thickness and refractive index of oxide and nitride films on a silicon substrate are analyzed. It is found that the accuracy of a determination of a film's parameters, thickness and refractive index, depends as much or more on the accuracy of the angle of incidence measurement as on the accuracy of the measurement of the ellipsometric angles Δ and ψ. If measurements of Δ and ψ are made close to the principal angle of incidence, the accuracy of the determined film parameters can be improved by measuring the incident angle to an accuracy better than Δ and ψ. This is especially true for thin films of oxide less than a few tens of nanometers. Because of the higher refractive index of silicon nitride relative to silicon dioxide, a nitride film's thickness can be determined more accurately than an oxide film's thickness. Therefore, silicon nitride may make a good candidate film for a standard thickness sample.

21664. Jerke, J. M.; Wendell, C. E. **Use of the National Bureau of Standards (NBS) antireflective (AR)-chromium optical linewidth standard for measurements on other types of chromium photomasks,** *Proc. SPIE Int. Soc. Photo-Opt. Instrum. Eng., Integrated Circuit Metrology, Arlington, VA, May 4-5, 1982,* **342,** 15-26 (SPIE, P.O. Box 10, Bellingham, VA, 1982).

Key words: antireflective chromium photomask; chromium photomask; coincidence shearing micrometer; filar micrometer; image-shearing micrometer; integrated circuits; line-spacing measurements; linewidth calibration; linewidth measurements; linewidth standard; micrometrology; optical microscopy; photomask; semiconductor technology.

Both antireflective (AR)-chromium and bright-chromium photomasks are currently used in the production of integrated circuits. Differences in the optical transmittance and reflectance of these photomasks can significantly change the line-image threshold required for accurate edge detection in optical microscope linewidth measurements. The suitability of using a calibration curve based on an AR-chromium optical linewidth-measurement standard (SRM 474) from the National Bureau of Standards (NBS) to correct linewidth measurements on other types of photomasks is discussed. Linewidths on each of three chromium photomasks of different chromium thicknesses were measured on four different types of optical microscope linewidth measurement systems. These measurements were corrected using an SRM 474 and compared with measurements made on the NBS optical linewidth calibration system. For the two bright-chromium specimens with low transmittance, the residual differences between the corrected values and the NBS values as measured on the NBS calibration system are generally less than ±0.05 μm for three of the measurement systems. For the see-through AR-chromium photomask with a higher transmittance, the calibration curve does not correct all systematic errors greater than ±0.05 μm. These results support theoretical studies showing that the degree of correction for systematic linewidth errors varies with the transmittance of the chromium photomask being measured and with the measurement system.

21665. Lin, I. H.; Anderson, T. L.; deWit, R.; Dawes, M. G. **Displacements and rotational factors in single edge notched bend specimens,** *Int. J. Fract.* **20,** R3-R7 (1982).

Key words: C(T)OD; elastic-plastic; J contour integral; pipeline steel; plastic rotational factor; SENB.

This note reviews the definition and experimental measurement of the plastic rotational factors that are used with single edge notched bend specimens for estimates of crack tip opening displacements or, alternatively, for estimates of J contour integral values. Some new relationships are presented along with some experimental data for an API 5 LX-70 pipeline steel.

21666. Halbritter, J. **On resonant tunneling,** *Surf. Sci.* **122,** 80-98 (1982).

Key words: junction tunneling; niobium; resonance tunneling.

Localized electron states in oxides adjacent to metals hybridize with conduction electron states forming interface states, which at the localized site have an amplitude resonantly enhanced over the amplitude of the conduction electron states. The interface states mediate a continuous transition between the metal and the semiconducting or insulating oxide. Resonant tunneling via these interface states to an opposing metal surface can dominate over direct and intermediate-state tunneling. Resonant tunneling is obstructed by the correlation (Coulomb) energy which causes voltage, temperature and time dependencies. The obstruction increases with distance of the localized state from the metal and this increased obstruction causes the transition from resonant to intermediate-state tunneling. This corresponds to a space-wise metal-insulator transition. In oxides, like Nb_2O_5, the correlation energy is small and the hybridization is strong and thus resonant tunneling through localized states at the Fermi energy can account for various tunnel anomalies observed in the normal or superconducting state.

21667. Blessing, G. V.; Eitzen, D. G. **Variables affecting ultrasonic reference block calibration,** *Proc. ASNT Fall Conf., Pittsburgh, PA, Oct. 4-7,* pp. 9-12, (American Society for Nondestructive Testing, Columbus, OH, 1982).

Key words: nondestructive evaluation; ultrasonic calibration; ultrasonic reference blocks; ultrasonics.

The variables affecting ultrasonic reference block calibrations are many. In a paper presented at the last ASNT conference, we suggested that they be divided into five principal categories: (1) the material, (2) the transducer, (3) the pulser/receiver, (4) the operator, and (5) block geometry. Of these, the transducer has received the most attention, and perhaps justifiably so. Sophisticated approaches toward parameterizing its behavior, however, have met with limited sucess. We will present a relatively simple empirical approach whereby the peak amplitude of the transducer's far-field center lobe is normalized to its Y_0^+ value, and correction factors applied. An example of this approach follows, together with a discussion of the other principal system variables.

21668. Dai, H. L.; Specht, E.; Berman, M. R.; Moore, C. B. **Determination of Arrhenius parameters for unimolecular reactions of chloroalkanes by IR laser pyrolysis,** *J. Chem. Phys.* **77,** No. 9, 4494-4506 (Nov. 1, 1982).

Key words: Arrhenius parameters; chloroalkanes; IR laser; temperatures; thermal rate constants.

A simple and reliable method is elaborated for accurate measurements of thermal rate constants of homogeneous gas phase unimolecular reactions. A pulse of CO_2 laser radiation was used to multiphoton excite SiF_4 sensitizer molecules and consequently produce temperatures in the range 1100–1400 K. Expansion of the

heated gas column quenches pyrolysis reactions on a 10 μs time scale. There are no hot surfaces to induce chemistry. HCl elimination from C_2H_5Cl, E_a=57.4 kcal/mol and log $A(s^{-1})$=13.8, was used as an internal temperature standard. For the molecular elimination $CCl_3CH_3 \rightarrow HCl + CCl_2CH_2$, E_a=49.5±1.3 kcal/mol and log $A(s^{-1})$=13.1±0.3, were determined. In these experiments the major decomposition products of $CHCl_2CH_2Cl$ are HCl and *cis-* or *trans-*CHClCHCl with E_a=58.5±2, log A=14.1±0.4 and E_a=59.5±2, log A=13.9±0.4, respectively. HCl elimination to give CCl_2CH_2 and C-Cl bond breaking to $CHClCH_2Cl$ radical have higher activation energies. The method is generally useful for kinetics at high temperature.

21669. Salomone, L. A.; Kovacs, W. D. **The determination of thermal soil properties for energy transfer modeling of buildings,** *Proc. Energy Conservation in Building Design, Construction and Management Conf., Minneapolis, MN, Sept. 15-16, 1982,* pp. 137-161 (Dept. of Conferences University of MN, 315 Pillsbury Drive, SE., Minneapolis, MN 55455, Sept. 1982).

Key words: Atterberg limit tests; field tests; heat flow; laboratory tests; soil moisture; soil tests; thermal conductivity; thermal resistivity.

Field thermal probe tests were performed in the vicinity of test houses at the National Bureau of Standards (NBS) annex in Gaithersburg, Maryland. The test houses were constructed to validate the mathematical model being used to predict surrounding earth temperatures and floor heat loss of the test houses. Also, laboratory thermal probe tests were performed at the NBS geotechnical laboratory on an AASHTO Material Reference (AMRL) soil. The laboratory tests were performed to confirm the correlation between soil thermal behavior with the limit states of fine-grained soil behavior and to identify an approach for predicting the thermal performance of fine-grained soils. Using the approach and field thermal probe measurements, the thermal behavior of the soils surrounding the test houses was assessed.

The paper presents the factors that affect the thermal conductivity of soils that surround buildings and demonstrates the importance of predicting in-situ soil thermal properties. The state-of-the-art field and laboratory procedures used to evaluate the thermal conductivity of fine-grained soils are presented. Results demonstrate the need for incorporating changes in thermal resistivity caused by changes in soil moisture in computer models of the thermal performance of buildings.

21670. Feldman, A.; Vorburger, T. **Comparison of optical and mechanical methods of thickness measurement,** *Proc. SPIE Int. Soc. Photo-Opt. Instrum. Eng., Integrated Circuit Metrology, Arlington, VA, May 4-5, 1982,* **342,** 92-99 (SPIE, P.O. Box 10, Bellingham, WA, 1982).

Key words: channeled spectra; dual-beam interferometry; ellipsometry; guided waves; multiple beam interferometry; prism coupler; refractive index; stylus profiling; thickness; thin film.

A variety of techniques is used for the measurement of thin film thicknesses of the order of one micrometer. These techniques include stylus profilometry, multiple beam interferometry, dual beam interferometry, guided waves, channel spectra and ellipsometry. The principles underlying each of the techniques are discussed and where available, experimental comparisons of the techniques are presented. Advantages, disadvantages, and sources of error are also discussed.

21671. Kulin, G.; Schuk, W. W.; Kugelman, I. J. **Evaluation of a dissolved oxygen field test protocol,** *J. Water Pollut. Control Fed.* **55,** No. 2, 178-186 (Feb. 1983).

Key words: activated sludge basin; dissolved oxygen meters; sewage plant instrumentation; test methods, field; wastewater treatment process control.

A test protocol which was developed for on-line dissolved oxygen meters was evaluated in a 60-day field test conducted in an activated sludge aeration basin with thirteen meters from seven cooperating manufacturers. The paper discusses the important features of the test protocol and describes the procedures and results of the field test. These results provide information on methods for testing, calibrating and performance monitoring, information useful for developing specifications, and information on routine maintenance for on-line dissolved oxygen meters in a specific plant environment.

21672. Kent, E. W. **A hierarchical, model-driven, vision system for sensory-interactive robotics,** *Proc. COMPSAC '82, Sixth Int. Conf., Chicago, IL, Nov. 8-12, 1982,* pp. 400-409 (IEEE Computer Society, P.O. Box 80452, Worldway Postal Center, Los Angeles, CA 90080, 1982).

Key words: hierarchical vision; robotics; robot sensory system machine vision; robot vision; structured light.

A robot sensory system for industrial robotics, employing structured light vision techniques, is described. Alternate frames (one illuminated by two parallel planes of light, and one by a point source) are obtained, and analyzed by a hierarchically organized group of microprocessors. The system uses knowledge of ideal objects and of robot action to generate visual expectancies. At each level of the hierarchy, an interpretative process is guided by an expectancy-generating modeling process. The modeling process is itself driven by a store of *a priori* knowledge, by knowledge of the robot's movements, and by error feedback from the interpretative process. At higher levels, the interpretative and modeling processes describe the data with higher order constructs, and over longer time frames. All levels of the hierarchy provide output, in parallel, to guide corresponding levels of the robot's hierarchical control system. At the lowest level other senses (proximity, tactile, force) are handled separately; above this level, they are integrated with vision into a multi-modal world model.

21673. Schmid, L. A. **Use of thermocapillary migration in a controllable heat valve,** *J. Appl. Phys.* **53,** No. 12, 9204-9207 (Dec. 1982).

Key words: heat pipes; heat valve; interfacial tension; Marangoni effect; surface tension; thermocapillary.

In accordance with the Marangoni effect, immiscible droplets in a host fluid in which a temperature gradient exists move in the direction of increasing temperature. It is proposed that this thermocapillary migration could be used to construct a "liquid wick" that would return the condensed vapor at the condenser end of a heat pipe back to the evaporator, thus completing the fluid circuit. The droplets would be formed by capillary pressure forcing the condensate through a perforated diaphragm whose temperature would control the droplet flux, and hence the heat flux between the two ends of the heat pipe, thus making it a controllable heat valve.

21674. Goodman, D. A.; Bennett, L. H.; Watson, R. E. **Valency effects and relative solubilities in transition metal alloys,** *Scr. Metall.* **17,** 91-96 (1983).

Key words: alloy phase diagrams; alloy solubilities; d-bands; relative valency; transition metals.

The prediction of terminal solubilities for a given metal solute and solvent is a formidable problem, and it remains a major unsolved question in metallurgy. In this paper we attempt to describe the role of relative valency in the relative solubilities of the transition metals in one another. We discuss the problem of defining an appropriate measure of solubility for the transition metal alloys which have many intermediate phases, we present a map of relative solubilities for the transition metals, and we delineate the trend which occurs.

21675. Spence, D.; Wang, R. G.; Dillon, M. A. **Pseudo-optical absorption spectra in $HgCl_2$ and $HgBr_2$ from 4 to 14 eV,** *Appl. Phys. Lett.* **41,** No. 11, 1021-1023 (Dec. 1, 1982).

Key words: electron scattering; energy levels; energy loss spectra; $HgCl_2$; $HgBr_2$.

Using a high-resolution electron-impact energy-loss spectrometer we have measured the energy-loss spectra of electrons scattered near the forward direction from $HgCl_2$ and $HgBr_2$, for incident energies of 200 eV and energy loss between 4 and 14 eV. Under these conditions the energy-loss spectra correspond closely to optical-absorption spectra. In addition to the well known $^1\Pi_u$ and $^1\Sigma_u^+$ absorption bands, we observe many new energy-loss processes beginning at 7.9 eV in $HgBr_2$ and 8.60 eV in $HgCl_2$. The relative cross sections and energies of these processes are in excellent agreement with those inferred as being necessary to account for discharge and fluorescence measurements in *e*-beam sustained mercuric bromide lasers.

21676. Soares, C. G.; Ehrlich, M.; Padikal, T. N.; Gromadzki, Z. C. **A system for electron therapy dosimetry surveys with thermoluminescence dosimeters,** *Int. J. Appl. Radiat. Isot.* **33,** 1007-1013 (1982).

Key words: absorbed dose to water; charge accumulation; dosimeter response; dosimetry survey; high-energy electrons; LiF thermoluminescence dosimeters; polystyrene phantom; radiation therapy; rate dependence; water phantom; ^{60}Co gamma radiation.

Radiation-therapy dosimetry surveys employing thermoluminescence dosimeters (TLDs) are now being considered for high-energy electron beams. Using a system of individually calibrated pressed LiF TLDs in a water and a polystyrene phantom, we established that the distortions of depth-dose distributions in non-conducting materials previously observed at high absorbed doses and high dose rates were not detectable in the present geometry at doses and dose rates as much as 40 times higher than those employed in radiation therapy. The system was then used to measure TLD response in water and in polystyrene in the nominal electron-energy range from 7 to 18 MeV. In the water phantom, the wellknown trend for TLD response to decrease with increasing electron energy was observed. In the polystyrene phantom, TLD response was found to be independent of electron energy.

21677. Sugar, J.; Kaufman, V.; Cooper, D. **B I isoelectronic sequence: Observation of $2s2p^2$–$2p^3$ intersystem lines in Sc XVII and improved measurements for Cl XIII, K XV, Ca XVI, Sc XVII, and Ti XVIII,** *Phys. Scr.* **26,** No. 4, 293-295 (1982).

Key words: calcium; chlorine; energy levels; potassium; scandium; titanium; wavelengths.

Spectra of Cl through Ti (excluding Ar) were produced with 1 GW 15 ns) pulses from a Nd-glass laser impinging on solid targets, and observed with a 10.7 m grazing incidence spectrograph. Transition arrays $2s^m2p^n$–$2s^{m-1}2p^{n+1}$ in the B I isoelectric sequence were recorded. Two intersystem transitions $2s2p^2\ ^4P$–$2p^3\ ^2D$ of Sc XVII were identified, and improved wavelength measurements of allowed lines were made for each spectrum. From a least squares fit of radial energy integrals to Sc XVII energy levels, percentage compositions of the levels were obtained.

21678. Smyth, K. C.; Mallard, W. G. **Two-photon ionization processes of PO in a C_2H_2/air flame,** *J. Chem. Phys.* 77, No. 4, 1779-1787 (Aug. 15, 1982).

Key words: Franck-Condon factor; optogalvanic spectroscopy; phosphorous oxide; photoionization; premixed flame; two-photon.

Laser induced two-photon ionization processes are observed for PO in a premixed C_2H_2/air flame in the 302–334 nm wavelength region. The ionization signal obtained as a function of energy shows distinct band heads, which correspond to one-photon absorption from the ground state to the resonant intermediate $B\ ^2\Sigma^+$ state. A second photon of the same energy then either (1) excites PO to high-lying electronic states from which collisional ionization occurs or (2) directly photoionizes the PO molecule, depending upon the total excitation energy available. Several new bands are assigned on the basis of calculated spectra. The intensities of the observed ion signals vary in an unexpected fashion for transitions which reach the same vibrational level of the resonant intermediate state. Further analysis indicates that absorption of the second photon makes a significant contribution to the overall intensity of some of the observed bandheads. This result is attributed to the presence of short-lived autoionizing states which lie close to the ionization limit, despite some uncertainties encountered in calculating Franck-Condon factors for absorption of the first photon. It is estimated that PO can be easily detected at a mole fraction of 1×10^{-8} with a laser pulse energy of 100 μJ.

21679. Miiller, A. P.; Cezairliyan, A. **Transient interferometric technique for measuring thermal expansion at high temperatures: Thermal expansion of tantalum in the range 1500–3200 K,** *Int. J. Thermophys.* **3,** No. 3, 259-288 (1982).

Key words: high temperature; interferometry; pulse heating; tantalum; thermal expansion.

The design and operational characteristics of an interferometric technique for measuring thermal expansion of metals between room temperature and temperatures in the range 1500 K to their melting points are described. The basic method involves rapidly heating the specimen from room temperature to temperatures above 1500 K in less than 1 s by the passage of an electrical current pulse through it, and simultaneously measuring the specimen expansion by the shift in the fringe pattern produced by a Michelson-type polarized beam interferometer and the specimen temperature by means of a high-speed photoelectric pyrometer. Measurements of linear thermal expansion of tantalum in the temperature range 1500–3200 K are also described. The results are expressed by the relation: $(l-l_0)/l_0 = 5.141\times10^{-4}+1.445\times10^{-6}T+4.160\times10^{-9}T^2 -1.309\times10^{-12}T^3+ 1.901\times10^{-16}T^4$ where T is in K and l_0 is the specimen length at 20°C. The maximum error in the reported values of thermal expansion is estimated to be about 1% at 2000 K and not more than 2% at 3000 K.

21680. Stapor, W. J.; Crannell, H.; Lightbody, J. W., Jr.; Maruyama, X. K.; O'Brien, J. T. **A flowing gas target system for precision electron scattering measurements,** *Nucl. Instrum. Methods* **203,** 97-100 (1982).

Key words: density stabilization; electron scattering; flowing gas; gas target; pycnostat; temperature monitor.

We describe a flowing gas target system which can be used in various electron scattering experiments that require gas density stabilization to one part in 10^3. The main advantage of this system is that both target pressure and temperature are directly monitored during the data taking process. This eliminates the need to use extra beam time to measure the dependence of local target density on beam current. The system has been successfully used in an elastic electron scattering experiment to obtain a precise measurement of the nuclear ground state rms charge radius of ^{4}He.

21681. Wu, W.; Cobb, E.; Dermann, K.; Rupp, N. W. **Detecting margin leakage of dental composite restorations,** *J. Biomed. Mater. Res.* **17,** 37-43 (1983).

Key words: composite restoration; marginal leakage; silver staining; thermal cycling.

The degree of microleakage between a restoration and the cavity wall is difficult to quantify objectively. A silver-staining method is used and compared to the radioisotope method with results that indicate a superior definition and more accurate evaluation of microleakage. In addition to the accuracy, two advantages are presented: (1) scoring of the leakage can be refined and divided into more precise numbers, and (2) teeth can be observed directly in a microscope without resorting to the indirect interpretation of film or photograph.

21682. Wiederhorn, S. M. **Effect of deuterium oxide on crack growth in soda-lime-silica glass,** *J. Am. Ceram. Soc.* **65,** No. 12, C-202–C-203 (Dec. 1982).

Key words: crack growth; deuterium oxide fracture; glass; heavy water; strength.

Crack growth in acidic and basic deuterium oxide solutions was studied. An isotopic effect was observed in basic deuterium oxide solutions but not in acidic deuterium oxide solutions. The results suggest that the rate-limiting step for crack growth differs for basic and acidic environments.

21683. Nesbitt, D. J.; Leone, S. R. **Laser-initiated Cl_2/hydrocarbon chain reactions: Time-resolved infrared emission spectra of product vibrational excitation,** *J. Phys. Chem.* **86,** No. 25, 4962-4973 (1982).

Key words: chain reaction; chlorine; hydrocarbon; infrared emission; infrared spectra; laser chemistry.

Rapid gas-phase chain reactions of Cl_2/hydrocarbon mixtures are initiated by selective laser photodissociation of Cl_2 and investigated by time-resolved infrared emission spectra of chain products. The basic two-center chain chlorination reaction sequence is $Cl\cdot+RH\rightarrow HCl(v)+R\cdot$, $R\cdot+Cl_2\rightarrow RCl\ddagger+Cl\cdot$. At low hydrocarbon reagent pressures ($[RH]\lesssim20$ Pa), analysis of emission from HCl(v) is used to determine the chain rate constants k_1 and k_2 under controlled room temperature conditions. At higher pressures of RH ($\gtrsim300$ Pa) the

chain reaction generates vibrationally excited polyatomic products, RCl‡, at rates comparable to or faster than relaxation of RCl‡. Time- and wavelength-resolved emission from vibrationally hot RCl‡ is used to investigate chain reaction behavior in this regime of rapidly rising temperatures. Extensive vibrational emission from reagent molecules is also observed, indicating a rapid and complete sharing of product vibrational excitation with the reagent molecules. The dispersed emission spectra of the products (3.0–15.0 μm) is fit by a simple model that assumes a common vibrational temperature, T_{vib}, and varies the relative concentrations of the emitters. Product isomer ratios obtained from these spectral fits are in good agreement with literature values. Vibrational temperatures as high as 700 K are observed. These are significantly hotter than the measured bulk gas temperatures (400–500 K), which suggests that the vibrational and translational degrees of freedom are not in equilibrium under the rapid burning conditions in these systems.

21684. Padial, N. T.; Norcross, D. W.; Collins, L. A. **Vibrationally elastic scattering of electrons by HCl,** *Phys. Rev. A* **27,** No. 1, 141-148 (Jan. 1983).

Key words: electron collisions; HCl; polar molecules; rotational excitation.

Results of close-coupling calculations are reported, in which several models of the interaction potential are investigated. Cross sections for rotational transitions involving the lowest ten levels are obtained in the first detailed application of the MEAN approximation. The results are subject to a strong cooperative effect involving exchange and polarization. Rotationally elastic transitions are shown to be quite important at thermal energies and to dominate the total cross section above 4.0 eV. Transitions for which the angular momentum changes by two are found to be responsible for a broad resonance at ~2.5 eV. No structure indicative of a resonance or virtual state at very low energies is, however, obtained. Total differential, momentum-transfer, and integrated cross sections are in satisfactory agreement with measured values.

21685. Unassigned.

21686. Schoenwetter, H. K. **A sensitive analog comparator,** *IEEE Trans. Instrum. Meas.* **IM-31,** No. 4, 266-269 (Dec. 1982).

Key words: analog comparator; comparator; overdrive; settling time measurements; strobed comparator; voltage comparator; voltage limiting.

A strobed, sensitive analog comparator has been developed for use in the NBS Data Converter Test Facility. The comparator has a sensitivity of 1.5 μV and a response time of 30 μs to within 10 μV, following input steps up to 20 V. Signal voltages up to $\pm$10 V are compared with reference voltage levels of opposite polarity, using a precision resistive divider. The input offset has a temperature coefficient of –1 μV/°C and changes less than $\pm$5 μV under worst case dynamic conditions. Following a strobe pulse, the digital output is retained until the next strobe pulse. Optical isolators provide isolation between the analog and digital circuits.

21687. Pine, A. S. **The Q branch of the $2\nu_1+\nu_4$ band of CF_4,** *J. Mol. Spectrosc.* **96,** 395-403 (1982).

Key words: CF_4(FREON 14); high resolution spectroscopy; infrared; low temperatures; Q-branch of $2\nu_1+\nu$ band; tunable lasers.

The Q branch of the $2\nu_1+\nu_4$ band of CF_4 was recorded with Doppler-limited resolution at T=296 and 77 K using a tunable difference-frequency laser spectrometer. The low-temperature spectrum is fit to within 1.1×10^{-4} cm^{-1} rms for $J\leqslant40$ using the simple diagonal approximation terms, m, ν, and g, without centrifugal distortion. Extrapolation to higher J for the room-temperature measurement is moderately successful.

21688. Mulholland, G. W. **How well are we measuring smoke?,** *Fire Mater.* **6,** No. 2, 65-57 (1982).

Key words: light extinction; optical density; smoke measurement; smoke density chambers.

Estimates of the errors in light extinction measurements of smoke resulting from forward scattered light entering the detector and from the spectral width of the light source are presented. It is shown for specific examples that each of these effects can lead to an error of about 25% in typical applications. A potential method for calibrating extinction instruments is described.

21689. Albers, J. **Spreading resistance probe-spacing experiment simulations: Effects of probe-current density and layer thickness,** *J. Electrochem. Soc.* **129,** No. 12, 2788-2795 (Dec. 1982).

Key words: Laplace's equation; layer thickness; probe-current density; probe-spacing experiment simulations; sheet resistance; spreading resistance.

Model spreading resistance data were calculated using three forms of the probe-current density: the original Schumann and Gardner version, the Choo uniform current density, and the ring delta function current density in order to determine whether probe-spacing experiment simulations are sensitive to the specific form of the probe-current density. Further, since the probes of the spreading resistance and of the four-probe sheet resistance apparatus view the material as a continuum, the dependence of the results of the probe-spacing simulation on the number of layers used in the calculation was also investigated. From the analysis, it is possible to conclude, aside from the differences in the interpreted radii, that the results of the probe-spacing simulations in the surface region are not particularly sensitive to the choice of either the current density or the number of layers used in the simulation (provided, of course, that the number of layers is of reasonable size to be representative of the continuous nature of the underlying resistivity). The failure of the probe-spacing experiment simulation to obtain the correct surface sheet resistance for the case of a lightly to moderately doped layer over a substrate of the same conductivity type is not changed by either the probe-current density or the discrete layer nature of the calculations used to generate the data. The variable that has the strongest influence on the outcome of the probe-spacing experiment is the substrate resistivity. Hence, for junction-isolated layers and for heavily doped layers over substrates of the same conductivity type, probe-spacing experiments will yield the correct sheet resistance in the surface region.

21690. Sengers, J. V.; Van Leeuwen, J. M. J. **Nonlocal gravity-induced density profiles in gases near the critical point,** *Physica* **116A,** 345-367 (1982).

Key words: critical phenomena; density gradients; gravity effects; inhomogeneous fluids; interfaces; nonlocal thermodynamics.

The gravitational field induces density gradients in gases near the critical point. These density gradients are usually evaluated with the assumption that the relationship between the local density and local chemical potential is the same as for a macroscopic system in thermodynamic equilibrium. Very close to the critical point the assumption of local equilibrium ceases to be valid. In this paper we obtain the actual density profiles including nonlocal effects. For this purpose we extend the theory of van der Waals and of Fisk and Widom for the interfacial density profile below the critical temperature to the one-phase region above the critical temperature. The nonlocal effects in the density profiles are found to be significant in temperature intervals that are accessible with currently available experimental techniques for temperature control.

21691. Schuller, I. K.; Hinks, D.; Soulen, R. J., Jr. **Search for superconductivity in Pd-Ag alloys,** *Phys. Rev. B* **25,** No. 3, 1981-1982 (Feb. 1, 1982).

Key words: paramagnons; PdAg alloys; superconductivity.

We have measured low-temperature properties of twelve Pd_cAg_{1-c} samples ($0.59\lesssim c\lesssim0.81$) and find no evidence of superconductivity.

21692. Pommersheim, J. M.; Clifton, J. R.; Frohnsdorff, G. J. **Mathematical modeling of tricalcium silicate hydration. II. Hydration sub-models and the effect of model parameters,** *Cem. Concr. Res.* **12,** 765-772 (1982).

Key words: cement; hydration; mechanisms; models; particle size; tricalcium silicate; water-to-cement radio.

Further details are reported for a previously developed mathematical model for the hydration of tricalcium silicate. The model is based on conceptual models for the different stages of hydration. Sub-models are given which consider the effects of the particle size, thickness of the barrier layer, and diffusivities through the hydrate layers. Model predictions were consistent with experimental data.

21693. Boisvert, R. F.; Howe, S. E.; Kahaner, D. **The GAMS classification scheme for mathematical and statistical software,** *SIGNUM Newslett.* **18,** No. 1, 10-18 (Jan. 1983).

Key words: classification scheme; data base; mathematical software; scientific computing; scientific software; statistical software.

An extensive tree-structured problem-oriented scheme for classifying mathematical and statistical software is presented. The scheme is a substantially modified version of a scheme proposed by Bolstad, which was based on the widely-used SHARE system. In an attempt to reflect more accurately the current state of mathematical and statistical software, this scheme reflects a substantial reorganization of broad subject areas as well as considerable tuning at more detailed levels. Our changes resulted from using the Bolstad scheme as the basis for the NBS Guide to Available Mathematical Software (GAMS), which provides NBS scientists information about subprograms in the IMSL, NAG, and PORT libraries, and in dozens of public-domain subprogram packages.

21694. Hsu, S. M.; Ku, C. S.; Becker, D. A. **Re-refined base oil characterization and consistency monitoring,** Paper in *Base Oils for Automotive Lubricants, SP-526,* pp. 87-104 (Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, 1982).

Key words: chemical properties; consistency engine tests; hydrogen structures; oxidation performance; physical properties; quality and re-refined base oils.

Re-refined lubricating base oils are base oils derived from reprocessing of used lubricating oils to remove contaminants, oxidized products, and additives. Early studies suggested that the basic molecular structures of the hydrocarbons were not altered in use, and there were no systematic variations in either contaminants or compositions in the used oils from geographical or seasonal variations. Various processing technologies are available to remove the contaminants from used oil, most notably the acid/clay process. The acid/clay process has long been used throughout the world and was the dominant process in 1976 when National Bureau of Standards (NBS) initiated its Recycled Oil Program. Due to the environmental problems associated with the disposal of acid sludge, the acid/clay process is rapidly being displaced by new ones: e.g., hydrogenation, vacuum distillation, short-path distillation, solvent extraction. Most new processes have some pretreatment steps to remove sludge, water, and additive metals. Re-refined base oils are primarily in the 200–400 neutral range. The light ends in the original base oils are lost through evaporation during the use cycle. The very heavy ends are usually removed during re-refining.

Under the Energy Policy and Conservation Act (1975) the National Bureau of Standards is required to study re-refined lubricating base oils and develop test procedures to assess the substantial equivalency between re-refined and virgin oil products. In order to help fulfill this responsibility, a detailed study was made of the comparison between the re-refined and virgin base oil. Seventeen lubricating base oils were selected for detailed characterization in these studies, ten re-refined and seven virgin base oils. These base oils represent a cross-section of available processing technologies, crude sources, and viscosity grades. This paper describes the detailed characterization of these seventeen oils and discusses the various aspects of quality and consistency associated with re-refined base oils. Based on these results, a tentative set of test procedures is recommended for monitoring the quality and consistency of re-refined base oils for automotive applications.

21695. Hsu, S. M.; Ku, C. S.; Lin, R. S. **Relationship between lubricating basestock composition and the effects of additives on oxidation stability,** Paper in *Base Oils for Automotive Lubricants, SP-526,* pp. 29-56 (Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, 1982).

Key words: additive-base oil interaction; additive response; base oils; basestock chemical composition; correlation engine oils; lubricants; oxidation stability; oxidation test (thin-film) optimum aromaticity; re-refined base oils.

Over fifty lubricating base oils from various crude sources and processing technologies, including ten re-refined base oils, have been studied. An SE/CC additive package was added to the base oils and the effects of the additives on oxidation stability of the oils were measured by a thin film oxygen uptake test. This oxidation test has demonstrated correlation with ASTM engine sequence IIID viscosity increase results.

Chemical composition parameters such as sulfur, nitrogen, basic nitrogen, polar, saturate, and aromatic contents were systematically examined for correlation with the effects of additives on oxidation stability. Combinations of these compositional parameters were also investigated. Large differences in oxidation induction times of the various basestocks were found. Some of the differences could be related to the saturate and the sulfur content of the base oils.

21696. Ventre, F. T. **Building in eclipse, architecture in seccession,** *Prog. Archit.* **63,** No. 12, 58-61 (Dec. 1982).

Key words: architectural design; building performance; building research; building technology; capital investment; knowledge; productivity.

Paper documents gradual shifts in the Nation's investment mix and more abrupt changes in market share among the professions providing design and consulting services to the building industry. The article suggests reasons for these shifts and identified possible responses by the design and consulting professions and, particularly, by the growing community of building researchers.

21697. Unguris, J.; Seiler, A.; Celotta, R. J.; Pierce, D. T.; Johnson, P. D.; Smith, N. V. **Spin-polarized inverse photoelectron spectroscopy of solid surfaces: Ni(110),** *Phys. Rev. Lett.* **49,** No. 14, 1047-1050 (Oct. 4, 1982).

Key words: bremmstrahlung; electron spin polarization; inverse photoemission; surface magnetism.

Inverse photoemission spectra have been measured on Ni(110) at 9.7-eV photon energy with a spin-polarized electron source. Consistent with band theory, a *d*-band-derived peak is observed just above the Fermi level that corresponds to transitions to minority-spin states only, and which increases in intensity and displays a slight (0.1-eV) energy dispersion as the angle of electron incidence is increased. The inelastic background displays an unexpected nonzero ($\sim$–5%) polarization.

21698. Heinrich, K. F. J. **The accuracy of quantitation in x-ray microanalysis, particularly of biological specimens,** *Scanning Electron Microsc.* **1,** 281-287 (1982).

Key words: accuracy; counting statistics; electron probe; error propagation; metrology; microanalysis; precision; random errors; standards; systematic errors; x-ray spectrometry.

The accuracy of results of microanalytical analyses depends on errors in the measurement, separation of the signal from interferences such as background, the quality of the theoretical assumptions underlying the evaluation process, the accuracy of constants and parameters used in the evaluation, the propagation of errors through the evaluation, the quality of the reference standards, the preparation of the specimen before analysis, and the damage inflicted upon it during analysis. The meaning of the results in turn is closely related to the manner in which they expressed, and to the localization which can be achieved in microprobe analysis. The latter aspect includes the capability of the operator to orient the exciting beam towards the topographic features of interest on the specimen.

21699. Motz, J. W.; Danos, M. **Quantum noise-limited images in screen film systems,** (Proc. Application Optical Instrumentation in Medicine X (1982), New Orleans, LA, May 9-12, 1982), *SPIE* **347,** 62-66 (Society of Photo-Optical Instrumentation Engineers, Box 10, Bellingham, WA 98227-0010, 1982).

Key words: low contrast images; modulation transfer function (MTF); screen film systems; spatial resolution; x-ray images; x-ray quantum noise.

The limits imposed on the spatial resolution obtained with screen-film systems for low contrast images are determined primarily by x-ray quantum noise rather than by the spatial response (MTF curve) of the system. For 40 keV x rays incident on a HiPlus/XRP screen-film system, the x-ray quantum noise limits the spatial resolution in the density region of unity from approximately 0.2 to 1 line pair per mm for film density differences respectively in the region from .02 to 0.1. By comparison, the MTF effect over most of this region of density differences, produces less than a 10 percent degradation of the spatial resolution.

21700. Egelhoff, W. F., Jr. **Thin Ag films on Al(100),** *Appl. Surf. Sci.* **11/12,** 761-767 (1982).

Key words: clusters; epitaxial growths; photo emission; thin films.

X-ray photoelectron spectra of thin (up to 100 Å) Ag films deposited on Al(100) under ultrahigh vacuum conditions indicate that the Ag electronic structure does not converge on bulk Ag character until a thickness of around 40 Å or about 20 monolayers. This is surprising since theoretical calculations suggest convergence around 3 or 4 monolayers if the growth mode is layer by layer. This suggests the film is highly granular (at least, below about 20 monolayers). Strikingly similar data for Cu and Au films together with known properties of Au suggest that all three metals grow initially with a morphology that may roughly be described as tightly packed overlapping clusters whose diameter approximately equals the average film thickness.

21701. Kao, J. Y.; Pierce, E. T. **A study of sensor errors on building energy consumption,** *Proc. Seventh Energy Management and Controls Society Conf., Salt Lake City, UT, Nov. 14-17, 1982,* 9 pages (Energy Management and Controls Society, 1925 North Lynn Street, Suite 1002, Arlington, VA 22209, 1982).

Key words: building energy conservation; building energy consumption; building temperature control; HVAC system control; sensor error.

A computer simulation was used to examine the effects of errors in the sensors of automatic controls for HVAC systems. The simulation examined two types of sensors, dry-bulb temperature and dew point temperature, used in air handling systems. Four sensor functions were studied: outside air and return dry-bulb temperature sensor, outside air and return dew point sensor, mixed air temperature sensor, and cooling coil discharge air sensor. Errors in these sensors may result from inferior quality, improper calibration, or drift. The BLAST computer program was used to simulate errors in each of these sensor functions for a hypothetical small office building located in Washington, D.C. This building was assumed to have a constant volume terminal reheat system with a chilled water cooling coil. The computer calculations indicated that sensor errors could increase the annual energy requirements attributable to the air handling system by as much as 30 to 50 percent. Errors in the mixed air temperature sensor and the cooling coil sensor appear to be most critical for the type of HVAC studied.

21702. Whipple, T. A.; Brown, E. L. **Deformation and fracture of stainless steel castings and weldments at 4 K,** (Proc. Joining Division American Society for Metals, New Orleans, LA, Nov. 16-18, 1981), Paper in *Trends in Welding Research in the United States,* pp. 601-621 (American Society for Metals, Metals Park, OH 44073, 1982).

Key words: castings; cryogenic properties; deformation; fracture; stainless steel; weldments.

A number of stainless steel weldments and castings, that were deformed at 4 K have been examined with optical and electron microscopy. The purpose of this investigation was to assess the effects of residual delta-ferrite on the deformation and fracture mechanisms of these materials at cryogenic temperatures.

Weldments and castings have very similar microstructures, but the delta-ferrite in castings is much coarser as a result of slower solidification and cooling rates. This wide variation in the scale of the structure provides a good opportunity for the study of structure and property relationships in these materials.

It has been found that deformation and fracture are greatly influenced by the ferrite morphology. The study of the coarser structure in castings has allowed more direct observation of fracture, which has led to some preliminary conclusions concerning fracture mechanisms. Cleavage fractures of delta-ferrite particles have been observed. It appears that these fractures, although not forming a continuous crack path, assist in the void formation in the ductile austenite matrix. Another observed crack propagation mechanism is that of void nucleation near the austenite delta-ferrite interface. Although interface separation has not been observed, the inhomogeneous deformation near the interface appears to cause premature void nucleation and growth. The occurrence of one of the above mechanisms rather than the other depends on a number of factors, including ferrite morphology and the properties of the two phases. The morphology and properties, in turn, depend on both the alloy composition and solidification conditions.

21703. Caswell, R. S.; Coyne, J. J.; Randolph, M. L. **Kerma factors of elements and compounds for neutron energies below 30 MeV,** *Int. J. Appl. Radiat. Isot.* **33,** No. 11, 1227-1262 (1982).

Key words: absorbed dose; cancer therapy; energy transfer coefficients; kerma factors; neutrons; secondary charged particles.

Based on recently calculated tables of neutron kerma factors for 19 elements, kerma factors for 44 compounds have been calculated. The neutron energy range covered extends from 8 eV to 30 MeV. Because of the increased uncertainty in the nuclear data at the higher energies, care must be taken when the tables are applied above 15 MeV. The user must also be careful when applying these results to compounds at low neutron energies, because of the difficulties in associating kerma values with molecular materials at energies below ~30 eV.

21704. Chen, T. M.; Brauer, G. M. **Solvent effects on bonding organosilane to silica surfaces,** *J. Dent. Res.* **61,** No. 12, 1439-1443 (Dec. 1982).

Key words: bonding to silica; n-propylamine as promoter; silanization; silica composite; silica-silane bonding; solvent effect in silanization; stability of silica-silane bond; γ-methacryloxypropyltrimethoxysilane.

Interfacial bonding and stability of γ-methacryloxypropyltrimethoxysilane with silica surfaces have been studied by means of infrared spectroscopy. The addition of n-propylamine enhances silanization of γ-methacryloxypropyltrimethoxysilane to silica surfaces in normal aliphatic hydrocarbons, and cyclohexane yields a more water-resistant silica-silane bond, and improves the diametral tensile strength of the composite.

21705. Paffenbarger, G. C.; Rupp, N. W.; Patel, P. R. **Dimensional changes of a high-tin content amalgam,** *J. Dent. Res.* **61,** No. 12, 1423-1426 (Dec. 1982).

Key words: age changes; amalgam-composition; dental amalgam; setting changes; silver-tin alloys; silver-tin amalgam.

Amalgam made with Brewster Alloy (62% Ag, 33% Sn, 5% Cu, and 0.2% Zn) had little or no dimensional change during 24 h at 23°C.

Brewster amalgam stored for five yr in air expanded 186, 68, and 14 μm/cm at 60, 37, and 23°C, respectively.

Nearly "stable" conditions were approached at about 50 mo.

21706. McIlrath, T. J.; Lucatorto, T. B. **Observations of the effect of increasing core charge on Rydberg spectra in the Xe isoelectronic sequence,** *J. Phys. Colloq.* **C2,** No. 11, 255-263 (Nov. 1982).

Key words: atomic spectra; autoionization; Ba^{++}; laser excited photospectroscopy; MQDT; Rydberg series.

The Rydberg spectra and autoionizing levels of atoms can show large variations along an isoelectronic sequence. These variations reflect the effect of core structure on high lying levels. We have obtained the spectrum of Ba^{++} in absorption and compare it with the isoelectronic Xe spectrum. The dramatic decrease in autoionization width with increasing core charge is explained through an analysis based on MQDT. The autoionizing widths are shown to be an

especially sensitive indicator of the importance of correlations and term dependence along the isoelectronic sequence.

21707. McLaughlin, W. L.; Jarrett, R. D., Sr.; Olejnik, T. A. **Dosimetry,** Chapter 8 in *Preservation of Food by Ionizing Radiation,* **1,** E. S. Josephson and M. S. Peterson, eds., 189-245 (CRC Press, Boca Raton, FL, 1982).

Key words: calorimetry; chemical dosimetry; dose distribution; dosimetry; electron beams; ferrous sulfate dosimeters; food preservation; gamma radiation; process control; quality control; radiation processing; radiochromic dosimetry.

This chapter deals with methods and systems for measuring radiation quantities, in particular the absorbed dose which can be released to each biological effect of interest in the irradiation of foods. Primary reference dosimetry techniques for calibrating routine dosimeters are described, as well as ways to apply these measurement devices in research, commissioning, and quality control of radiation process. An important consideration is the determination of dose distributions in food items and the use of these data to ascertain with suitable statistical controls the dose extremes and the dose uniformity ratio in a process run. A large number of dosimeter systems is included here. It must be emphasized that only systems that are well-established and proven under practical processing conditions should be accepted for routine use. The less familiar systems are those with possibilities for future applications, once they have proven "tried and true."

21708. Egelhoff, W. F., Jr. **Nitric oxide reduction,** Chapter 9 in *The Chemical Physics of Solid Surfaces and Heterogeneous Catalysis, Fundamental Studies of Heterogeneous Catalysis,* D. A. King and D. P. Woodruff, eds., **4,** 397-426 (Elsevier Scientific Publ. Co., New York, NY, 1982).

Key words: catalysis; dissociation; nitric oxide; reduction; review article.

This article provides a review of the recent literature on the subject of nitric oxide reduction by catalytic reactions. It covers both the most notable research on nitric oxide reduction by supported catalysts and the research on nitric oxide interactions with single crystal surfaces. The research on supported catalysts has made it clear that nitric oxide reduction is a complex set of interwoven chemical reactions which are poorly understood. Among the major outstanding problems are the necessity of using rare, expensive elements such as rhodium, the lack of any nitric oxide reduction catalysts which can operate in excess oxygen, and the commonly observed production of ammonia by the catalysts actually in use. Basic research on the interactions of nitric oxide with single crystal surfaces has so far been quite limited in scope but in some cases may provide insights into the fundamental chemical physics of nitric oxide reduction. Platinum and palladium seem to be poor nitric oxide reduction catalysts due to an activation energy barrier which greatly retards the rate of nitric oxide dissociation. Rhodium and reuthenium seem to function well in nitric oxide reduction due to their high rate of nitric oxide.

21709. Weiss, G. H.; Rubin, R. J. **Random walks: Theory and selected applications,** *Adv. Chem. Phys.* **52,** 363-505 (1983).

Key words: continuous time random walks; correlated diffusion; first passage time; generalized master equation; motion of microorganisms; multistate random walks; polymer chain adsorption; polymer chain dimensions; random walks; trapping models; wormlike chains.

The theory of discrete step random walks in discrete time and continuous time is outlined. The relation between continuous time random walks and a generalized master equation is developed. In the limit of long walks, the following asymptotic properties are discussed: 1) return to the origin, 2) number of distinct sites visited, 3) central limit results, and 4) walks with steps of infinite variance. The effect of boundary conditions and traps on random walk behavior, maximum displacements and spans and the application of Wald's identity for first passage time problems is treated in a chapter devoted to boundary conditions.

Applications of the general theory in four areas are discussed: 1) *polymer physics,* freely jointed chains, size and shape parameter of random flight chains, determination of distribution of end-to-end distance from moments, the wormlike chain, and polymer chain adsorption at a surface, 2) *multistate random walks,* 3) *solid state physics,* correlated diffusion models, trapping models, nonlattice models, transport in disordered structures, and random walk in ID with disordered rate constants, and 4) *models of the motion of microorganisms.*

21710. Havrilla, G. J.; Weeks, S. J.; Travis, J. C. **Continuous wave excitation in laser-enhanced ionization spectrometry,** *Anal. Chem.* **54,** No. 14, 2566-2570 (Dec. 1982).

Key words: analytical flame spectrometry; atomic spectrometry; continuous wave laser; diffusion; laser enhanced ionization; laser spectrometry; matrix effects; mobility.

Continuous wave (CW) excitation in laser-enhanced ionization (LEI) exhibits distinct advantages when compared to pulsed excitation. Limits of detection are given for eight elements determined by continuous wave excited LEI. The LEI signal responses for both pulsed and continuous wave excitation are compared. Results indicate a greater resistance to matrix effects for CW excitation than for pulsed excitation.

21711. Eby, R. K.; Broadhurst, M. G.; Davis, G. T.; Sanchez, I. C.; Fanconi, B. M.; Wang, F. W.; Cassel, J. M. **Polymer science and standards division,** *Kobunshi/High Polym., Japan* **31,** 1026-1029 (Nov. 1982).

Key words: history; industrial; National Bureau of Standards; polymers; program; research.

There has been research on polymeric materials at the U.S. National Bureau of Standards since its early days. The background and function of the Polymer Science and Standards Division is reviewed. The present program is discussed in the context of the large, rapidly growing, and economically important U.S. synthetic polymer industry which contributes strongly to national productivity. The program develops concepts, measurements, standards, and data that can be used to insure the reliable performance and effective use of polymers in solving national problems including the growth of industrial productivity, improved national security, more efficient government, improved health, and better materials utilization.

21712. Simiu, E.; Batts, M. E. **Wind-induced cladding loads in hurricane-prone regions,** *J. Struct. Div. Am. Soc. Civ. Eng.* **109,** No. 1, 262-266 (Jan. 1983).

Key words: building (codes); climatology; hurricanes; statistical analysis; structural engineering; wind (meteorology); wind direction.

A brief review is presented of a procedure for estimating wind-induced pressures on cladding which is rigorous statistically and convenient for practical application. The procedure, as originally proposed in Ref. 5, takes into account the dependence of the extreme wind speeds upon direction, but is not applicable to the estimation of cladding loads in hurricane-prone regions. An extension of that procedure for application to such regions is then presented. The theory that makes this extension possible is explained, and a computer program for calculating cladding pressures induced by hurricane winds is described. Examples are given which show that procedures which do not take into account the dependence of the extreme wind speeds upon direction may result in gross over-estimates of cladding pressures, and inevitably result in strongly nonuniform probabilities of cladding failure for the various panels of a building facade.

21713. Haber, S. **Personel scientific computers,** *J. Wash. Acad. Sci.* **72,** No. 3, 87-97 (Sept. 1982).

Key words: computers; desktop computers; integrated circuits; mathematical software; microcomputers; personal computers; programming languages; scientific computers; very-high-level languages.

This paper discusses the sorts of small, low-priced computers that are now available for scientific work, and that are expected to become available during this decade. The background technological developments are described briefly and projections are made of the capabilities that may be expected in desktop computers. Software questions that are especially relevant to the use of such computers are taken up. It is suggested that some software developments may lead

scientists to extend the ways in which they use computers.

21714. Broadhurst, M. G.; Bur, A. J.; Schwartz, R. B. **The effect of neutron irradiation on electric conductivity in cellulose acetate,** *Radiat. Prot. Dosimetry* **3,** No. 1/2, 107-108 (1982).

Key words: cellulose acetate; dosimetry; humidity; neutron irradiation; resistivity.

Resistivities of cellulose acetate (CA) were measured before and after neutron irradiation in order to investigate the possibility of using this material for neutron dosimetry. Following the work by Fadel, which showed a 50% decrease in resistivity after irradiation with AM-Be neutrons (average energy=4.5 MeV) to a fluence of 10^9 cm^{-2}, we have irradiated our samples with ^{252}Cf neutrons (average energy= 2.1 MeV) to a fluence of 3.18×10^9 cm^{-2}. Since the resistivity of CA is a sensitive function of humidity, resistivities of control samples were also measured and these controls were subjected to the same storage conditions and humidity controls as the irradiated samples. Our measurements showed that the decrease in resistivity for the irradiated samples was only about 10% when compared to the control samples. We therefore conclude that it will be very difficult to use the phenomenon of resistivity change in CA as the basis of a practical neutron dosemeter for personnel protection.

21715. Miller, A.; McLaughlin, W. L. **Calculation of the energy dependence of dosimeter response to ionizing photons,** *Int. J. Appl. Radiat. Isot.* **33,** 1299-1310 (1982).

Key words: alanine dosimeter; cavity theory; ceric sulfate dosimeter dosimetry; electrons; energy absorption coefficients; energy dependence; ethanol chlorobenzene dosimetry; gamma radiation; glutamine dosimeter; lithium fluoride dosimeter; photons.

Using a program in BASIC applied to a desk-top calculator, simplified calculations provide approximate energy dependence correction factors of dosimeter readings of absorbed dose according to Bragg-Gray cavity theories. Burlin's general cavity theory is applied in the present calculations, and certain limitations of the theory are considered. Examples of the use of the program are given for ^{60}Co γ-ray irradiation of a LiF dosimeter held in aluminum and for evaluation of the influence of changes in broad γ-ray spectra on the response of several dosimeters. The BASIC program and typical data plots as given here are available for certain dosimeter probe materials and combinations used with intermediate energy photon spectra (0.01–100 MeV).

21716. Kafadar, K.; Rice, J.; Spiegelman, C. **One-sided trimming in small samples with asymmetric contamination,** *Commun. Statist. Theor. Meth.* **12,** No. 4, 477-496 (1983).

Key words: location estimation; mean squared error; minimax estimation; outliers; sensitivity curve.

An estimator for location, given a sample of only four or five observations, is proposed. The underlying distribution of the sample may (with probability p) be contaminated by an outlier from a rightly-skewed distribution. The estimator minimizes the maximum mean squared error over all values of p. In fact, there exists an estimator which is unbiased in both the outlier-free and extreme-outlier cases, but its mean square error is substantially higher than the mean squared error for the minimax estimator. Mean squared errors for various underlying distributional situations are calculated and compared with those of other location estimators such as the mean and the median.

21717. Frohnsdorff, G.; Dise, J. R.; Clifton, J. R. **A reference sample program for fly ashes as a stimulus to technological progress,** *Proc. Workshop Res. Develop. Needs for Use of Fly Ash in Cement Concrete, Subsec. 5.4,* 5-14–5-21 (Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA 94304, Sept. 1982).

Key words: blended cement; cement; data base; fly ash; reference sample.

The ultimate level of acceptance of fly ashes for use in concrete will depend upon their performance in concrete and upon the predictability of their performance. The desired level of knowledge about fly ash performance and uniformity is not yet available because of the scarcity of suitable data for the testing of hypotheses about factors affecting performance and also uncertainty about the appropriateness and reliability of current standard tests of performance. A practical way of simultaneously contributing to the data base for research and promoting assurance of fly ash quality would be establishment of a fly ash reference sample program. The potential benefits are: 1) improved quality of standard testing, 2) improved knowledge of differences between fly ashes, 3) establishment of a large data base for use by researchers and others, and 4) establishment of a source of well-characterized fly ashes for further research. An ASTM-sponsored reference sample program for blended cements, specifically portland-fly ash cements, was established in 1979. The establishment of a similar reference sample program for fly ashes for use in concrete is recommended.

21718. Church, E. L.; Howells, M. R.; Vorburger, T. V. **Spectral analysis of the finish of diamond-turned mirror surfaces,** *SPIE* **315,** 202-217 (1981).

Key words: diamond turning; light scattering; optical mirror; optical surface; power spectral density; rms roughness; stylus; surface roughness; surface topography; synchrotron light; total integrated scatter.

This paper discusses the effects of surface topographic scattering on the performance of optical elements and illustrates the results in terms of the focussing mirrors of the Brookhaven plane-grating monochromator. Performance figures are described in terms of the power spectral density of the surface roughness, where the contributing range of surface spatial wavelengths, d, lies between the wavelength of the operating radiation and the aperture of the part: from nanometers to centimeters. This is considerably greater than the range included in "total-integrated scatter" or "TIS" measurements involving visible light at normal incidence: d=0.65 to 12 μm. In order to explore the contributions of longer surface wavelengths we have measured the profiles of several optical-quality surfaces—polished, diamond-turned and turned-and-polished—with a mechanical stylus gauge, and have estimated their power spectral densities over the range d=2 to 500 μm. The power spectra generally increase with increasing wavelength, although the spectral shapes vary widely. Contributions from d>12 μm are significant in all of the cases examined, and are completely dominant in several cases. These preliminary results show that any useful characterization of surface finish must involve the power spectral density of its surface roughness over an extended range of surface wavelengths, including the critical long-wavelength region. A general discussion of measurement techniques and performance figures is given to provide a rational basis for the systematic study of these issues.

21719. Houghton, R. C., Jr. **Software tools for quality software development,** *Proc. 24th Annu. COCACM Symp., Columbus, OH, May 9, 1980,* 5 pages (ACM—Central Ohio Chapter, P.O. Box 3089, Columbus, OH 43210, May 9, 1980).

Key words: programming aids; software engineering; software tools.

This paper summarizes the types and functions of software tools in the major areas of concern to quality software development. Some NBS efforts to increase the effective use of software tools are reported.

21720. Poliakoff, E. D.; Dehmer, J. L.; Parr, A. C.; Leroi, G. E. **Fluorescence polarization as a probe of molecular autoionization,** *J. Chem. Phys.* **77,** No. 10, 5343-5345 (Nov. 15, 1982).

Key words: fluorescence; photoionization; polarization.

The polarization of fluorescence from the CO_2^+ A $^2\Pi_u$ to CO_2^+ X $^2\Pi_g$ state was used. The National Bureau of Standards SURF II storage ring was used to obtain monochromatic photons from 720 Å to 690 Å as an excitation source. The polarization of fluorescence shows pronounced variations in autoionization resonance regions.

21721. Paffenbarger, G. C.; Rupp, N. W.; Coyne, M. P. **Dimensional changes of four amalgams after five years of storage in air at 60, 37, and 23°C,** *J. Dent. Res.* **61,** No. 12, 1427-1430 (Dec. 1982).

Key words: alloy; amalgam; dimensional change; expansion; metal.

Amalgam cylinders, 4 mm in diameter and 8 mm long, made from four alloys, expanded lengthwise from 204 to 220 at 60°C, 18 to 46 at 37°C, and 6 to 35 at 23°C, μm/cm, respectively, after storage in air at the indicated temperatures for five yr.

21722. Kaufman, V. **The spectrum of neutral sulfur (S I) in the vacuum ultra-violet,** *Phys. Scr.* **26,** 439-442 (1982).

Key words: energy levels; ionization energy; spectrum; sulfur; vacuum ultraviolet; wavelengths.

Observations and measurements were made of 114 lines of S I between 1157 Å and 2169 Å in the first, second and third orders of the NBS 10.7-m normal incidence vacuum spectrograph. All of these lines involve transitions to levels of the $3s^23p^4$ ground configuration. Two lines at 4152 and 4157 Å were also measured. Wavelength uncertainties range from less than ±1 mÅ up to ±3 mÅ. Energy levels and their uncertainties derived from these data are given. The ionization energy is 83 559.3±0.3 cm^{-1}.

21723. Sugar, J.; Kaufman, V. **Resonance lines in the Pd I isoelectronic sequence: I VIII to Ho XXII,** *Phys. Scr.* **26,** 419-421 (1982).

Key words: Dy; Eu; Gd; Ho; Pd I sequence; Sm; Tb; wavelengths.

Identification of resonance lines of $4d^94f$ and $4d^95p$ configurations of the Pd I isoelectronic sequence is extended from Nd XV through Ho XXII and for Xe IX. Spectra were obtained with a high voltage spark and photographed with a 10.7 m grazing incidence spectrograph. Calculations of the levels and eigenvectors confirm the identifications and the observed relative intensities of the lines.

21724. Parks, E. J.; Johannesen, R. B.; Brinckman, F. E. **Characterization of organometallic copolymers and copolymerization by size-exclusion chromatography coupled with trace metal- and mass-sensitive detectors,** *J. Chromatogr.* **255,** 439-454 (1983).

Key words: acetic acid; adsorption; copolymer; differential refractive index; fractionation; graphite furnace atomic absorption; methylmethacrylate; organotin; SEC; tributyltin acetate; tributyltin methacrylate.

An important class of controlled-release, biocidal triorganotin-containing copolymers (OPMs) is produced by the free radical initiated reaction of a triorganotin methacrylate (typically tributyltin methacrylate, TBTM) with methyl methacrylate. In earlier studies, we have demonstrated that size-exclusion chromatography (SEC) on μStyragel, coupled with an in-line graphite furnace atomic absorption detector (GFAA) quantifies at least two well-resolved tin-bearing molecular weight fractions observed in many different commercial OMP formulations: a polymer fraction, and, probably, unreacted TBTM. When tetrahydrofuran is used as the eluent, a third component, believed to be an ionic tin-containing compound, is adsorbed and slowly eluted. We now verify that a dilute solution of acetic acid in the tetrahydrofuran efficiently desorbs this species.

If a one percent solution of acetic acid in tetrahydrofuran is introduced into the mobile phase as a discrete, injected volume several minutes after the injection of the polymer formulation, there appears in the SEC-GFAA chromatogram: the polymer peak, the monomer peak, several minutes of tailing, and, finally a spike, with little additional tailing.

However, when a one percent solution of acetic acid in tetrahydrofuran is used as the eluent, the high polymer peak is substantially reduced in size owing to acid hydrolysis of polymeric esters to which the tributyltin is chemically bonded; the low-molecular-weight peak is substantially increased. Thus, delayed injection of acetic acid serves the purpose of avoiding acid hydrolysis of the polymer.

In the work described, only trace amounts of acetic acid (0.5 μl to 5.0 μl) were introduced by injection into the tetrahydrofuran mobile phase, whereas prolonged exposure to dilute solutions of acetic acid in tetrahydrofuran—e.g., introduced by a gradient method—could be expected to shorten column life.

Partial decomposition of esters was found in partially reacted OMPs after one year of storage at -78°C.

21725. Laufer, A. H.; Yung, Y. L. **Equivalence of vinylidene and $C_2H_2^*$: Calculated rate constant for vinylidene abstraction from CH_4,** *J. Phys. Chem.* **87,** No. 1, 181-183 (1983).

Key words: abstraction; mechanism; methane; radicals; rate constants; vinylidene.

The structure of the long-lived intermediate, $C_2H_2^*$, has been shown to be equivalent to the vinylidene radical ($H_2C{=}C$) in the case of the acetylene photosensitized decomposition of CH_4. Rate constants for abstraction from CH_4 by both vinylidene and vinyl radicals have been calculated using the semi-empirical bond energy-bond order (BEBO) and bond strength-bond length (BSBL) techniques.

21726. Chiu, Y. N. **Triplet-to-singlet cyclopropylidene—Allene rearrangement. A molecular example of spin angular momentum coupling in orthogonal π systems,** *J. Am. Chem. Soc.* **104,** No. 25, 6937-6942 (1982).

Key words: allene; cyclopropylidene; molecular rearrangement; orthogonal π-systems; spin-orbital interaction; triplet carbene.

Valence-bond and molecular-orbital theories are used to support each other in showing the feasibility of triplet-to-singlet cyclopropylidene-allene rearrangement. It is shown that the symmetry of the orbitals involved and the symmetry of the spin-orbit interaction operators demand an orbitally rotated state corresponding to an orthogonal allene, so as to have a nonvanishing spin-orbit matrix element. As a result, singlet *orthogonal* allene will have a favorable transmission coefficient from triplet cyclopropylidene. This is believed to be general in all perpendicular π-electron systems. Use is made of Hückel-Möbius orbitals for *both* the reactant and the product, to ensure symmetry correlation and orbital following. In addition, a method is devised to correlate an *individual* electron in a spin orbital that circumvents the conventional restriction of having to correlate a spatial orbital with *both* of the two electrons at once. This method simultaneously accounts for molecular-orbital configuration interaction and ensures the correct dissociation limit. It is also postulated that the intermediate state involves angular momentum coupling of two triplets containing a total of four electrons. The resultant singlet-state function correlates well with that of the two orthogonal π bonds of the product allene.

21727. Jenkins, D. R.; Knab, L. I.; Mathey, R. G. **Laboratory studies of infrared thermography in roofing moisture detection,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 779,* pp. 207-220 (1982).

Key words: heat transmission; infrared detection; insulation; moisture in roofing; nondestructive testing; roofing; temperature measuring instruments; thermal resistance; thermography.

A laboratory evaluation of infrared thermography for detecting moisture in roofing specimens is presented. This study was based on laboratory controlled specimen preparation and testing conditions. For steady state heat flow, and in a few cases, transient heat flow, the effects of moisture on the surface temperature of the roofing specimens were determined by thermocouples and thermography. Surface temperatures determined by infrared thermography were shown to correlate well with the thermocouple temperatures. Two system performance parameters were assessed: threshold moisture content and the slope of the instrument response versus moisture content curve.

21728. Weiss, A. W. **Correlation corrections to energy levels of Fe XXI,** *J. Phys. B: At. Mol. Phys.* **15,** 4331-4338 (1982).

Key words: atomic structure; correlation; Pauli approximation; relativistic corrections.

L-shell correlation energies are computed for the non-relativistic states of $2s^22p^2$, $2s2p^3$ and $2p^4$ of Fe^{20+}. These results are combined with Pauli approximation intermediate coupling calculations to derive residual correlation corrections to relativistic multiconfiguration Dirac-Fock calculations. The excitation energies are significantly improved, and it is concluded that such hybrid schemes may be considered reliable to within 2000 cm^{-1}, at least for ions at this stage of ionisation.

21729. Younger, S. M. **Dielectronic recombination rate coefficients for highly ionized heliumlike ions,** *J. Quant. Spectrosc. Radiat. Transfer* **29,** No. 1, 67-73 (1983).

Key words: aluminum; argon; carbon; dielectronic recombination; helium isoelectronic sequence; iron.

Dielectronic recombination rate coefficients have been calculated in a distorted wave approximation for several highly ionized heliumlike ions. Special attention is given the role of intercombination stabilizing transitions. The results are in reasonable agreement with the simple formula of Burgess.

21730. Younger, S. M. **Electron ionization rate coefficients for highly ionized iron and scandium,** *J. Quant. Spectrosc. Radiat. Transfer* **29,** No. 1, 61-66 (1983).

Key words: distorted wave theory; electron ionization; iron; scandium.

Cross sections and rate coefficients for the electron ionization of Fe(IX)–(XV) and Sc(IV)–(X) have been computed in a distorted wave Born exchange approximation. The scaled cross section for ejection of a $3p$ electron was found to be roughly linear in the number of $3p$ electrons in the ion. Analytic fits to the distorted wave cross sections and rate coefficients are included.

21731. Melmed, A. J.; Ceyer, S. T.; Graham, W. R. **Reply to comment on "A LEED inquiry into the question of reconstruction of {001}Nb",** *Surf. Sci. 124,* p. L11 (1983).

Key words: LEED; Nb; reconstruction; surface structure.

This is a reply to a comment on the authors' publication "A LEED Inquiry into the Question of Reconstruction of (001) Nb".

21732. Pine, A. S.; Lafferty, W. J. **Rotational structure and vibrational predissociation in the HF stretching bands of the HF dimer,** *J. Chem. Phys.* **78,** No. 5, 2154-2162 (Mar. 1, 1983).

Key words: Doppler-limited resolution; HF dimer; HF stretching vibrations; hydrogen bonding; infrared spectrum; rovibrational structure; tunable laser; vibrational predissociation.

The rotational structure in the HF stretching bands of the HF dimer has been recorded with nearly Doppler-limited resolution using a tunable difference-frequency laser spectrometer and a long-path cell held at low temperatures and pressures. Two bands are observed; the higher frequency band, corresponding principally to the "free" hydrogen stretch, has the appearance of a B-type or perpendicular band with two prominent Q subbranches ${}^{R}Q_0$ and ${}^{P}Q_1$; the lower band is an A-type or parallel band arising primarily from the "bonded" hydrogen vibration. The $K=0$ subbands of both vibrations have been fully assigned and fit with polynomial expansions in $J(J+1)$ to yield ground state constants in excellent agreement with a previous microwave resonance molecular beam study of the HF dimer. The subbands exhibit doubling and 10:6 intensity ratios for alternate J indicative of the internal rotation tunneling motion proposed in the microwave study. A pressure-independent broadening of the lines to about twice the Doppler width, attributed to vibrational predissociation, is observed for the bonded hydrogen stretching band.

21733. Kurylo, M. J.; Murphy, J. L.; Knable, G. L. **Rate constant measurements for the reaction of Cl atoms with nitric acid over the temperature range 240–300 K,** *Chem. Phys. Lett.* **94,** No. 3, 281-284 (Jan. 21, 1983).

Key words: chlorine atoms; kinetics; nitric acid; rate constant; resonance fluorescence; stratosphere.

Rate constants for the reaction between Cl atoms and $HONO_2$ were measured at 243, 264, and 298 K by the flash photolysis resonance fluorescence technique. The data can be fit to the Arrhenius expression $k_1=5.1\times10^{-12}\exp(-1700/T)$ cm^3 molecule^{-1} s^{-1} and indicate that the reaction is unimportant in stratospheric Cl atom removal. Sources of measurement error in this and earlier studies are discussed.

21734. Kurylo, M. J.; Knable, G. L.; Murphy, J. L. **A reinvestigation of the Cl+ClONO$_2$ reaction by flash photolysis resonance fluorescence,** *Chem. Phys. Lett.* **95,** No. 1, 9-12 (Feb. 18, 1983).

Key words: chlorine atoms; chlorine nitrate; flash photolysis; kinetic; rate constant; resonance fluorescence; stratosphere.

The reaction of Cl atoms with chlorine nitrate has been reinvestigated by flash photolysis resonance fluorescence over the temperature range 220–296 K. The new results can be fit to the Arrhenius expression $k_1=7.3\times10^{-12}\exp(165/T)$ cm^3 molecule^{-1} s^{-1}, in good agreement with another recent study but significantly different from our earlier work. Reasons for these differences are suggested and their significance discussed.

21735. Magerl, A.; Rush, J. J.; Rowe, J. M.; Richter, D.; Wipf, H. **Local hydrogen vibrations in Nb in the presence of interstitial (N,O) and substitutional (V) impurities,** *Phys. Rev. B* **27,** No. 2, 927-934 (Jan. 15, 1983).

Key words: defects; hydrogen in metals; local potential; neutron scattering; trapping; vibration.

We have measured the hydrogen vibrations in $NbV_{0.008}H_{0.005}$, $NbN_{0.004}H_{0.003}$, and $NbO_{0.011}H_{0.010}$ between 295 and 4 K. In the case of $NbV_{0.008}H_{0.005}$, these spectroscopic measurements suggest a down shift of the phase boundary for H precipitation by about 30 K. At low temperatures we find excitations at 117 and 166 meV, which are characteristic of an ordered hydride phase. On the contrary, O or N interstitial defects totally suppress the precipitation of H due to trapping. The vibrational energies of H trapped by N (or O) are 106 (107) and 160 (163) meV, which are very close to energies measured for free H in $NbH_{0.005}$ at 295 K. This clearly indicates that H atoms in these systems are trapped at relatively unperturbed tetrahedral-type sites. The peak shapes are distinctly different for the trapping and the nontrapping defects. Several mechanisms that can cause the large widths observed are discussed.

21736. Knab, L, I.; Clifton, J. R. **Cumulative damage of reinforced concrete subjected to repeated impact,** *Cem. Concr. Res.* **12,** 359-370 (1982).

Key words: damage; fiber reinforced concrete; impact penetration resistance; ultrasonic.

This study was performed to develop methods of measuring the cumulative damage of steel reinforced concrete slabs subjected to repeated impact. Cumulative damage was monitored by measuring the crater depth and the reduction in ultrasonic pulse velocity across the impact region. Crater depth generally increased with increasing number of impacts and therefore was determined to be a reasonable indicator of cumulative damage. The percent reduction in velocity generally increased with increasing number of impacts up to about 40 percent or more of the total number of impacts to failure. Beyond that, interpretation of the ultrasonic results with respect to the failure mechanism appears necessary. The addition of steel fibers to the bar grid reinforcement resulted in substantial increases (about 2 to 7 times or more) in the total number of impacts to failure as compared to specimens with only bar grid or expanded metal placed at the midpoint of the slab thickness.

21737. Falk, R. A.; Dunn, G. H. **Electron-impact ionization of Be$^+$,** *Phys. Rev. A* **27,** No. 2, 754-761 (Feb. 1983).

Key words: Be^+; crossed beams; electron-ion collisions; excitation autoionization; ionization; Li isoelectronic sequence.

The electron-impact ionization cross section for Be^+ has been measured from threshold to 1600 eV with an absolute uncertainty of 8%. The cross section has a peak value of 46.5×10^{-18} cm^2 at an energy of ~50 eV, and structure ascribed to the excitation autoionization of the $1s2s2p$ state at 118.5 eV is observed. Calculations using the semiempirical formula of Lotz for direct ionization and the semiempirical effective Gaunt-factor formula for excitation autoionization give summed cross-section values which agree well with the experiment over the entire energy range. Comparisons are also made with other calculations and cross sections in the literature.

21738. Huennekens, J.; Gallagher, A. **Cross sections for energy transfer in collisions between two excited sodium atoms,** *Phys. Rev. A* **27,** No. 2, 771-784 (Feb. 1983).

Key words: sodium; energy transfer.

We have measured cross sections, σ_{nL}, for the excitation transfer process $Na(3P)+Na(3P)\rightarrow Na(3S)+Na(nL)$, where nL is the $4D$ or $5S$ level. Our results are $\sigma_{4D}=23$ Å$^2\pm35\%$ and $\sigma_{5S}=16$ Å$^2\pm35\%$ at $T\sim600$ K. To obtain these cross sections we have used pulsed excitation and measured the intensities of $4D$, $5S$, and $3P$ fluorescence emissions, and the spatial distribution of excited atoms resulting from radiation diffusion, as well as the excited atom density as a function of time. Additionally, we have accounted for (time-dependent) radiation trapping of $3P$ and nL level radiation and for the resulting anisotropies of these fluorescence emissions. Comparisons of our results with theory have been made, and their relevance to other experiments is discussed.

21739. Falk, R. A.; Dunn, G. H.; Gregory, D. C.; Crandall, D. H. **Measurement of the contribution of excitation autoionization to electron-impact ionization of ions: Ti^{3+}, Zr^{3+}, Hf^{3+}, and Ta^{3+},** *Phys. Rev. A* **27,** No. 2, 762-770 (Feb. 1983).

Key words: crossed beams; cross sections; electron impact; excitation-autoionization; Hf^{3+}; ionization; Ta^{3+}; Ti^{3+}; Zr^{3+}.

Measurements were made of the cross section for electron-impact single ionization of the transition-element ions Ti^{3+}, Zr^{3+}, Hf^{3+}, and Ta^{3+} for an electron-energy range from threshold to 1000 eV. The cross sections are enhanced by as much as a factor of 20 due to excitation autoionization primarily involving $\Delta n=0$ transitions, $np^6nd^m\rightarrow np^5nd^{m+1}$. Comparisons with recent theoretical predictions show reasonable agreement between measured and predicted positions of the autoionization states; however, the magnitudes of the theoretical cross sections are greater than the experimental values by a factor of approximately 2.5.

21740. Kagann, R. H.; Elkins, J. W.; Sams, R. L. **Absolute band strengths of halocarbons F-11 and F-12 in the 8- to 16-μm region,** *J. Geophys. Res.* **88,** No. C2, 1427-1432 (Feb. 20, 1983).

Key words: band strengths; Fourier transform infrared spectroscopy (FTIR); halocarbon F-12; halocarbons F-11; infrared.

The infrared strengths of three vibrational band systems of halocarbon F-11 and four vibrational band systems of halocarbon F-12 in the 'atmospheric window' between 8 and 16 μm were measured at 296±1 K using a Fourier transform infrared spectrometer. These results were obtained at a maximum instrumental resolution of 0.06 cm^{-1}. Our measurements of the total infrared band strengths for F-11 and F-12 would indicate approximately 17% and 5% greater absorbance, respectively, than those strengths used in recent greenhouse warming calculations by Ramanathan (1975), Wang et al. (1976), and Lacis et al. (1981), and consequently, a corresponding increase in the possible atmospheric warming effect by these halocarbons.

21741. Scheer, M. D. **Thermal dehydration kinetics of disaccharides,** *Int. J. Chem. Kinet.* **15,** 141-149 (1983).

Key words: disaccharide dehydration; kinetics; mechanism; temperature dependence.

The vacuum decomposition of sucrose and cellobiose has been observed in the 150–250°C temperature range. The predominant decomposition product of both sugars is H_2O with less than 5% CO, CO_2, CH_2O, CH_3CHO, CH_3OH, and C_2H_5OH formed. The detailed rates and temperature dependences suggest that with the possible exception of C_2H_5OH, the minor products are formed in secondary reactions of the dehydration products. Further it is shown that the so-called "melting with decomposition" of a sugar is in reality a high-temperature dissolution of the disaccharide in the eliminated water.

21742. Thomson, R. M.; Sinclair, J. E. **Mechanics of cracks screened by dislocations,** *Acta Metall.* **30,** 1325-1334 (1982).

Key words: COD; elastic two-dimensional medium; force; fracture mechanics; singularities; stress.

We develop a general theorem for the force on singularities in an elastic two-dimensional medium in terms of the residues of the stress at the singularities. This theorem is then applied to a sharp crack screened by a cloud of dislocations. A total fracture criterion can then be derived in principle by specifying the local cleavage condition at the crack and the lattice resistance of the dislocations. The COD of the crack is shown to be given by the total screening Burgers vector of the dislocation cloud and the wake of a moving crack is discussed in terms of the resistance to moving the screening cloud. Finally, limitations of the model are discussed in terms of the geometrical effects on the cleavage plane caused by blunting the crack.

21743. Weertman, J.; Lin, I. H.; Thomson, R. **Double slip plane crack model,** *Acta Metall.* **31,** No. 4, 473-482 (1983).

Key words: cleavage plane; crack model; cyclic loading; elastic enclave; stationary crack; stress intensity.

In this paper a simple crack model is proposed and the behavior of this crack under stress is explored. The crack consists of an ordinary Griffith crack, but on either side of this crack, at a distance w, exist two slip planes that are parallel to the crack plane. It is assumed that slip can only take place on these two planes. Elsewhere the material is elastic. When w is set equal to zero the crack becomes a Bilby-Cottrell-Swinden crack. This crack model simulates in a simple way the elastic crack tip enclave model of a crack. Because w has a finite value the material around the crack tip is elastic. The crack is considered to be stressed in either mode II (plane strain shear) or mode III (anti-plane strain shear). It is found that for a virgin, stationary crack the stress intensity factor at the crack tip is equal to the conventional stress intensity factor when the stress is raised under a monotonically increasing load. However, when the crack tip advances under such a load the crack tip stress intensity factor is smaller than the conventional stress intensity factor. The fracture stress is proportional to the surface energy of the solid raised to a power. In general, this power is not equal to one half. For cyclic loading by using qualitative arguments it is shown that the crack can grow an incremental distance each cycle, and the growth law is a fourth power Paris equation.

21744. Wilson, C. L.; Blue, J. L. **Modeling of ionizing radiation effects in short-channel MOSFETs,** *IEEE Trans. Nucl. Sci.* **NS-29,** No. 6, 1676-1680 (Dec. 1982).

Key words: device modeling; interface trapped charge; MOSFETs; oxide trapped charge; radiation effects; short-channel effects.

The effect of ionizing radiation on short-channel MOSFETs is modeled using a charge-sheet approach. The primary effect of ionizing radiation is the introduction of oxide trapped charge (OTC) and interface trapped charge (ITC). Using a two-dimensional charge-sheet model, transistors with channel lengths between 4.65 μm and 0.27 μm were studied. A range of net OTC and ITC values of $\pm4.0\times10^{11}$ cm^{-2} corresponding to a dose of approximately 10^6 rad (SiO_2) was used to study total dose effects.

ITC and OTC cause significant effects in each region of operation. In the subthreshold region, the sensitivity of drain current to these charges is exponential. A more realistic model must include the energy distribution of the ITC charge as well as two-dimensional charge sharing effects. In the triode region, the effects of ITC and OTC are indistinguishable from two-dimensional charge sharing effects. This implies that a simple analysis of threshold voltage offsets in short-channel MOSFETs is incapable of providing a physical separation of two-dimensional effects from radiation-induced effects. In the saturation region, the combined OTC and ITC contribute a fixed charge component to the channel charge which can shift the critical field point at the edge of the pinch-off region in the channel. This critical field effect alters the formation of the "knee" region of the output characteristic and can alter the output conductance in the saturation region for short-channel transistors.

21745. Yap, W. T.; Durst, R. A.; Blubaugh, E. A.; Blubaugh, D. D. **Chronoamperometry of polymer-modified electrodes: Charge transport by diffusion and migration,** *J. Electroanal. Chem.* **144,** 69-75 (1983).

Key words: charge transport; chronoamperometry; current-time relations; diffusion; eigenfunctions; migration; polymer-modified electrode.

A theoretical analysis of charge-transport phenomena due to both diffusion and electrostatic migration in a polymer-modified electrode is presented for chronoamperometry. Concentration distributions and current-time curves were derived for the simple case of a constant electric field in the polymer film.

21746. Zeisler, R.; Greenberg, R. R. **Ultratrace determination of platinum in biological materials via neutron activation and radiochemical separation,** *J. Radioanal. Chem.* **75,** Nos. 1-2, 27-37 (1982).

Key words: biological materials; human liver; neutron activation analysis; platinum; radiochemical separation; standard reference materials; ultratrace analysis.

A neutron activation analysis scheme based upon a radiochemical separation of the activation products has been developed. The method utilizes the inherent sensitivity of the activation reaction $^{198}Pt(n,\gamma)^{199}Pt$ and counting of the daughter nuclide ^{199}Au. This nuclide is radiochemically separated from interfering activities by homogeneous precipitation as elemental gold. The remaining interference of the secondary reaction $^{197}Au(n,\gamma)^{198}Au(n,\gamma)^{199}Au$ from gold in the samples is quantitatively assessed and corrected. During this process accurate gold concentrations in the samples are obtained at ultratrace levels. The analysis scheme is applied to gold and platinum determinations in biological Standard Reference Materials and human liver specimens. Gold and platinum are determined at concentrations of $5 \cdot 10^{-11}$ g/g, and at higher levels.

21747. Doering, D. L.; Madey, T. E. **The adsorption of water on clean and oxygen-dosed Ru(001),** *Surf. Sci.* **123,** 305-337 (1982).

Key words: adsorption; ESDIAD; oxygen; Ru(001); water.

Water adsorption on clean and oxygen-dosed Ru(001) has been examined using thermal desorption spectroscopy (TDS), AES, LEED, and electron stimulated desorption ion angular distributions (ESDIAD). On the clean Ru(001) surface, three water TDS peaks were observed at 215 K (A_1), 180 K (A_2) and 155 K (C). The structure of the water on the surface was determined by ESDIAD and LEED as a function of coverage and temperature. The $(\sqrt{3}\times\sqrt{3})R30°$ LEED pattern indicated that water is in registry with the Ru substrate which is responsible for the close match of the ice and Ru lattice spacings. ESDIAD patterns were able to determine the presence of water monomers at low coverages and temperatures and to distinguish between water structures on the surface as a function of temperature. Both the A_1 and A_2 TDS peaks were found to be due to the desorption of water molecules from two-dimensional clusters. The energy separation of the two peaks was related to the dipole-dipole interactions from water bound into the clusters in two different orientations. A complex temperature- and coverage-dependent LEED structure was also observed which was attributed to an ordered domain structure of the water clusters. Preadsorption of oxygen on Ru(001) *inhibited* the azimuthal ordering of the adsorbed water as determined by ESDIAD and LEED for all water coverages and oxygen coverages. Oxygen pre-exposures also had a strong influence on the TDS peaks. The strong interaction of water with adsorbed oxygen induced an unfavorable water-substrate geometry.

21748. O'Leary, D. P.; Simmons, J. A. **A bidiagonalization-regularization procedure for large scale discretizations of ill-posed problems,** *Soc. Ind. Appl. Math. J. Sci. Stat. Comput.* **2,** No. 4, 474-489 (Dec. 1981).

Key words: first kind integral equation; ill-posed problems; Lanczos algorithm; regularization.

In this paper, we consider ill-posed problems which discretize to linear least squares problems with matrices K of high dimensions. The algorithm proposed uses K only as an operator and does not need to explicitly store or modify it. A method related to one of Lanczos is used to project the problem onto a subspace for which K is bidiagonal. It is then an easy matter to solve the projected problem by standard regularization techniques. These ideas are illustrated with some integral equations of the first kind with convolution kernels, and sample numerical results are given.

21749. Gaylord, R. J.; Lohse, D. J.; Guttman, C. M.; DiMarzio, E. A. **The "sandwich" model of the amorphous material in semicrystalline polymers, block copolymers and filled or reinforced elastomers,** *Polym. Bull.* **3,** 301-304 (1980).

Key words: amorphous material; block copolymers; filled or reinforced elastomer; sandwich model; semicrystalline polymers.

A theoretical model of the amorphous material in semicrystalline polymers, block copolymers and filled or reinforced elastomers is presented. The model consists of a dense system of bridges, loops, cilia and floating chains 'sandwiched' between a pair of parallel walls. A prescription is given for determining the total free energy of the model.

21750. Collins, B. L.; Lerner, N. D. **Assessment of fire-safety symbols,** *Hum. Factors* **24,** No. 1, 75-84 (Feb. 1982).

Key words: fire-safety; internationally proposed symbols; International Organization for Standardization (ISO); modes of symbol presentation.

Twenty-five internationally proposed symbols for fire-safety alerting were evaluated for understandability by 91 U.S. participants. Three modes of symbol presentation (slides, placards, and booklets) and two modes of participant response (definition and multiple choice) were studied. Confidence ratings and production data (drawings) were also obtained. Mode of symbol presentation had no significant effect, while definition and multiple-choice response procedures led to generally similar conclusions. Confidence ratings were useful in reconciling discrepancies between the two response methods. The understandability of the 25 symbols ranged from near zero to virtually complete comprehension. The poor performance of some critical symbols such as "exit" was noted, and some potentially dangerous confusions in meaning were revealed.

21751. Joy, D. C.; Newbury, D. E.; Davidson, D. L. **Electron channeling patterns in the scanning electron microscope,** *J. Appl. Phys.* **53,** No. 8, R81-R122 (Aug. 1982).

Key words: bloch waves; crystallography; electron wavelength; scanning electron microscope.

The majority of contrast effects observed in the scanning electron microscope (SEM) are concerned with effects such as its surface topography or bulk chemical composition which are independent of the crystallography of the specimen. But in this paper we shall discuss a contrast mechanism in which visible effects are derived directly from the crystal structure of the specimen. Electron channeling patterns (ECP) are caused by a variation in the signal resulting from changes in the angle between the incident beam and the crystal lattice of the specimen. This effect is independent of, but may be superimposed on, the usual variation of the secondary and backscattered signals with the incident angle to the local surface normal. It will be shown that these make it possible to determine the crystalline orientation and symmetry of the sample, and that such features of the lattice as tilt and grain boundaries, and in some cases even individual defects, have been imaged and identified.

21752. Penn, D. R.; Girvin, S. M.; Mahan, G. D. **Dispersion relation approach to the x-ray edge problem,** *Phys. Rev. B* **24,** No. 12, 6971-6983 (Dec. 15, 1981).

Key words: core-hole potential; dispersion; matrix element; multiple-scattering; threshold; x-ray edge problem.

We present a dispersion relation formulation of the open-line amplitude for the x-ray edge problem within the contact potential model. Using both multiple-scattering and determinant techniques, we find that to a very good approximation the many-body effects can be described within a single-particle transition-rate expression using a renormalized matrix element. This renormalized matrix element may be expressed exactly in terms of a frequency integral over the scattering phase shift for the core-hole potential. There are small corrections to the transition rate due to multiple particle-hole-pair final states, and a systematic series expansion for these is presented. This series is summed at threshold to yield an exact expression for the critical amplitude multiplying the power-law singularity. Our analytic results given an exact description at threshold and are shown to be quite accurate away from threshold. Comparison with the asymptotic expression of Nozières and De Dominicis is made.

21753. Smyth, K. C.; Lias, S. G.; Ausloos, P. **The ion-molecule chemistry of $C_3H_3^+$ and the implications for soot formation,** *Combust. Sci. Technol.* **28,** 147-154 (1982).

Key words: atmospheric pressure; cyclic and linear isomers; $C_3H_3^+$; molecular ions; soot formation.

The ion-molecule chemistry of $C_3H_3^+$ is systematically investigated with a series of alkenes, alkynes, and aromatic molecules under low-pressure, room temperature conditions. Based upon their reactivity differences, two $C_3H_3^+$ structures are distinguished and are assigned as the cyclic (the most stable) and linear isomers. Cyclic $C_3H_3^+$ readily reacts with unsaturated compounds having four or more carbon atoms. Linear $C_3H_3^+$ is found to be even more reactive and, in particular, forms condensation products with acetylene and benzene. The relevance of these results for the higher temperature and atmospheric pressure conditions of a flame environment is discussed. Since $C_3H_3^+$ has been found to be the dominant positive ion for rich and sooting hydrocarbon flames, its high reactivity provides a rapid first step in the ion models of soot formation.

21754. Rosenstock, H. M.; Buff, R.; Ferreira, M. A. A.; Lias, S. G.; Parr, A. C.; Stockbauer, R. L., Holmes, J. L. **Fragmentation mechanism and energetics of some alkyl halide ions,** *J. Am. Chem. Soc.* **104,** No. 9, 2337-2345 (1982).

Key words: alkyl halide ions; electron-ion coincidence; fragmentation mechanism; Franck-Condon factors; kinetic energy; metastable transition; zero-kelvin thresholds.

Halogen loss from iodoethane, 1-bromopropane, 2-bromopropane, 1-iodopropane, and 2-iodopropane has been studied by means of electron-ion coincidence techniques and by observation of metastable transition. Analysis of the breakdown curves and the study of residence times gave the zero-kelvin thresholds for halogen loss and indicated the size of the kinetic shift. The fragmentation onset for iodoethane was located in a Franck-Condon gap. The zero-kelvin thresholds for the propyl halides were found to lie at or just above the upper spin-orbit level of the parent ion. All of the propyl halides exhibited a unimolecular metastable transition. At fragmentation onset the 2-halopropane ions have negligible fragment kinetic energy while the 1-halopropane produce secondary propyl ions with 100–200 meV of kinetic energy. It was established that a potential barrier must be surmounted in this fragmentation-isomerization process and analysis suggest a dynamic mechanism other than conventional QET, for example, weak couplings of vibrational modes. Analysis of the 2-halopropane fragmentation thresholds leads to an accurate, absolute value for the proton affinity of propylene, 751.4±2.9 kJ/mol at room temperature. This value reconciles some differences inherent in the proton affinity scale based on various relative measurements.

21755. Noble, R. D. **Mathematical modelling in the context of problem solving,** *Math. Modelling* **3,** No. 3, 215-219 (1982).

Key words: creativity; heuristics; mathematical modelling; maxims; relevant observations.

The process of mathematical modelling is shown to fit within the general context of problem solving. A problem solving process is described and detailed with examples from mathematical modelling. Creativity is discussed with descriptions of elements which are conductive to creativity, and also blocks to creativity are outlined. Heuristics or general guides to aid in solving problems are shown. This then gives one a general approach to mathematical modelling.

21756. Cooper, L. Y.; Harkleroad, M.; Quintiere, J.; Rinkinen, W. **An experimental study of upper hot layer stratification in full-scale multiroom fire scenarios,** *Proc. 20th Joint ASME/AIChE Natl. Heat Transfer Conf., Milwaukee, WI, Aug. 2-5, 1981, Reprint No. 81-HT-9,* 12 pages (American Society of Mechanical Engineers, 345 E. 47 Street, New York, NY 10017, 1981).

Key words: comparisons; dynamics of smoke; experimental data base; full scale experiments; mathematical fire simulation models; predictive capability; upper hot layer stratification.

This paper describes an experimental study of the dynamics of smoke filling in realistic, full-scale, multiroom fire scenarios. A major objective of the study was to generate an experimental data base for use in the verification of mathematical fire simulation models. The test space involved 2 or 3 rooms, connected by open doorways. During the course of the study the areas were partitioned to yield four different configurations. One of the rooms was a burn room containing a methane burner which produced either a constant energy release rate of 25, 100, or 225 kW or a time-varying energy release rate which increased linearly with time from zero at ignition to 300 kW in 10 min. An artificial smoke source near the ceiling of the burn room provided a means for visualizing the descent of the hot layer and the dynamics of the smoke filling process in the various spaces. The development of the hot stratified layers in the various spaces was monitored by vertical arrays of thermocouples and photometers. A layer interface was identified and its position as a function of time was determined. An analysis and discussion of these results are presented.

21757. Cooper, L. Y. **Heat transfer from a buoyant plume to an unconfined ceiling,** *Proc. 20th Joint ASME/AIChE Natl. Heat Transfer Conf., Milwaukee, WI, Aug. 2-5, 1981, Reprint No. 81-HT-7,* 9 pages (American Society of Mechanical Engineers, 345 E. 47 Street, New York, NY 10017, 1981).

Key words: buoyant plume; critical review; enclosure fires; experimental studies; heat transfer; unconfined ceiling.

The heat transfer to confined ceilings during enclosure fires is related to the heat transfer to unconfined ceiling surfaces from buoyant plume driven ceiling jets. This paper briefly discusses this relationship, and then focuses attention on the unconfined ceiling problem. Previously published theoretical and experimental studies dealing with interactions of unheated free jets and solid surfaces as well as literature which focuses directly on fire plume-unconfined ceiling interactions are brought to bear on the problem. A critical review of all of this literature results in easily applicable formulae for estimating the heat transfer in question.

21758. Cooper, L. Y. **Measuring the leakage of door assemblies during standard fire exposures,** *Fire Mater.* **5,** No. 4, 163-174 (1981).

Key words: door assemblies; fire scenarios; high-rise buildings; smoke leakage; standard fire endurance test; test method.

The results of applying the tentative, high temperature, International Standards Organization test method DP 5925 Part 3, which was developed to measure smoke leakage of door assemblies during the course of a standard fire endurance test, are reported. A critical analysis reveals that the basic objective of the test method is limited in its utility in that fire scenarios in high-rise buildings may not be adequately simulated. Independent of this limitation, the analysis then identifies certain theoretical problems with the test method and its procedures. These lead to a conclusion that the test method is not generally reliable. An alternative test concept which appears to remove this limitation and all of its problems is described, and its development is advocated.

21759. Mulholland, G.; Ohlemiller, T. J. **Aerosol characterization of a smoldering source,** *Aerosol Sci. Technol.* **1,** 59-71 (1982).

Key words: aerosol; air flow rate; cellulosic insulation; filtration; plume; smoldering combustion source.

The aerosol emitted by a moderately large smoldering combustion source (16 cm in diameter) has been characterized in detail. The fuel is a permeable bed of cellulosic insulation (wood fibers) receiving its primary air supply by flow up from the bottom of the bed while the smolder wave propagates downward. The mass mean particle size of the aerosol is 2–3 μm; this shows no clear trend with smolder wave depth in the bed or with air flow velocity. The large average particle size is shown to imply that, compared to punk smoke, the present aerosol requires a sevenfold greater concentration to trigger an ionization detector. Coagulation of the aerosol in the plume above the source is shown to be minimal, but substantial coagulation can occur within the source. The apparent fractional conversion of gasified mass (60–75% of the fuel) to aerosol mass decreases with smolder wave depth in the bed and with decreasing air flow rate. The mass and number flow rate of the aerosol show these same trends. The decreasing aerosol emissions with wave depth or air flow rate are plausibly explained by filtration effects in the smolder bed.

21760. Gualtieri, J. A.; Kincaid, J. M.; Morrison, G. **Phase equilibria in polydisperse fluids,** *J. Chem. Phys.* 77, No. 1, 521-536 (July 1, 1982).

Key words: cloud-point surface; critical temperature and density; generalizing; mathematical framework; mole fraction density function; mole fraction distribution function; phase equilibria; thermodynamics.

We present a new approach for solving phase equilibria problems in multicomponent systems together with several applications. A mathematical framework is developed that provides a method for generalizing the thermodynamics of a finite-component system to that of a system with an infinite number of components—a polydisperse system. Two new functions, the mole fraction distribution function and the mole fraction density function, play a key role in our method. The phase equilibria conditions are written in terms of these functions and are formally solved. We illustrate the utility of our approach by solving, for a polydisperse generalization of the van der Waals model, three phase-equilibria problems: (1) the fractionation of a polydisperse impurity dissolved in a solvent; (2) the shift of the critical temperature and density due to the presence of a polydisperse impurity; (3) the calculation of the cloud-point surface and critical point of a completely polydisperse system.

21761. Kwon, O.; Beaglehole, D.; Webb, W. W.; Widom, B.; Schmidt, J. W.; Cahn, J. W.; Moldover, M. R.; Stephenson, B. **Thickness of the liquid-vapor wetting layer,** *Phys. Rev. Lett.* **48,** No. 3, 185-188 (Jan. 18, 1982).

Key words: binary solutions; ellipsometry; intermolecular potential; liquid phases; thickness.

In certain binary solutions the lower of the two liquid phases forms a layer which intrudes between the upper liquid phase and the vapor. The intruding layer's thickness (measured by ellipsometry) was between 70 and 400 Å. It varied approximately as $L^{-1/3}$ where L is the height spanned by the upper liquid phase. This behavior was predicted by de Gennes using the idea that the long-ranged part of the intermolecular potential governs the layer's thickness. Deviations from $L^{-1/3}$ behavior occur near consolute points.

21762. Alvarez, R.; Rasberry, S. D.; Uriano, G. A. **NBS Standard Reference Materials: Update 1982,** *Anal. Chem.* **54,** No. 12, 1226 A-1228 A-1235 A-1244 A (Oct. 1982).

Key words: calibration; certified; chemical physical properties; measurement applications; standard reference materials.

In 1966, the National Bureau of Standards reported in Analytical Chemistry (1) the rejuvenation of its Standard Reference Materials program. Ten years later an update, noting considerable progress, was reported in Analytical Chemistry (2). Now, after only six years, so much has changed in this 76-year old program that readers of the Journal may be interested in a status report. It is the purpose of this Report to update the scope and results of this program to 1982 and to provide a glimpse of the future.

21763. Mathew, M.; Kingsbury, P.; Takagi, S.; Brown, W. E. **A new struvite-type compound, magnesium sodium phosphate heptahydrate,** *Acta Crystallogr.* **B38,** 40-44 (1982).

Key words: magnesium sodium phosphate heptahydrate; single-crystal; struvite analog; struvite-type compounds; x-ray diffraction.

The crystal structure of $MgNaPO_4.7H_2O$, a new struvite analog, has been determined by single-crystal X-ray diffraction study. The crystals are tetragonal with $a=6{\cdot}731$ (2), $c=10{\cdot}982$ (4) Å, space group $P4_2/mmc$, $Z=2$, $V=497{\cdot}5$ Å^3, $d_m=1{\cdot}77$, $d_c=1{\cdot}791$ Mg m^{-3}. The structure was refined by full-matrix least-squares techniques to $R=0{\cdot}038$ and $R_w=0{\cdot}056$ for 418 reflections with $F_0>3\sigma(F_0)$. All cations and anions are completely surrounded by water molecules. The environment of the PO_4^{3-} ion consists of 12 water molecules, all of which are hydrogen bonded to PO_4 oxygens, thus providing a model of a completely hydrated PO_4^{3-} ion in the crystalline state. The most interesting feature of the structure is the novel type of face-sharing linkage of $Mg(H_2O)_6$ octahedra and PO_4 tetrahedra. All four faces of the PO_4^{3-} ion are linked to faces of four different $Mg(H_2O)_6$ octahedra *via* hydrogen bonds, and each $Mg(H_2O)_6$ octahedron is linked to four PO_4 faces. The linkage of $Mg(H_2O)_6$ and PO_4 (along a and b) forms a cross-linked layer-type structure, leaving a relatively open channel along c, which is occupied by a column of alternating Na^+ ions and water molecules. Relationships with other struvite-type compounds are discussed.

21764. Gann, R. G.; Manka, M. J. **Ignitability of decomposed transformer fluids,** *Fire Technol.* **18,** No. 3, 251-258 (Aug. 1982).

Key words: chemical composition; decomposed transformer fluids; flammability; ignition potential; temperature.

The effects of an electrical field (12 kV/cm) and elevated temperature (300°C) on the ignition potential of transformer fluids, which are candidate replacements for polychlorinated biphenyls (PCBs), have been studied. The combined results indicate that the chemical composition of the fluids were alerted, often in such a manner as to increase the ease of ignition.

21765. Belić, D. S.; Dunn, G. H.; Morgan, T. J.; Mueller, D. W.; Timmer, C. **Dielectronic recombination: A crossed-beams observation and measurement of cross section,** *Phys. Rev. Lett.* **50,** No. 5, 339-342 (Jan. 31, 1983).

Key words: crossed beams; cross section; dielectronic recombination; magnesium.

Dielectronic recombination has been directly observed with use of crossed beams of electrons and Mg^+ ions. Measurements were made of delayed coincidences between the stabilizing photon near 280 nm and the resultant neutral atom, and cross sections were determined. Theoretical cross sections are more than a factor of 5 smaller than those measured.

21766. Irwin, G. R.; de Wit, R. **A summary of fracture mechanics concepts,** *J. Test. Eval., Am. Soc. Test. Mater.* **11,** No. 1, 56-65 (Jan. 1983).

Key words: Charpy; corrosion; crack extension; cracking (fracturing); fatigue; fracture mechanics; fractures (materials); modulus of elasticity; plasticity; strain; stress; toughness.

The basic concepts of fracture mechanics are presented in a logical sequence. Each concept is given in a concise definition-like paragraph. The concepts of toughness, process zone, crack, and linear-elastic fracture mechanics are first introduced. The crack-tip characterizations, that is, stress-intensity factor, crack extension force, J integral, and crack-tip opening displacement are then discussed. The constraints in plane stress, plane strain, and three dimensions are pointed out. Various methods of evaluating the crack-tip characterizations are explained. The concept of fracture toughness is presented in relation to resistance curves, dynamics, constraints, and fast-stable crack growth. Some practical empirical fracture toughness relations are given. Then slow-stable crack growth is discussed, that is, stress corrosion cracking, fatigue cracking, corrosion fatigue, and viscous (creep) cracking. The summary concludes with the concept of fracture control plans.

21767. Agarwal, G. S.; Kunasz, C. V. **Four-wave mixing in stocbastic fields: Fluctuation-induced resonances,** *Phys. Rev. A* **27,** No. 2, 996-1012 (Feb. 1983).

Key words: fluctuations; four-wave mixing.

The effect of pump fluctuations on various coherent processes that arise in three-level systems interacting with two external fields is examined. Such coherent processes include the forward Hanle effect and various four-wave mixing effects such as the generation of phase-conjugate signals. A general formulation that enables one to calculate the influence of laser linewidth on the coherent signals produced in various directions is presented. Ensemble averages, over laser temporal fluctuations, of various physical quantities, such as atomic polarization, are calculated. The spectrum of polarization fluctuations is shown to consist of several new features which lead to coherent radiation in different directions depending on the resonant frequencies in the polarization fluctuations. The influence of pump linewidth on pressure-induced extra resonance (PIER) is treated in detail. The possibility of producing a laser-fluctuation-induced coherent signal at one of the atomic frequencies is examined. This new signal, which is produced in a direction different from that of the PIER signal, but has the same type of resonant character as PIER, is found to have significantly different pressure dependence than the PIER signal. The results of our numerical computations are qualitatively explained in terms of the convolutions of products of third-order susceptibilities

and pump field-correlation functions.

21768. Hollis, J. M.; Lovas, F. J.; Suenram, R. D.; Jewell, P. R.; Snyder, L. E. **Methanol in Orion A: Simultaneous observations of corresponding rotational transitions in the ground and torsionally excited states,** *Astrophys. J.* **264,** No. 2, 543-545 (Jan. 15, 1983).

Key words: interstellar, molecules; nebulae, Orion Nebula.

We have detected the 2_{-1}–1_{-1} E and 2_0–1_0 A^+ and partially resolved the 2_1–1_1 E and 2_0–1_0 E transitions of torsionally excited methanol in Orion while simultaneously observing the same transitions in the ground state. These observations suggest that the ground-state transitions come from a 90 K region, while the torsionally excited transitions may come from a 200 K region.

21769. King, D. S.; Cavanagh, R. R. **Streak-camera analysis of XeCl- and N_2-pumped dye-laser outputs,** *Opt. Lett.* **8,** No. 1, 18-20 (Jan. 1983).

Key words: dye laser; excimer; modelocked; output; pulse width; streak camera.

The temporal and spectral content of modified Hänsch-type organic dye lasers pumped by either XeCl or N_2 lasers has been studied. Two extreme cases of amplitude-squared detector mode beating and mode-locked laser output are examined. Experimental consequences are briefly discussed.

21770. Stephenson, J. C.; King, D. S. **Laser intensity effects in the IR multiphoton dissociation of CF_2HCl and CF_2CFCl,** *J. Chem. Phys.* **78,** No. 4, 1867-1875 (Feb. 15, 1983).

Key words: carbon dioxide laser; chlorodifluoromethane; chlorotrifluoromethene; laser chemistry; laser-induced fluorescence; multiphoton chemistry.

CO_2 laser pulses of 2, 10, and 50 ns duration, for which the temporal profile was approximately rectangular, were used in the multiphoton dissociation of low pressure CF_2HCl and CF_2CFCl. Probing a region of well-defined CO_2 laser intensity, laser excited fluorescence determined the yield of CF_2 formed in the $v=0$ and in the high vibrationally excited $v_2=5(E_{vib}=3335\ cm^{-1})$ levels as a function of fluence (F) and intensity (I) over a factor of 100 variation. In the dissociation of CF_2HCl by pulses of a given F, increasing I by a factor of 25 (50 vs 2 ns pulse) typically increased $CF_2(v=0)$ yield by factors of 8; this I dependence is probably due to power broadening of the discrete levels. The $CF_2(v=0)$ yield from CF_2CFCl was almost independent of I over this range, which may reflect the coincidence of the 1079 cm^{-1} $R(24)$ laser frequency with a CF_2CFCl Q branch head at 1080 cm^{-1}. The ratio of $CF_2(v_2=5)/CF_2(v=0)$, which is insensitive to discrete levels effects in the excitation process, increases with I for both reactants. This ratio may be expressed as a vibrational temperature, T_v for the CF_2 fragments, and varied from about 1400 to 2600 K and from 900 to 1400 K for CF_2CFCl and CF_2HCl reactants, respectively, as I increased from 55 MW/cm^2 to 3.3 GW/cm^2 for the 50 ns laser pulses. Arguments are presented relating these results to the establishment of steady-state excitation conditions and to absorption cross sections in the continuum levels.

21771. Hutchinson, J. M. R.; Mullen, P. A. **Calibration of K-x-ray-emission rates in the decay of ^{49}V,** *Int. J. Appl. Radiat. Isot.* **34,** No. 2, 539-542 (1983).

Key words: calibration; half-life; K-x-ray; proportional counting; vanadium-49; 4.5-keV.

^{49}V K-x-ray point sources with an average energy of 4.55-keV have been standardized for emission rate by two methods, namely by 2π-proportional counting and by comparison with a calibrated ^{55}Fe point source. The two results agree to within 1%. The half-life of ^{49}V has been measured to be 338 ± 5 days.

21772. Gadzuk, J. W.; Landman, U.; Kuster, E. J.; Cleveland, C. L.; Barnett, R. N. **Rovibrational excitation within the infinite conical well: Desorption of diatomic molecules,** *J. Electron Spectrosc. Relat. Phenom.* **30,** 103-110 (1983).

Key words: adsorbed molecules; desorption; hindered rotational states.

An analytic model for the hindered rotational states of a diatomic molecule adsorbed upright on a solid surface is discussed. Various model dynamics situations, within the sudden approximation, designed to simulate desorption are presented and rotational state distributions are calculated including both rotational and translational degrees of freedom. Criteria are established for observing rotationally cool desorbed molecules.

21773. Friar, J. L.; Fallieros, S.; Tomusiak, E. L.; Skopik, D.; Fuller, E. G. **Electric polarizability of the deuteron,** *Phys. Rev. C* **27,** No. 3, 1364-1366 (Mar. 1983).

Key words: Compton scattering; deuteron photoabsorption; dispersion relation; electric polarizability; low-energy theorem; magnetic susceptibility.

An experimental value of the electric polarizability of the deuteron is extracted from deuteron photoabsorption data, a dispersion relation, and the low-energy theorem for Compton scattering. The experimental number requires the calculation of several small corrections, which are primarily magnetic in origin. Our value is somewhat smaller than, but consistent with, a recently reported experimental determination.

21774. Cahn, J. W. **Transitions and phase equilibria among grain boundary structures,** *J. Phys.* **43,** No. 12, C6-199–C6-213 (1982).

Key words: grain boundaries structures; grain boundary orientation; grain misorientation; phase equilibria; phase transitions; symmetry.

The characteristics of equilibrium first-order phase changes of the grain boundaries themselves are such that it leads to a definition of grain boundary phases in which smoothly curving boundaries are of the same phase. Different grain boundary phases coexist at facet edges and corners. The phase rule, phase diagrams, and some phase change mechanisms are developed. For a wide variety of problems orientation of the normal is shown to be analogous to composition in ordinary three-component systems. The role of symmetry in modifying the phase rule and in sectioning phase diagrams is explored. Reports of boundary phase changes are re-examined critically.

21775. Baum, H. R.; Rehm, R. G.; Mulholland, G. W. **Computation of fire induced flow and smoke coagulation,** *Proc. Nineteenth Int. Symp. Combustion, Haifa, Israel, Aug. 8-13, 1982,* pp. 921-931 (The Combustion Institute, Union Trust Building, Pittsburgh, PA 15219, 1982).

Key words: dynamics of smoke; enclosure fires; fire induced flow; hot gases; mathematical models; smoke coagulation.

Mathematical models for the calculation of the dynamics of smoke and hot gases induced by enclosure fires are presented. The models predict the evolution of the size distribution of smoke aerosol under the influence of coagulation, as well as the large scale fluid motion and temperature fields. The calculations contain three main ingredients: a finite difference solution of a hydrodynamics problem, the computer evaluation of an exact solution to the aerosol coagulation equation, and a Lagrangian particle tracking scheme to imbed the coagulation dynamics in the hydrodynamics. The hydrodynamics model is a time dependent variable density, two dimensional, infinite Grashof number flow driven by a prescribed heat source. No turbulence model is employed; the large scale eddy motion is calculated directly from the equations of motion. The mathematical particles each represent a large ensemble of aerosol particles, distributed initially in size according to the experimentally observed Junge distribution. They are introduced into the spatial grid in a random fashion near the heat source. The subsequent evolution of the size distribution in space and time is calculated deterministically from the solution to the Smoluchowski equation for the size distribution and the Lagrangian equations of motion for the spatial coordinates. Sample results of the hydrodynamic and aerosol properties are presented. Comparisons between calculations and relevant experiments are shown.

21776. Cooper, L. Y. **Convective heat transfer to ceilings above enclosure fires,** *Proc. Nineteenth Int. Symp. Combustion, Haifa, Israel, Aug. 8-11, 1982,* pp. 933-939 (The Combustion Institute, Union Trust Building, Pittsburgh, PA 15219, 1982).

Key words: buoyant plumes; convective heat transfer; fire combustion; plume gases; unconfined ceilings.

Several theoretical and experimental results which are useful in estimating convective heat transfer from buoyant plumes to unconfined ceilings are to be found in the literature. While these results are applicable for estimating ceiling heat transfer in enclosure fires at early times, this is not generally the case once the inevitable layer of hot plume gases starts to accumulate near the ceiling. In this paper a method for estimating ceiling heat transfer under the general conditions of the latter scenario is outlined, and a partial verification of its validity is provided. The method requires results for unconfined ceiling heat transfer which are also summarized.

21777. Waksman, D.; Walton, W. D. **Fire testing of solar collectors by ASTM E 108,** *Fire Technol.* **18,** No. 2, 174-186 (May 1982).

Key words: fire tests; roofing fire resistance; roofing fire tests; solar collectors.

A study was undertaken to investigate the use of ASTM E 108 (NFPA 256, UL 790), Fire Tests of Roof Coverings, for testing roof-mounted solar energy collectors. Data are presented showing the results of the testing conducted. An evaluation of the testing procedures as they apply to roof-mounted solar collectors is given.

21778. Caswell, R. S. **Radiation protection and the International Commission on Radiation Units and Measurements (ICRU),** *Radiat. Prot. Dosimetry* **1,** No. 4, 241-244 (1981).

Key words: dosimetry; International Commission on Radiation Units and Measurements (ICRU); International System on Units (SI); quantities and units; radiation measurement; radiation protection.

The principal objectives of the ICRU include the development of internationally acceptable recommendations concerning quantities and units of radiation and radioactivity and their measurement. Special concepts, quantities and units have been developed and practical guidance and advice is given in a series of publications the latest of which is currently in press.

21779. Olofsson, G.; Angus, S.; Armstrong, G. T.; Kornilov, A. N. **Assignment and presentation of uncertainties of the numerical results of thermodynamic measurements,** *J. Chem. Thermodyn.* **13,** 603-622 (1981).

Key words: bias in measurements; equilibrium measurements; pooled standard deviation; precision indices; propagation of error; publication guidelines; systematic errors; thermochemical calorimetric measurements; uncertainties, assignment of.

In 1972 the IUPAC Commission on Thermodynamics and Thermochemistry published its "Guide to procedures for the publication of thermodynamic data" (hereinafter referred to as the Guide), which sets out in detail the requirements to be met in the detailed description of experiments. In that document, the requirements for reporting the uncertainty of experimental results are given as follows: "In addition to the presentation of the data themselves, estimates of the precision indices and probable accuracy of the data should be given by the authors. The various sources of uncertainty should be rigorously described with clear separation of measurement imprecisions, numerical analysis deviations, and possible systematic biases. The methods and assumptions for the statistical analyses should be indicated. Possible sources and magnitudes of systematic errors should be identified and enumerated." The purpose of this report is to amplify and, where necessary, to modify this paragraph. It will be assumed that the reader is already familiar with the other recommendations of the Guide.

21780. Roy, R.; Elliot, D. S.; Meschede, D.; Pipkin, F. M.; Smith, S. J. **Low-pressure collisional narrowing in CO_2,** *Chem. Phys. Lett.* **93,** No. 6, 603-607 (Dec. 24/31, 1982).

Key words: carbon dioxide; collisional; laser; line-narrowing; Q-branch; Raman; vibration-rotation.

We report the observation of collisional narrowing of the Q branch of the Raman spectrum for the (000)→(100) transition in CO_2 at very low pressures. The minimum linewidth is reached at ≈250 Torr. An estimate for the difference in rotational constants of the (100) state and the ground state is obtained. The narrowing of the linewidth and the changes in lineshape are interpreted in terms of velocity changing collisions and rotationally inelastic collisions between the CO_2 molecules.

21781. Hamilton, C. E.; Duncan, M. A.; Zwier, T. S.; Weisshaar, J. C.; Ellison, G. B.; Bierbaum, V. M.; Leone, S. R. **Product vibrational analysis of ion-molecule reactions by laser-induced fluorescence in a flowing afterglow: $O^- + HF \rightarrow OH(v=0,1) + F^-$,** *Chem. Phys. Lett.* **94,** No. 1, 4-9 (Jan. 7, 1983).

Key words: flowing afterglow; ion-molecule reaction; laser-induced fluorescence; O^-; OH; vibrational excitation.

Laser-induced fluorescence is coupled to a flowing afterglow to obtain product state distributions of thermal energy ion-molecule reactions. For OH produced in the $O^- + HF \rightarrow OH(v=0,1) + F^-$ reaction, $v=0/v=1$ is 1.0/0.22. Ion vibrational relaxation and obscuring Penning ionization reactions preclude accurate measurements for the $N^+ + CO \rightarrow CO^+(v=0,1,2) + N$ system.

21782. Smith, M. A.; Bierbaum, V. M.; Leone, S. R. **Infrared chemiluminescence from vibrationally excited NO^+: Product branching in the $N^+ + O_2$ ion-molecule reaction,** *Chem. Phys. Lett.* **94,** No. 4, 398-403 (Jan. 28, 1983).

Key words: flowing afterglow; infrared chemiluminescence; ion-molecule reaction; nitric oxide ion; product branching; vibrational excitation.

Vibrational chemiluminescence is detected from the reaction $N^+(^3P) + O_2(X\ ^3\Sigma_g^-)$ in a flowing afterglow. The atom-transfer product, $NO^+(X\ ^1\Sigma^+, v)$, displays a bimodal vibrational distribution spanning the range $v=1$–14. Excited $N(^2D)$ is found to be the major charge transfer product by observation of its further reaction with O_2 to produce $NO(X\ ^2\Pi, v=1$–12).

21783. Thorne, L. R.; Suenram, R. D.; Lovas, F. J. **Microwave spectrum, torsional barrier, and structure of BH_3NH_3,** *J. Chem. Phys.* **78,** No. 1, 167-171 (Jan. 1, 1983).

Key words: borane monoammoniate; dipole moment; microwave spectrum; rotational constants; rotational spectrum; structure; torsional barrier.

The microwave spectra of nine isotopic species of borane monoammoniate ($^{11}BH_3NH_3$, $^{10}BH_3NH_3$, $^{11}BH_3ND_3$, $^{10}BH_3ND_3$, $^{11}BD_3NH_3$, $^{11}BH_3{}^{15}NH_3$, $^{10}BH_3{}^{15}NH_3$, $^{11}BD_2HNH_3$, $^{11}BH_3ND_2H$) have been observed. The rotational constants, centrifugal distortion constants, dipole moment, torsional barrier, and molecular geometry of borane monoammoniate were determined from these spectra. The r_s structure is: BN = 1.6576(16) Å, BH = 1.2160(17) Å, NH = 1.0140(20) Å, ∠NBH = 104.69(11), ∠BNH = 110.28(14). The dipole moment is 5.216(17) D. The torsional barrier about the B-N bond, V_3, is 2.047(9) kcal mol^{-1} for $^{11}BH_3ND_2H$ and 2.008(4) kcal mol^{-1} for $^{11}BD_2HNH_3$.

21784. Smith, M. A.; Leone, S. R. **Product vibrational state distributions in thermal energy associative detachment reactions: $F^- + H,D \rightarrow HF(v), DF(v) + e^-$,** *J. Chem. Phys.* **78,** No. 3, 1325-1334 (Feb. 1, 1983).

Key words: associative detachment; flowing afterglow; fluoride ion; hydrogen fluoride; ion-molecule reaction; vibration.

Nascent product vibrational state distributions are obtained by the method of spectrally resolved infrared chemiluminescence for the associative detachment reactions: $F^- + H \rightarrow HF(v \leqslant 5) + e^-$, $\Delta H = -238.3$ kJ mol^{-1} and $F^- + D \rightarrow DF(v \leqslant 7) + e^-$, $\Delta H = -245.3$ kJ mol^{-1}. These reactions are carried out under thermal energy conditions in a flowing afterglow. The nascent distribution for HF(v) is $N_{v=1} = 0.0^{+0.06}_{-0.0}$ $N_{v=2} = 0.09 \pm 0.01$, $N_{v=3} = 0.21 \pm 0.01$, $N_{v=4} = 0.41 \pm 0.02$, $N_{v=5} = 0.30 \pm 0.02$ with an average fraction of energy deposited into vibration, $\langle f_v \rangle = 0.72 \pm 0.03$ and for DF(v): $N_{v=1} = 0.08^{+0.01}_{-0.07}$, $N_{v=2} = 0.09 \pm 0.01$, $N_{v=3} = 0.15 \pm 0.02$, $N_{v=4} = 0.11 \pm 0.02$, $N_{v=5} = 0.15 \pm 0.01$, $N_{v=6} = 0.24 \pm 0.03$, $N_{v=7} = 0.18 \pm 0.02$ with $\langle f_v \rangle \leqslant 0.61 \pm 0.04$. Simple kinematic effects based on angular momentum constraints are not able to explain the broader distribution observed for DF as compared to HF. Several possibilities for this difference are discussed. In an argon buffer, which is much less effective than helium for rotational

relaxation, the DF emission exhibits highly nonthermal rotational excitation.

21785. Zahn, M.; Forster, E. O.; Kelley, E. F.; Hebner, R. E., Jr. **Hydrodynamic shock wave propagation after electrical breakdown,** *J. Electrostat.* **12,** 535-546 (1982).

Key words: breakdown; dielectrics; high voltage; insulation; liquids; shock waves; transformer oil.

Laser schlieren measurements in liquid dielectrics have been used to examine the radial expansion of both the acoustic shock wave and the conductive breakdown channel during the first few microseconds after electrical breakdown under high voltage impulse conditions. It was found that the acoustic shock wave expands at a constant velocity while the expanding radius of the breakdown channel is proportional to the fourth root of the energy and the square root of time. These dependencies are predicted by modeling the breakdown channel as an expanding adiabatic ideal gas with an instantaneous input of energy. The Rankine-Hugoniot boundary conditions in the strong shock limit are used to relate discontinuities in velocity, pressure, and mass density across the cylindrical shock front using the same analysis which was used previously to describe exploding wires in air. When the expansion velocity of the gas column decreases below the acoustic wave velocity in the liquids, an acoustic wave propagates ahead of the electrohydrodynamic shock.

21786. Amis, E. J.; Han, C. C. **Cooperative and self-diffusion of polymers in semidilute solutions by dynamic light scattering,** *Polymer* **23,** 1403-1406 (Sept. 1982).

Key words: cooperative diffusion coefficient; dynamic light scattering; reptation; scaling; self-diffusion coefficient; semidilute solution.

The quasielastic light scattering from semidilute solutions of polystyrene in tetrahydrofuran has been measured and we observe two distinct exponential decays separated by several orders of magnitude. The angular dependence of the decay constants is indicative of diffusive processes which we identify with the cooperative diffusion coefficient, D_c and the self diffusion coefficient, D_s. It is found that D_c, identified with the fast decay, increases with polystyrene concentration and is independent of molecular weight. However, D_s decreases sharply with concentration and molecular weight. An explanation is given for the light scattering detection of these two diffusion coefficients which is based only on the assumptions inherent in the reptation model. In a limited region of molecular weight and concentration the experimental results appear to be consistent with the predictions of scaling theory.

21787. Matsushita, Y.; Furuhashi, H.; Choshi, H.; Noda, I.; Nagasawa, M.; Fujimoto, T.; Han, C. C. **Preparation and characterization of block copolymers of ordinary and deuterated styrenes,** *Polym. J.* **14,** No. 6, 489-493 (1982).

Key words: anionic polymerization; block copolymer; deuterated styrene; narrow molecular weight distribution; neutron scattering.

Polymers containing deuterated segments, such as the block copolymers of ordinary and deuterated styrenes, are in demand for use in small angle neutron scattering techniques in polymer science. The samples should have narrow distributions with respect to both molecular weight and composition. However, the deuterated polymer samples used so far in neutron scattering measurements appear to have distributions broader than ordinary hydrogen polymer samples. In this work, an attempt was made to obtain polystyrenes containing a styrene-d_8 sequence as a block by the anionic polymerization technique, but the preparation of di-block and tri-block copolymers of styrene and styrene-d_8 was found to be much more difficult than that of ordinary block copolymers. The reason for this stemmed from the particular kind of impurities contained in commercially available styrene-d_8. It seems worth-while to report in detail of our method of preparation, since no deuterated styrene block copolymers of sufficiently narrow molecular weight distribution has as yet been reported in the literature.

21788. Blau, P. J.; Whitenton, E. P. **Some mechanisms in the unlubricated running-in behaviour of an Al-Si-Cu alloy against 52100 steel,** *Tribol. Int.,* 209-217 (Aug. 1982).

Key words: aluminium alloys; friction; running-in; wear.

Friction coefficients of samples of an Al-Si-Cu alloy sliding against 52100 steel were determined on a tribometer. The alloy was chosen to represent a generic class of materials having wear resistant microstructures in which hard particles are contained within a softer metal matrix. These results together with microstructural observations from these samples and from comparative tests with silicon and 2024-T4 alloy led to a sliding running-in (break-in) model which takes account of the initial state of the surface, whether etched or polished.

21789. Ayres, R. L.; Hirshfeld, A. T. **Radioactivity standardization of ^{99m}Tc and ^{99}Mo,** *Int. J. Appl. Radiat. Isot.* **33,** 835-841 (1982).

Key words: half-lives; molybdenum-99; radioactivity standards; radiopharmaceuticals; technetium-99m; $4\pi\beta$-γ coincidence.

The "$4\pi\beta$-γ" coincidence calibration of ^{99m}Tc and ^{99}Mo at the National Bureau of Standards is described. The "$4\pi\beta$-γ" coincidence technique used is reviewed extensively. The results of various decay scheme parameter measurements for both radionuclides are reported.

21790. Eisenhauer, C. M.; Schwartz, R. B. **The effect of room-scattered neutrons on the calibration of radiation protection instruments,** *Proc. 4th Symp. Neutron Dosimetry, GSF, Munich-Neuherberg, Germany, June 1-5, 1981,* pp. 421-430 (The Commission of the European Communities, Luxemburg, Germany, 1981).

Key words: calibration; dosimeter; neutrons; remmeter; room scatter; ^{252}Cf (Californium-252).

Measurements of the response of 9-inch spherical remmeters, 3-inch spheres, and albedo dosimeters to neutrons from a Cf fission neutron source are presented. Measurements as a function of source-detector distance in several different calibration facilities support the argument that the response of an instrument to neutrons reflected from the room surfaces is constant over the central volume of the room. Approximate expressions are given for understanding the response to reflected neutrons in terms of the energy spectrum of the neutron source, the type of detector, and the size of the calibration room.

21791. Chesler, S. N.; Guenther, F. R.; May, W. E.; Parris, R. M. **Standard reference materials for accurate analyses of PCBs in oil,** *ASTM Stand. News* **10,** No. 6, 15-20 (June 1982).

Key words: electron capture detection; gas chromatography; liquid chromatography; motor oil; PCBs; standard reference material; transformer oil; wallcoated open-tubular column.

A hybrid technique utilizing both high-performance preparative-scale liquid chromatography and capillary column gas chromatography has been developed for the determination of polychlorinated biphenyls (PCBs) in hydrocarbon matrices, such as transformer coolant and motor oils. This procedure has been used in the certification of a Standard Reference Material entitled "Polychlorinated Biphenyls in Oil" at the National Bureau of Standards.

21792. Deslattes, R. D. **Synchrotron radiation—A possible general purpose ring application,** *Proc. Conf. New Horizons Electromagnetic Physics, Charlottesville, VA, April 21-24, 1982,* pp. 366-384 (University of Virginia, Charlottesville, VA, 1983).

Key words: crystallography; spectroscopy; storage rings; synchrotron radiation; x rays.

This report attempts a very brief outline of the present-day synchrotron radiation facilities. It also considers a few applications to which these facilities are uniquely suited. Finally, it contains a provisional discussion of the possible role of a general purpose ring in this area.

21793. Hoppes, D. D.; Schima, F. J. **Nuclear data for the efficiency calibration of germanium spectrometer systems,** *Int. J. Appl. Radiat. Isot.* **34,** No. 2, 491-492 (1983).

Key words: calibration of gamma-ray detector efficiencies; half-life measurements; measurement uncertainties; photon probabilities per decay.

Members of the Alpha-, Beta- and Gamma-Ray Spectrometry Group of the International Committee for Radionuclide Metrology agreed in 1979 to collect the nuclear data from any measurements in their laboratories that were pertinent to the calibration of the efficiency of germanium spectrometry systems. The contributions from 14 laboratories are contained in the NBS Special Publication 626.

21794. Hutchinson, J. M. R.; Mullen, P. A. **"Pin-well"-NaI(Tl) counting of 59.5-keV γ-rays in the decay of ^{241}Am,** *Int. J. Appl. Radiat. Isot.* **34,** No. 2, 543-546 (1983).

Key words: americium-241; gamma-ray probability per decay; improved accuracy; pin-well-NaI(Tl) detector.

The 59.5-keV γ-ray-emission rate in the decay of an ^{241}Am source has been measured using a specially constructed NaI(Tl) thin-walled-well detector. From this measurement, and an α-particle-emission rate measurement on quantitatively related sources, the 59.5-keV γ-ray probability per decay is 0.3582 ± 0.0012.

21795. Tung, M. S.; Brown, W. E. **Characterization and modification of electrochemical properties of teeth,** *J. Dent. Res.* **62,** No. 1, 60-64 (Jan. 1983).

Key words: caries; dentin; enamel; modification of tooth; permselectivity.

Permselectivity of teeth was studied by membrane potential measurements. The enamel was found to have a preferential affinity for calcium and hydrogen ions. Its permselectivity could be modified by anionic compounds, such as phytate and alginate; by cationic compounds, such as protamine, polyarginine, and polylysine; or by an alternating coating of the above compounds.

21796. Okabe, H. **Photochemistry of acetylene at 1849 Å,** *J. Chem. Phys.* **78,** No. 3, 1312-1317 (Feb. 1, 1983).

Key words: acetylene; diacetylene; photochemistry; quantum yield; 1849 Å.

The photochemistry of acetylene at 1849 Å has been studied over the pressure range from 13 to 2660 N m^{-2} (0.1–20 Torr). The quantum yield of diacetylene formation has been measured as a function of C_2H_2 pressure and the partial pressures of He and N_2. The quantum yield of H_2 formation has also been obtained. It was concluded that the quantum yield for $C_2H_2 \rightarrow C_2H + H$ is 0.06 and that for $C_2H_2 \rightarrow C_2 + H_2$ is 0.1. The remaining process is the formation of a metastable acetylene which reacts either with C_2H_2 to form C_2H radicals or is deactivated by collisions with the walls or inert gases. The C_2H radicals react 0.240 ± 0.015 times as fast with C_2H_2 and 0.469 ± 0.041 times as fast with C_3H_8 as with C_2H_2. The role of acetylene photolysis in the Titan atmosphere is briefly discussed.

21797. Mjör, I. A.; Hensten-Pettersen, A.; Bowen, R. L. **Biological assessments of experimental cavity cleansers: Correlation between *in vitro* and *in vivo* studies,** *J. Dent. Res.* **61,** No. 8, 967-972 (Aug. 1982).

Key words: acids; adhesion; bioassay; pulp response; smear layer; toxicity.

Adhesive bonding of resins to dentin surfaces requires the removal of the layer of debris caused by the cutting. Certain isotonic acidic solutions can do this rapidly. Five solutions were evaluated using cell cultures and pulp studies in monkeys. At concentrations above 10%, each solution caused the cultured human epithelial cells to respond unfavorably, probably due to the low pH of the culture medium. None of these experimental cleanser solutions caused significant pulpal irritation.

21798. Levelt Sengers, J. M. H. **The state of the critical state of fluids,** *Pure Appl. Chem.* **55,** No. 3, 437-453 (1983).

Key words: asymmetric tricritical points; critical exponent values; interfaces; nucleation; symmetric tricritical points; Wegner expansion.

A review is given of recent progress in the understanding of critical phenomena in fluids and fluid mixtures. The topics discussed are: critical exponent values; the Wegner expansion for corrections to scaling, and its application in pure fluids and binary liquid mixtures; weak critical anomalies in binary liquid mixtures; symmetric and asymmetric tricritical points; interfaces and nucleation.

21799. Tung, M. S. **Surface properties of hydroxyapatite in fluoride solution,** *Colloids Surf.* **6,** 283-285 (1983).

Key words: adsorption; electrophoretic mobility; fluoride; fluoroapatite; hydroxyapatite; surface properties.

The error in a published report is pointed out and a new mechanism is proposed for the fluoride effect on the surface charge of hydroxyapatite slurry.

21800. Fassett, J. D.; Travis, J. C.; Moore, L. J.; Lytle, F. E. **Atomic ion formation and measurement with resonance ionization mass spectrometry,** *Anal. Chem.* **55,** No. 4, 765-770 (Apr. 1983).

Key words: Langmuir vaporization; laser ionization; mass spectrometry; molybdenum; resonance ionization; rhenium; vanadium.

Resonance ionization mass spectrometry has been used to study the formation of the atomic ions of molybdenum, rhenium, and vanadium. A one-wavelength, two-photon ionization scheme was used that is potentially applicable to nearly 50 elements. The first photon resonantly excites a bound transition in the near-ultraviolet region and a second photon promotes the electron into the ionization continuum. Wavelength-dependent ion formation from a thermally produced atom reservoir was demonstrated for these elements by scanning a Nd/YAG-pumped tunable dye laser across specific resonant electronic transitions and recording the mass-selected ion intensities in a single magnetic sector mass spectrometer. Limitations on potential analytical sensitivity and selectivity appear to result from two-photon backgrounds of atomic and molecular ions and from the appearance of untabulated spectral features.

21801. Raufaste, N. J. **Safety research programs conducted at the Center for Building Technology,** *South. Build.,* pp. 7-8 (Apr.-May 1983).

Key words: building technology; construction safety; guardrails; occupancy safety; slips; trenching.

This paper reviews safety research at the Center for Building Technology, National Bureau of Standards. This research addresses safety during construction and in use and provides a sound technical basis for the codes and standards development process.

21802. Becker, D. A. **Re-refined lube oil consistency and quality: The ultimate question,** *Proc. Conf. Second European Congr. Recycling of Used Oils, Paris, France, Sept. 30-Oct. 2, 1980,* pp. 171-174 (D. Reidel Publ. Co., Dordrecht, Holland/Boston, USA/London, England, 1981).

Key words: lubricating oil; lubrication; motor oil; oil testing; recycled oil; re-refined oil.

Legislation and activities in the United States on the subject of oil recycling have increased dramatically in the past several years. These activities are mostly positive in nature, encouraging the more efficient and effective utilization of a valuable natural resource, while minimizing the adverse environmental effects of improper reuse or disposal. However, a substantial fraction of both industry and government in the U.S. have some concerns about the lack of scientific and technical data on certain aspects of the quality and consistency of recycled lubricating oils, particularly re-refined engine oils. Since 1976, the (U.S.) National Bureau of Standards (NBS) has had a legislatively mandated program to "...develop test procedures for the determination of substantial equivalency of re-refined or otherwise processed used oil...with new oil for a particular end use" (42 U.S. Code 6363c). The NBS technical effort is currently focussed on the development and evaluation of test procedures capable of monitoring the quality, consistency and additive response of a re-refined oil basestock in-between qualifications by means of engine sequence tests. The NBS research involves identification of the important characteristics which must be monitored, review and evaluation of existing tests for those required characteristics, and development of new or modified test procedures where necessary to adequately monitor an important characteristic or property. I believe

that complete consumer acceptance of re-refined oils, and thus parity in the marketplace, will not be obtained until fully accepted test procedures for consistency are established.

21803. Becker, D. A. **Research methodology in used oil recycling,** *Proc. Conf. Atomic Nuclear Methods Fossil Energy Research, Mayaguez, Puerto Rico, Dec. 1-4, 1980,* pp. 257-269 (Plenum Publ. Corp., 233 Spring Street, New York, NY 10013, 1982).

Key words: bromine; chlorine; elemental speciation; hydrocarbon characterization; lead; neutron activation analysis; oil recycling; petroleum testing.

Legislation and activities in the United States on the subject of used oil recycling have increased dramatically in the past several years. However, a substantial portion of both industry and government have some concerns about the lack of scientific and technical research and data on certain aspects of the quality and consistence of recycled petroleum oils, particularly re-refined engine oils. Further, there are some significant environmental concerns about pollution aspects of used oils and their recycling by-products and wastes. Since 1976, the (U.S.) National Bureau of Standards (NBS) has had a legislatively mandated program to "...develop test procedures for the determination of substantial equivalency of re-refined or otherwise processed used oil...with new oil for a particular end use" (42 U.S. Code 6363c). The NBS research includes identification of problem areas in the characterization of used and recycled oils, research into new measurement methods for determination of novel constituents in these materials, and the development and evaluation of appropriate test procedures and standards for recycled oil products. Aspects of this research discussed in this paper include analysis of total elemental content and speciation studies on lead and on the halogens (chlorine and bromine) and hydrocarbon type characterization studies on lubricating oil fractions.

21804. Cooper, L. Y. **A mathematical model for estimating available safe egress time in fires,** *Fire Mater.* **6,** No. 3-4, 135-144 (Sept./Dec. 1982).

Key words: combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits.

A mathematical model for estimating the time available for safe egress from a fire is formulated. The model simulates the conditions which develop during the course of an enclosure fire. Since life safety considerations are primary, the simulation model which is adopted focuses attention only on phenomena which develop between the times of fire ignition and onset of hazardous conditions. This allows significant simplifications in modeling which may not be otherwise justified. Using computed variables of a simulated fire scenario of interest, times of fire detection and onset of hazard which are deduced from realistic detection and hazard criteria would be estimated. The Available Safe Egress Time (ASET) would be defined as the length of the time interval which separates these two events. Quantitative specifications for a variety of detection and hazard criteria are identified. Results of exercising the model are presented, and ASET estimates are obtained for a wide variety of realistic fire scenarios. A comparison between experimental results of a multi-room fire test and prediction of the single-room model suggest that the model has potential utility in providing practical simulations of multi-room fire environments.

21805. Persily, A. K.; Grot, R. A. **Air infiltration and building tightness measurements in passive solar residences,** *Proc. Fifth Annu. Conf. ASME Solar Energy Division, Orlando, FL, Apr. 18-21, 1983,* pp. 116-121 (The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1983).

Key words: air infiltration; air tightness; building diagnostics; building tightness; passive solar buildings; pressurization; tracer gas.

The airtightness of about fifty passive solar homes located throughout the United States was studied using low cost measurement techniques. These homes are part of the Solar Energy Research Institute Class B program to evaluate the thermal performance of passive solar residential buildings. These tests provide the first set of building tightness measurements on a large group of passive solar buildings. The measurements include pressurization tests to measure airtightness and tracer gas measurements to determine air infiltration rates.

The pressure tests show a variation in the airtightness of these homes from 3 to 30 exchanges/hour at 50 Pascal, with a median of 9.5 exchanges/hour. The air infiltration measurements cover a wider range from 0.05 to 3.0 exchanges/hour, with a median of 0.5 exchanges/hour. In comparing the tightness of these homes to other U.S. homes, one finds that these passive solar homes are not significantly tighter than homes built with less of an emphasis on energy use.

21806. Nelson, H. E. **A fire safety equivalency system for overnight accommodations,** *Trends* **19,** No. 2, 31-36 (1982).

Key words: dormitories; fire safety; hotels; Life Safety Code; recreation areas; risk analysis; safety evaluation.

A quantitative evaluation grading system for National Park Service Hotel and Dormitory Accommodations is in advanced stages of development. This article reports the status and presents the format of the evaluation procedure. The article is directed to persons responsible for NFP or similar types of facilities.

21807. Ellingwood, B.; Redfield, R. **Ground snow loads for structural design,** *J. Struct. Eng., Am. Soc. Civ. Eng.* **109,** No. 4, 950-964 (Apr. 1983).

Key words: climatology; design (buildings); loads; probability theory; roofs; snow; statistical analysis; structural engineering.

Snow loads for structural design are calculated as the product of the ground snow load and a snow load coefficient that transforms the ground load to a roof load. This paper presents a statistical analysis of annual extreme water-equivalents (reported as inches of water) of ground snow measured at 76 weather stations in the northeast quadrant of the United States through the winter of 1979–1980. The analysis suggests that the lognormal distribution is preferable to a Type I distribution of extreme values for describing annual extreme ground snow loads at a majority of sites. Sampling errors and the selection of design loads from the statistical analysis are also described.

21808. Deprit, A. **The reduction to the rotation for planar perturbed Keplerian systems,** *Celestial Mech.* **29,** 229-247 (1983).

Key words: astrodynamics; averaging; celestial mechanics; mechanics; Morse theory; perturbations.

After the mean anomaly has been removed from the perturbations, the reduced Hamiltonian becomes a function over the Lie algebra determined by the infinitesimal generators associated with the dynamical symmetries of an unperturbed Keplerian system. The phase space being now the group SO(3), average motions consist of rotations, and the normalized Hamiltonian serves as a Morse function whose critical points determine the intrinsic topology of the perturbed system.

21809. Roberts, J. R.; Kaufman, V.; Sugar, J.; Pittman, T. L.; Rowan, W. L. **Magnetic-dipole transitions observed in highly ionized Ga, Ge, As, and Kr,** *Phys. Rev. A* **27,** No. 3, 1721-1723 (Mar. 1983).

Key words: isoelectronic sequence; krypton; magnetic dipole transitions; plasma; Tokamak; wavelength.

The Texas Experimental Tokamak (TEXT) was used to observe magnetic-dipole radiation arising from transitions within the $3s^2 3p^n$ ground-state configurations of highly stripped ions heavier than Ni. This device generates a plasma of 3×10^{13}-cm^{-3} electron density and $\sim$1.5-keV temperature, ideally suited for ionization of these atoms to the $n=3$ shell. Wavelength and transition-rate predictions were made with scaled Hartree-Fock radial energy integrals.

21810. Moody, J. R. **Sampling and storage of materials for trace elemental analysis,** *Trends Analyt. Chem.* **2,** No. 5, 116-118 (May 1983).

Key words: analytical blank; contamination; sampling; stabilization; storage; trace analysis.

Accurate analysis depends upon a valid, representative and uncontaminated analytical sample. For many trace metals, contamination overwhelms the sample, leading to inaccurate analytical data. Methods of controlling contamination and their implications for better methods of sampling and storage are discussed here.

21811. Howe, S. E. **The documentation of statistical software in GAMS: The Guide to Available Mathematical Software,** (Proc. 14th Symp. Interface, Troy, NY, July 5-7, 1982), Paper in *Computer Science and Statistics,* pp. 251-254 (Springer-Verlag, 175 Fifth Avenue, New York, NY 10010, 1983).

Key words: classification scheme; data base; mathematical software; scientific computing; statistical computing; statistical software.

In the first phase of a project to organize and publicize the mathematical and statistical software available to scientists at the National Bureau of Standards, Ron Boisvert, David Kahaner, Janice Knapp-Cordes, Martin Knapp-Cordes, and I have produced an approximately 400-page *Guide to Available Mathematical Software* (GAMS). All of the software which this guide documents is available on the Univac 1100/82 computer at NBS in Gaithersburg, Maryland, and most is available on the CDC Cyber 750 at the Department of Commerce laboratories in Boulder, Colorado, where some NBS staff are located. GAMS was produced by systematically querying a database management system designed for this project using DMS-1100, Univac's CODASYL database management system.

GAMS is based on a extensive scheme for classifying both statistical software and software for mathematical computations of interest to statisticians—such as special functions, linear algebra, integrals, differential equations, and optimization. The current edition classifies and contains documentation for approximately 2300 subroutines in the IMSL, NAG, and PORT proprietary libraries and three dozen high-quality public-domain packages including LINPACK, FFTPACK, and QUADPACK. A future edition will include programs and interactive systems as well as more subroutines, and will take the form of a more easily maintained and searched on-line database.

21812. Deslattes, R. D.; LaVilla, R. E.; Cowan, P. L.; Henins, A. **Threshold studies of a multivacancy process in the $K\beta$ region of argon,** *Phys. Rev. A* **27,** No. 2, 923-933 (Feb. 1983).

Key words: argon; satellites; synchrotron radiation; x-ray spectra.

Threshold-region measurements are reported for the production of single-vacancy and multiple-vacancy configurations of atomic argon by monochromatic x-ray photons in the region of the 1*s* ionization threshold. The experiment used monochromatized synchrotron radiation produced in the six-pole wiggler at the Stanford Synchrotron Radiation Laboratory with 3.2-GeV electrons at circulating currents of 20–30 mA. Secondary radiation including elastically and inelastically scattered radiation as well as fluorescent spectra were analyzed in a focusing spectrometer with a linear position-sensitive detector. Fluorescent spectra in the $K\beta$ region were modeled by inclusion of spontaneous decay of double-vacancy configurations of the type $KM \rightarrow M^2$. This multiplet model permitted extraction of partial cross sections for the production of $KM_{\rm I}$ and $KM_{\rm II,III}$ configurations. This report also contains new data on details of absorption fine structure in the region of the single-vacancy threshold and the principal double-vacancy thresholds.

21813. Lovas, F. J.; Suenram, R. D.; Evenson, K. M. **Laboratory measurement of the 4_{04}–3_{13} 70 GHz transition of ground-state methylene (CH_2),** *Astrophys. J.* **267,** L131-L133 (Apr. 15, 1983).

Key words: laboratory spectra; molecular processes.

Measurement of the $N_{KK}=4_{04}$–3_{13} rotational transition of $X\ ^3B_1$ CH_2 is reported. The rotational transition is split into three fine-structure components due to electron spin and spin-rotation interactions. These were observed at 68.37 GHz, 69.01 GHz, and 70.68 GHz, each line within 20 MHz of the values predicted from a prior analysis of the far-infrared rotational spectrum. Also, the triplet hyperfine structure due to the proton nuclear spin was well resolved.

21814. Yamabe, C.; Buckman, S. J.; Phelps, A. V. **Measurement of free-free emission from low-energy-electron collisions with Ar,** *Phys. Rev. A* **27,** No. 3, 1345-1352 (Mar. 1983).

Key words: argon; drift-tube; electrons; emission; free-free radiation; infrared; visible.

The production of free-free radiation in collisions of low-energy electrons with Ar atoms has been measured using the drift-tube technique. The excitation coefficients were obtained from measurements of the absolute intensity of continuum radiation at wavelengths of 500, 650, and 1300 nm. At 650 nm the electric-field-to-gas-density ratio E/N was varied from 0.25×10^{-21} to 10×10^{-21} V m^2 corresponding to mean electron energies from 1.2 to 5.4 eV. As expected, the emission was proportional to the argon density from 3×10^{24} to 15×10^{24} atoms/m^3. The experimental excitation coefficients are in good agreement with calculations using theoretical free-free emission cross sections and electron energy distributions and serve to demonstrate the usefulness of simple formulas relating the free-free emission cross section to measured momentum-transfer cross sections.

21815. Yamabe, C.; Phelps, A. V. **Excitation of the $O_2(a^1\Delta_g)$ state by low energy electrons in O_2–N_2 mixtures,** *J. Chem. Phys.* **78,** No. 6, Pt. 1, 2984-2989 (Mar. 15, 1983).

Key words: electrons; excitation; low-energy; metastables; nitrogen; oxygen.

Coefficients for the excitation of the $a\ ^1\Delta_g$ state of O_2 by low energy electrons in mixtures of O_2–N_2–Ar and O_2–N_2 and in pure O_2 have been determined using a drift tube technique. The time dependence of the absolute intensity of 1.27 μm band emission was measured for 1% to 5% O_2 and 1% to 10% N_2 in Ar at total gas densities of 2 to 10×10^{24} m^{-3} and in 20% O_2–80% N_2 mxitures at a total density of about 2×10^{24} m^{-3}. The measured decay constants for $O_2(a\ ^1\Delta)$ metastable densities in these mixtures are in agreement with previous data. Comparison of experimental and calculated excitation coefficients for the mixtures shows the importance of $a\ ^1\Delta_g$ excitation by cascading from the states of the $A\ ^3\Sigma_u^+$, $C\ ^3\Delta_u$, and $c\ ^1\Sigma_u^-$ group near 5 eV in O_2 for mean electron energies between 1.5 and 5 eV. Using published $a\ ^1\Delta$ deexcitation rate coefficients, the measurements of absolute intensity at 1.27 μm from pure O_2 yield excitation coefficients that agree satisfactorily with theory at E/N values of $8\text{–}20\times10^{-21}$ Vm^2.

21816. Souders, T. M.; Flach, D. R.; Wong, T. C. **An automatic test set for the dynamic characterization of A/D converters,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 180-186 (Mar. 1983).

Key words: analog-to-digital converter; automated; code-transition levels; converters testing; dynamic testing; high resolution; settling time; step response.

An automatic test set is described for measuring the dynamic characteristics of A/D converters having up to 16 bits of resolution. The test converter is exercised with stepped input changes typical of the conditions of actual use. All dynamic test parameters are under program control, making it possible to separate and measure dynamic errors of various sources. Typical test results are included.

21817. Debenham, P. **Homogenizing the field in a picture-frame magnet,** *Proc. Workshop High-Resolution, Large-Acceptance Spectrometers, Argonne, IL, Sept. 8-11, 1981,* pp. III.G-1–III.G-14 (Argonne National Laboratory, Argonne, IL, Sept. 1981).

Key words: magnet design; magnetic spectrometers.

A picture-frame magnet with appropriate dimensions for a 1 GeV/c electron spectrometer is investigated. The magnetic field in the air gap is calculated and is found to contain a nonuniform, sextupole component of magnitude 5×10^{-4} relative to the dipole component, B_0. This value is intolerably large for many high-resolution spectrometers. A method is proposed to reduce the nonuniform component by incorporating auxillary air gaps (Purcell filters) in the picture-frame magnet. The sextupole field component is reduced to less than $\pm2\times10^{-5}$ B_0 in the range 0.5 to 1.4 Tesla with the proposed design.

21818. Musiol, K.; Jones, D. W.; Wiese, W. L. **Lifetime ratios for Ar I 4*p* levels,** *J. Quant. Spectrosc. Radiat. Transfer* **29,** No. 4, 321-327 (1983).

Key words: argon; atomic lifetimes; atomic transition probabilities; J-file sum rules; line strengths; wall-stabilized arc.

Relative transition probabilities of 13 transitions between the $3p^5 4s$ and $3p^5 4p$ configurations in Ar I have been measured in emission with a wall-stabilized arc. These data have been combined to yield relative lifetimes which are compared with recent direct lifetime measurements. An important consideration in our experiment was to minimize effects of radiation imprisonment since this effect may have played an important role in lifetime measurements by other methods. Our results agree well with most previously published lifetime data and emission measurements.

21819. Kelley, R. D.; Candela, G. A.; Madey, T. E.; Newbury, D. E.; Schehl, R. R. **Surface and bulk analysis of a deactivated Raney nickel methanation catalyst,** *J. Catal.* **80,** 235-248 (1983).

Key words: deactivated catalyst; methanation; Raney nickel; surface analysis.

In a joint PETC-NBS experiment, a Raney nickel methanation catalyst in a hot gas recycle (HGR) bench-scale reactor (used for catalyst lifetime testing) has been examined with a wide range of modern analytical techniques sensitive to both surface and bulk chemical properties of the catalyst. The reactor was designed to use a catalyst essentially identical to that used in previous lifetime testing and to allow both the sampling at various positions along the catalyst bed and the introduction of the samples into the various analytical instruments under inert atmospheric conditions (i.e., without exposure to oxygen, water, etc.). The purpose of this work was to explore the reasons for the premature failure of the catalyst in pilot plant lifetime tests. The results indicate that in spite of significant catalyst deactivation only low levels of carbon (a small fraction of a surface monolayer) are formed on the catalyst surface. The primary cause of catalyst deactivation in this lifetime test was determined to be the growth of the nickel crystallites and subsequent decrease in active catalyst surface area.

21820. Kahaner, D.; Stoer, J. **Extrapolated adaptive quadrature,** *Siam J. Sci. Stat. Comput.* **4,** No. 1, 31-44 (Mar. 1983).

Key words: adaptive quadrature; automatic quadrature; extrapolation; mathematical software; Romberg; Wynn's ϵ-algorithm.

In this paper we consider algorithms for numerical quadrature in one dimension which combine global adaption and extrapolation. We analyze the convergence of one specific algorithm in terms of the amount of work as a function of the input accuracy request. The main result is that asymptotically the expected amount of work is unaffected by the adaption. This is illustrated by numerical examples. An alternative algorithm is also suggested.

21821. Becker, D. A. **Used lube oil: Hazardous waste vs. valuable resource,** *Proc. 16th Annu. Conf. Trace Substances Environmental Health, Columbia, MO, May 31-June 3, 1982,* D. Hemphill, ed., pp. 22-27 (University of Missouri-Columbia, Columbia, MO, 1983).

Key words: chlorine analysis; chlorine speciation; hazardous waste; lead analysis; lead speciation; petroleum recycling; polychlorinated biphenyl (PCB) analysis; recycled oil; used oil.

Large amounts of used lubricating oil are generated in the United States each year. This oil is very widely dispersed throughout the country, especially by the 60 percent of motorists who change their own motor oil. Under current EPA regulations, the characteristics of most used oil would place it in the hazardous waste classification. This paper describes research on impurities and contaminants in used and recycled oil, including PCBs, lead and lead species, and the halogens chlorine and bromine. Additional data on the environmental consequences of improper used oil disposal are needed.

21822. Olien, N. A.; Mann, D. B.; Brennan, J. A.; Siegwarth, J. D.; LaBrecque, J. F. **Metrology and availability of thermophysical property data for liquefied natural gas,** (Proc. 15th World Gas Conf., Lausanne, Switzerland, June 14-15, 1982), Paper *IGU/H7-82,* pp. 1-4 (Commission d'administration du XVe Congres mondial du gaz, SWISSGAS Case postale 658 CH-8027 Zurich, Switzerland, 1983).

Key words: custody transfer; density; flow metering; fluid properties; heating value; hydrocarbons; liquefied natural gas; metering; methane; metrology; natural gas; PVT; thermophysical properties; transport properties.

The increasing international trade in liquefied natural gas (LNG) and the rising price of LNG has placed ever increasing importance on reducing the inaccuracies associated with the transfer of ownership (custody transfer) of this important energy commodity. This paper summarizes the available sources of accurate and wide-range data for the thermophysical properties of LNG and its constituents. The constituents include the lower alkanes, methane through butanes, as well as nitrogen, carbon dioxide and helium. Special emphasis is placed on accurate predictive techniques for properties, especially density, of LNG and its constituents. Part II of the paper discusses the methods used to determine, in the field, static volume in tanks, static and dynamic density and heating value. The uncertainties associated with each measurement are discussed in the context of the total custody transfer measurement process.

21823. Takagi, S.; Mathew, M.; Brown, W. E. **A glaserite-type structure: Calcium tripotassium hydrogenbis(phosphate), $CaK_3H(PO_4)_2$,** *Acta Crystallogr.* **C39,** 166-169 (1983).

Key words: calcium phosphate; crystal structure; glaserite-type; hydrogen bond; hydrogen phosphate; potassium phosphate.

M_r=348.34, monoclinic, space group $C2/m$, a=9.878(1), b=5.735(1), c=7.436(1) Å, β=94.28(1)°, V=420.08 Å^3, Z=2, D_m=2.77, D_x=2.754 Mg m^{-3} at 298 K, λ(Mo $K\alpha$)=0.7107 Å, μ=2.65 mm^{-1}. Final R=0.017 for 512 observed reflections. The structure consists of columns of cations, Ca and K(1), and columns of cations and anions, K(2) and PO_4. The arrangement of these columns in a pseudohexagonal form is similar to that of glaserite, $K_3Na(SO_4)_2$, *e.g.*, α-Ca_3 $(PO_4)_2$ (Mathew, Schroeder, in a symmetric hydrogen bond across a crystallographic center of inversion to form a dimeric $[H(PO_4)_2]$ unit.

21824. Danos, M,; Rafelski, J. **Particle radiation by hot quark-gluon plasma,** *Phys. Rev. D* **27,** No. 3, 671-674 (Feb. 1, 1983).

Key words: gluons; pion radiation; QCD; quark matter; quarks; Stefan-Boltzmann.

Highly excited hadronic matter consisting of quarks and gluons radiates an important fraction of its excitation energy by hadron emission. This relieves the surface pressure and reduces the importance of the expansion to the cooling of the plasma. Qualitative model calculations are presented.

21825. Bergquist, J. C.; Hemmati, H.; Itano, W. M. **High power second harmonic generation of 257 nm radiation in an external ring cavity,** *Opt. Commun.* **43,** No. 6, 437-442 (Nov. 15, 1982).

Key words: ADP; argon; cavity; doubling; external; laser; ring; single-mode.

Continuous wave high power frequency doubling of a stabilized, single mode argon ion laser in a resonant external ring cavity is discussed and experimental results are presented. The second harmonic is generated in a Brewster cut ADP crystal which is 90° temperature phase matched. Greater than 80 milliwatts of stable, usable radiation at 257 nm is generated. Successful operation of the ring cavity with an internal harmonic beamsplitter to extract the UV radiation is reported.

21826. Berger, M. J.; Seltzer, S. M. **Theoretical aspects of electron dosimetry,** *Proc. Symp. Electron Dosimetry Arc Therapy, University of Wisconsin, Sept. 10-11, 1981,* 19 pages (American Institute of Physics, Inc., New York, NY, 1982).

Key words: dosimetry; electrons; Monte Carlo; narrow-pencil beams; superposition; treatment planning.

This paper deals with the application of the superposition method to the calculation of absorbed-dose distributions in homogeneous water phantoms irradiated by electron beams. The first stage of the

calculation consists of the evaluation, by the Monte Carlo method, of elementary three-dimensional absorbed-dose distributions from narrow-pencil beams. In the second stage, the beam of interest is treated as a superposition of narrow-pencil beams, and the absorbed-dose distribution from the beam is obtained as a corresponding superposition of elementary distributions. A data base has been generated consisting of 14 elementary absorbed-dose distributions from monoenergetic pencil beams with energies between 1 and 60 MeV. Examples of such elementary distributions are presented, as well as other results obtained by applying the data base to other beam geometrics. These results include (1) depth-dose curves and practical ranges in broad-beam geometry; and (2) central-axis depth-dose curves, radial distributions of absorbed dose, and isodose patterns for beams with finite, circular field size.

21827. Rossiter, W. J., Jr.; Ballard, D. B.; Sleater, G. A. **Elevated temperature and humidity effects on urea-formaldehyde foam insulations observed by scanning electron microscopy,** (Proc. Conf. Thermal Insulation, Materials, and Systems for Energy Conservation in the 80's, Clearwater Beach, FL, Dec. 8-11, 1981), *Am. Soc. Test. Mater. Spec. Tech. Publ. 789,* pp. 665-687 (Mar. 1983).

Key words: cellular structure; foam; humidity; insulation; scanning electron microscopy; shrinkage; temperature; urea-formaldehyde.

Exposure of urea-formaldehyde foam insulation to elevated temperature and relative humidities may result in its deterioration, as evidenced by shrinkage, mass loss, and under severe conditions, by disintegration. This paper describes the results of a scanning electron microscope (SEM) study undertaken to determine the effect on the cellular microstructure of urea-formaldehyde foam insulations from exposure to elevated temperature and relative humidity conditions. Recommendations for a temperature-humidity exposure test for these insulations are given.

Four commercially-available foam samples, typical of those installed in residences, were prepared in wooden boxes. The percent linear shrinkage in the boxes was determined at various time intervals after filling. Specimens of each foam sample (after drying) were exposed to a variety of elevated temperature and humidity conditions. Changes in mass and volume of the specimens were periodically recorded during exposure. Three foam samples showed slight changes in volume under all exposure conditions. One sample was more susceptible to the exposures at the elevated conditions. SEM was used to investigate changes in cellular structure upon exposure. Results indicated that samples which underwent slight changes in volume during exposure had cellular structures which were not apparently altered. Conversely, SEM photomicrographs indicated cellular degradation in the sample which was affected by the elevated exposure conditions.

21828. Bachet, G.; Cohen, E. R.; Dore, P.; Birnbaum, G. **The translational-rotational absorption spectrum of hydrogen,** *Can. J. Phys.* **61,** No. 4, 591-603 (1983).

Key words: collision-induced absorption; double transitions; hydrogen; planetary atmosphere; spectral moment analysis; spectral shapes; translational-rotational spectrum.

The collision-induced translational-rotational spectrum of H_2 has been accurately measured in the region from about 30 to 2000 cm^{-1} at 195 and 297 K. A very weak feature due to the hexadecapole-induced dipole, the $U_0(1)$ line, has been detected at 195 K in the region around 1622 cm^{-1}. These spectra can be accurately represented by a simple, semi-empirical line shape. The effect of double transitions are considered and explicit expressions for these are given. Spectral integrals proportional to the zero and first moments are determined experimentally and compared with the theoretical moments computed on the basis of quadrupole induction for several potentials. The difference between the experimental and theoretical values, in the order of 20%, is attributed to anisotropic overlap induction, but the inferred magnitude of this component is strongly dependent on the assumed potential.

21829. Danos, M.; Williams, H. T. **Electron scattering from baryon resonances in nuclei,** *Phys. Lett.* **119B,** No. 1,2,3, 43-46 (Dec. 16, 1982).

Key words: baryon resonances; binding of deltas; electron scattering; high momentum components; momentum distribution; quasi-elastic peak.

A zero parameter model calculation of deep inelastic electron scattering in the energy range of the $\Delta(1236)$ resonance is presented. It is assumed that the major effect of the virtual photon is to excite a $\Delta(1236)$ from a nucleon, and that this resonance is bound to the remaining nucleons. The results are compared with existing experimental data and with other theoretical results.

21830. Levine, J. **The earth tides,** *Phys. Teacher,* pp. 588-595 (Dec. 1982).

Key words: earth tides; gravitational potential; gravity meter; tilt meter.

For centuries, people living along coastlines have noticed the diurnal and semidiurnal fluctuations in the height of the sea.

The connection between the moon and these tides was obvious, and, even before the formulation of any theory, quite satisfactory predictions of the ocean tides were published. Tidal tables were constructed by various indivulged methods, and these methods were often passed from father to son.

It was less widely appreciated that the earth itself is subjected to tidal stresses and undergoes tidal deformations. It is the purpose of this paper to investigate these tidal stresses and to see how the deformations may be measured.

21831. Hubbell, J. H. **Photon mass attenuation and energy-absorption coefficients from 1 keV to 20 MeV,** *Int. J. Appl. Radiat. Isot.* **33,** 1269-1290 (1982).

Key words: attenuation coefficients; dosimetry; gamma-rays; photons; tabulations; x rays.

Mass attenuation coefficients μ/π and mass energy-absorption coefficients μ_{en}/π are tabulated in units of $m^2\ kg^{-1}$ for photon energies 1 keV to 20 MeV for 40 elements ranging from hydrogen ($Z=1$) to uranium ($Z=92$). In addition, μ/π and μ_{en}/π values are tabulated over this same energy range for 45 mixtures and compounds of dosimetric interest, computed from the above data using fractions-by-weight of the constituent elements. Source data for these tables are primarily theoretical. The atomic photoeffect cross sections, with minor empirical modifications, are from the 1973 computations of Scofield. The incoherent (bound-electron Compton) and coherent scattering cross sections, also pair and triplet production cross sections, are from recently published (1975, 1979, 1980) compilations developed at NBS in collaboration with researchers from various laboratories including Kaman Sciences, Los Alamos Scientific Laboratory, Lawrence Livermore National Laboratory, Max-Planck-Institute (Mainz) and the University of Trondheim. Information is provided for estimating photonuclear contributions above 5 MeV. Differences from NSRDS-NBS 29 (1969) and Storm-Israel (1970) are of the order of 1% or less over most of the element-energy range, but in some cases are as much as 5%.

21832. Ellingwood, B.; Leyendecker, E. V.; Yao, J. T. P. **Probability of failure from abnormal load,** *J. Struct. Eng., Am. Soc. Civ. Eng.* **109,** No. 4, 875-890 (Apr. 1983).

Key words: abnormal loads; buildings (codes); design; loads; probability theory; progressive collapse; reliability; structural engineering.

Abnormal loads, which usually are not considered in structural design because of their low probability of occurrence, may initiate a catastrophic failure if they occur. A case study shows that the probability of structural failure due to a gas explosion in a residential compartment may exceed probabilities associated with unfavorable combinations of ordinary design loads. Therefore, specific provision in design standards to mitigate the effects of abnormal loads appear warranted.

21833. Way, J. D.; Noble, R. D.; Flynn, T. M.; Sloan, E. D. **Liquid membrane transport: A survey,** *J. Membr. Sci.* **12,** 239-259 (1982).

Key words: carrier-mediated transport; coupled-transport; facilitated transport; ion transport; liquid membranes; liquid surfactant membranes; mathematical modeling; membrane

transport; separations.

The literature pertaining to facilitated transport and liquid membrane separations is reviewed and summarized, especially work reported since 1977. Liquid membranes of all geometries are discussed, including immobilized liquid membranes and liquid surfactant or emulsion liquid membranes. Emphasis is placed on facilitated, or carrier-mediated transport in both configurations although other mechanisms such as coupled-transport and transport due to solubility differences are discussed. Mathematical modeling and analytical solutions for facilitated transport models are summarized. The possibility of industrial application of liquid membrane technology is mentioned and the most important experimental techniques for liquid membrane research are discussed. Also, directions for future research are recommended.

21834. Bertel, E.; Stockbauer, R.; Madey, T. E. **Resonant electron emission in Ti and TiO_2,** *Phys. Rev. B* **27,** No. 3, 1939-1942 (Feb. 1, 1983).

Key words: direct recombination; oxidation; resonant recombination; titanium; titanium dioxide; transition metals.

A direct electronic recombination process is observed following $3p$ excitation in both Ti and TiO_2. In Ti this leads to resonant photoemission from the $3d$ valence levels at a photon energy 14 eV above the $3p$ threshold. In TiO_2 the oxide valence-band emission is enhanced at the $3p$ resonance energy. This is the first observation of interatomic resonant photoemission in an oxide. The resonant electron emission is also observed in electronically excited Auger spectra.

21835. Siegwarth, J. D.; LaBrecque, J. F. **Calibration of densimeters for liquefied light hydrocarbons,** *Oil Gas J.* **80,** No. 64-69, 6 pages (Dec. 20, 1982).

Key words: archimedes; calibration; densimeter; density; liquefied natural gas.

A densimeter calibration apparatus is described in which an instrument to be calibrated is compared to a self-calibrating standard densimeter in homogeneous isothermal samples of liquids similar to those in which the instrument will be used. The calibration apparatus is estimated to give the true density to $\pm 0.055\%$. The results of tests of a number of densimeters for liquefied natural gas service are described.

21836. Pierce, D. T.; Celotta, R. J.; Unguris, J.; Siegmann, H. C. **Surface magnetic properties of amorphous ferromagnets studied using electron spin polarization,** *J. Magn. Magn. Mater.* **35,** 28-30 (1983).

Key words: spin-polarization; surface magnetization; surface magnons.

The temperature dependence of the surface magnetization of $Ni_{40}Fe_{40}B_{20}$ was determined by measurement of the intensity asymmetry after scattering a spin modulated incident electron beam. The energy dependence of the spin polarization of secondary electrons from $Fe_{81.5}B_{14.5}Si_4$ was measured and illustrates a new way to investigate surface magnetic microstructures.

21837. Carino, N. J.; Lew, H. S.; Volz, C. K. **Early age temperature effects on concrete strength prediction by the maturity method,** *J. Am. Concr. Inst.* **80,** No. 2, 93-101 (Mar.-Apr. 1983).

Key words: age-strength relation; compressive strength; concretes; curing; cylinders; temperature; tests.

A comparison was made between the strength-maturity relations of concrete cylinders cured outdoors and cylinders cured in a laboratory. It was found that when early age (assumed as 48 hr) temperatures of the outdoor-cured and laboratory-cured cylinders were similar, the strength-maturity relations were similar despite temperature fluctuations experienced by the outdoor-cured specimens. The relations were dissimilar when their early age temperatures differed. Another series of tests further investigated and confirmed the importance of early age temperature on the strength-maturity relation.

21838. Bowen, R. L.; Nemoto, K.; Rapson, J. E. **Adhesive bonding of various materials to hard tooth tissues: Forces developing in composite materials during hardening,** *J. Am. Dent. Assoc.* **106,** 475-477 (Apr. 1983).

Key words: composite resins; force; hardening; polymerization; shrinkage; stress.

Reported measurements show that significant tensile stresses develop during the hardening of composite resins if there is bonding to the cavity walls.

21839. Simiu, E. **Aerodynamic coefficients and risk-consistent design,** *J. Struct. Eng., Am. Soc. Civ. Eng.* **109,** No. 5, 1278-1289 (May 1983).

Key words: aerodynamics; climatology; extreme winds; loads; structural engineering; wind (meteorology).

A simple procedure is presented for estimating the reliability of wind-sensitive structures whose orientation is not specified. The procedure is based on a second moment reliability approach and makes use of: (1) Aerodynamic coefficients obtained experimentally as functions of wind direction, and (2) climatological data consisting of sets of largest annual speeds associated with winds blowing from each of the 8 (or 16) compass directions. An illustration of the procedure, based on sets of actual data, is presented. It is then shown that the tools presented in the paper can be applied to develop, from directional aerodynamic, and climatological data, nominal aerodynamic coefficients which in effect reduce wind loads with respect to those inherent in current U.S. practice, in a manner that reflects the directional dependence of both the aerodynamic behavior of structures and the extreme wind climate, while being consistent with respect to failure risk. These tools are first developed for the general case where the orientation of the structure is not known. It is then shown that criteria for risk-consistent design for buildings with specified orientation can be derived immediately as a particular case from the criteria applying to structures whose orientation is unknown.

21840. Weber, L. A. **Thermal conductivity of oxygen in the critical region,** *Int. J. Thermophys.* **3,** No. 2, 117-135 (1982).

Key words: coexistence curve; critical point; oxygen; Rayleigh scattering; thermal conductivity; thermal diffusivity.

The thermal conductivity of oxygen has been measured in a broad region around the critical point by means of Rayleigh light scattering. Measurements were made on two isochores and on the saturation boundary. The results are compared with current methods of predicting the anomalous thermal conductivity in the critical region.

21841. Lawn, B. R. **Physics of fracture,** *J. Am. Ceram. Soc.* **66,** No. 2, 83-91 (Feb. 1983).

Key words: atomically sharp cracks; ceramics; chemical effects; flaws; fracture; toughness.

The underlying physical bases of present-day fracture theory are examined. It is proposed that the automically sharp crack should be taken as the cornerstone for modeling propagation processes at the fundamental level. Transmission electron microscopy evidence is presented in support of this contention. Linear continuum fracture mechanics is shown to have intrinsic limitations in its capacity to describe crack-tip phenomena; a more realistic description is provided by lattice statics, incorporating the picture of a crack as a narrow slit terminated by nonlinear linkage bonds. This description establishes a powerful starting point for understanding and predicting the effects of important crack-tip interaction processes. Two such processes, chemically enhanced slow crack growth and process-zone toughening, are discussed in this light. Finally, the nature of strength-controlling flaws in brittle ceramics is considered, with particular reference to the validity of the widely adopted hypothesis that such flaws may be regarded as true microcracks.

21842. Jach, T.; Girvin, S. M. **Momentum-transfer dependence of Fano line shape in electron-energy-loss spectra of nickel,** *Phys. Rev. B* **27,** No. 3, 1489-1492 (Feb. 1, 1983).

Key words: electron energy loss spectroscopy; Fano interference; HEELS; inelastic electron scattering.

We have calculated the dependence on momentum transfer of Fano line shapes in inelastic electron scattering from nickel metal at the $3p$ excitation threshold. Using Hartree-Fock-Roothaan wave functions for the $3p$, $3d$, and ϵf continuum wave functions, we find a

momentum-transfer dependence of the line shapes which should be observable by high-energy electron-energy-loss spectroscopy. The line-shape dependence is sensitive to the screening model used in the nickel metal.

21843. Vian, J. P.; Danner, W. F.; Bauer, J. W. **Assessment of significant acoustical parameters for rating sound insulation of party walls,** *J. Acoust. Soc. Am.* **73,** No. 4, 1236-1243 (Apr. 1983).

Key words: acoustics; architectural acoustics; building acoustics; party walls; sound insulation; sound isolation; transmission loss.

To test the adequacy of French regulations for sound isolation in buildings, subjects were asked to rate their annoyance with samples of music filtered by electronic "insulation curves" representing different party walls. The insulation curves differed in their shape but all provided an A-weighted level difference of 51 dB with a pink noise source, measured over a 1/3-octave bandwidth of 40 Hz–10 kHz. However, the different insulation curves did not provide the same degree of sound isolation with various music samples due to source spectral differences. A statistically significant correlation was observed between annoyance and the A-weighted level difference ratings of the insulation curves when bandlimited pink noise (125 Hz–4 kHz) was used as a source. This correlation was not present when broadband (40 Hz–10 kHz) pink noise was used for the performance rating. Subjects showed a preference for insulation curves with steeper slopes (9 and 12 dB/oct), thus preferring a greater relative attenuation at higher frequencies. Additionally, the presence of coincidence dips was found to have an effect on subject preference that appeared to depend upon both the frequency range at which they occurred and the slope. The bandwidth of the music signals and the intelligibility of speech in the intruding sounds were also found to influence the annoyance ratings. These results indicate that the level difference method for rating sound insulation could better predict occupant response if the above results were accounted for in the procedure.

21844. Janev, R. K. **Electron capture into excited states in collisions of highly charged ions with atoms: A theoretical and experimental challenge,** *Comments At. Mol. Phys.* **12,** Nos. 5-6, 277-300 (1983).

Key words: atom-ion collisions; charge exchange; electron capture into excited states; highly charged ions; highly excited ionic states; selective-state capture.

The current status of the studies on creation of excited states by charge transfer collisions of multiply charged ions with atoms is discussed. Both theoretical and experimental problems involved in these studies are considered and suggestions are made for resolving some of them.

21845. Huennekens, J.; Gallagher, A. **Self-broadening of the sodium resonance lines and excitation transfer between the $3P_{3/2}$ and $3P_{1/2}$ levels,** *Phys. Rev. A* **27,** No. 4, 1851-1864 (Apr. 1983).

Key words: energy transfer; excitation transfer; line broadening; sodium.

Sodium vapor, in the density range 10^{13} to 5×10^{14} cm^{-3}, was excited by a cw dye laser, tuned 20–150 GHz from either the D_1 or D_2 resonance line. We observed a three-peak scattered spectrum, consisting of the Rayleigh component at the laser frequency, and the two fluorescence components (direct and sensitized) at the atomic resonance-line frequencies. Corrections to the Rayleigh signals for anisotropy and polarization effects, and to the fluorescence signals for radiation trapping, were made in order to obtain the ratio of the sum of the total intensities of the two fluorescence components to that of the Rayleigh component. This ratio combined with a measurement of the line-wing absorption coefficient yields the sodium density and the D-line self-broadening rate coefficients [$k_{br}=4.67\times10^{-7}$ cm^3 s^{-1} ($\pm15\%$) for the D_2 line and $k_{br}=3.07\times10^{-7}$ cm^3 s^{-1} ($\pm15\%$) for the D_1 line]. Asymmetry in the self-broadened line wings due to fine-structure recoupling was observed. The measured intensity ratio of the D lines, combined with pulsed measurements of the effective radiative decay rates in the presence of radiation trapping, yields the fine-structure collisional-mixing cross section [$\sigma(3P_{3/2}\rightarrow3P_{1/2})=172$ Å^2 ($\pm18\%$)] at $T\cong300$°C. Our results are compared to other experiments and to theory.

21846. Faller, J. E.; Guo, Y. G.; Rinker, R. L.; Zumberge, M. A. **Advanced absolute gravity determination,** *Proc. General Meet. Int. Assoc. Geodesy, Tokyo, Japan, May 7-15, 1982,* pp. 309-318 (Journal of the Geodetic Society of Japan, Tokyo, Japan, 1983).

Key words: absolute gravity; geodesy; geophysics; gravity.

During the past twenty years, a number of absolute gravimeters based on laser interferometry have been developed. At the Joint Institute for Laboratory Astrophysics (JILA) we have recently designed and built a new and highly-portable absolute gravity apparatus based on these principles for the purpose of surveying tectonically interesting regions. The status of this new instrument and our future plans for it as well as the general status of absolute gravity determinations will be discussed.

21847. Bernheim, R. A.; Gold, L. P.; Tipton, T. **Rydberg states of $^7Li_2$ by pulsed optical-optical double resonance spectroscopy: Molecular constants of $^7Li_2^+$,** *J. Chem. Phys.* **78,** No. 6, Pt. II, 3635-3646 (Mar. 15, 1983).

Key words: dissociation energy; laser spectroscopy; lithium dimer; lithium dimer ion; molecular Rydberg states; optical double resonance.

Three Rydberg series of electronic states of $^7Li_2$ have been characterized by pulsed optical-optical double resonance spectroscopy. The observed Rydberg states, which include the previously reported $E\ ^1\Sigma_g^+$ and $G\ ^1\Pi_g$ states, have been identified as $3\text{–}10s\sigma\ ^1\Sigma_g^+$, $3\text{–}10d\sigma\ ^1\Sigma_g^+$, and $3\text{–}15d\pi\ ^1\Pi_g$. The molecular constants for several of the upper members of each of the above series have been used to deduce the ionization potential of $^7Li_2$ and molecular constants for the $X\ ^2\Sigma_g^+$ state of $^7Li_2^+$. The former was determined to be $T_0(\infty)=41\,496\pm4$ cm^{-1}. The latter were found to be in good agreement with recent *ab initio* calculations.

21848. McKnight, R. H.; Kotter, F. R.; Misakian, M. **Measurement of ion current density at ground level in the vicinity of high voltage dc transmission lines,** *IEEE Trans. Power Apparat. Syst.* **PAS-102,** No. 4, 934-941 (Apr. 1983).

Key words: high voltage dc; measurement errors; transmission lines; vertical current density; Wilson plates.

Sensors for measuring vertical current density at ground level near high voltage dc (HVDC) transmission lines are subject to error when the sensor is not in the ground plane. The magnitude of this error, for guarded and unguarded sensors, has been investigated using both dc electric fields with space charge and ac electric fields in a parallel plate facility. For conditions like those expected under HVDC transmission lines, the results obtained using ac and dc methods agreed to within experimental uncertainty. The measured errors are as large as 25 percent for guarded sensors and significantly larger for unguarded sensors. Data for various sensor elevations and guarding are presented in graphs to aid the designer. Comparisons with results from an IEEE Working Group field day are also presented.

21849. Lowney, J. R.; Bennett, H. S. **Effect of ionized donors on the electron and hole densities of states in silicon,** *J. Appl. Phys.* **54,** No. 3, 1369-1374 (Mar. 1983).

Key words: density of states; donors; impurities; second Born approximation; silicon; Yukawa potential.

A self-consistent second Born approximation has been used to calculate the change in the electron and hole densities of states due to ionized donors in silicon. The results are compared with a previous partial-wave technique and found to be in good agreement for a case of common applicability, i.e., a donor density of 10^{20} cm^{-3} at room temperature.

21850. Poliakoff, E. D.; Dehmer, J. L.; Dehmer, P. M.; Parr, A. C. **Vibrationally resolved photoelectron angular distributions for H_2,** *Chem. Phys. Lett.* **96,** No. 1, 52-56 (Mar. 25, 1983).

Key words: autoionization; electron kinetic energy; photoelectron asymmetry parameter; photoionization; vibrational quantum number.

The photoelectron asymmetry parameter, β, is reported for individual vibrational levels of $H_2^+(X\ ^2\Sigma_g^+)$ formed by photoionization of $H_2(X\ ^1\Sigma_g^+)$ at wavelengths of 736, 584, 461 and 304 Å. At 584 Å, β exhibits a monotonic increase with vibrational quantum number (decreasing photoelectron kinetic energy) confirming the trend predicted by Itikawa.

21851. Knab, L. I.; Blessing, G. V.; Clifton, J. R. **Laboratory evaluation of ultrasonics for crack detection in concrete,** *Am. Concr. Inst. J., Tech. Pap. Title No. 80-3,* pp. 17-27 (Jan.-Feb. 1983).

Key words: amplitude; concretes; cracking (fracturing); evaluation; nondestructive tests; ultrasonic tests; velocity.

A laboratory study was performed to quantify the capabilities of ultrasonic through-transmission methods to detect cracks in concrete. Pulse velocity and amplitude measurements were taken perpendicular to the crack plane (in cracked concrete) and compared with measurements parallel to the crack plane (in uncracked concrete). The direct path length was 152 mm (6 in). Parallel crack surfaces, approximately 0.05 mm (0.002 in) apart and having depths of 19, 38, and 57 mm (0.75, 1.50, and 2.25 in) and widths of 152 mm (6 in), were fabricated in the specimens. Transducer frequencies of 150 and 54 kHz were used. .Concrete specimens with a 28 day compressive strength of about 36 MPa (5.2 ksi) were tested at several ages.

A sensitivity ratio was used to determine if the cracks could be detected. The numerator of the sensitivity ratio was the difference between velocity or amplitude values in the cracked as compared to uncracked concrete, while the denominator represented the variability of the velocity or amplitude values in both the cracked and uncracked concrete. With the 57 and 38 mm (2.25 and 1.5 in) deep cracks, nearly all the sensitivity values for velocity and amplitude indicated that these crack depths could be detected under the test conditions. The velocity and amplitude sensitivity values with the 19 mm (0.75 in) crack depth were lower, indicating that the 19 mm (0.75 in) crack depth could not be clearly detected. In this study, it was concluded, that both velocity and amplitude were meaningful parameters in crack detection. Based on the sensitivity values, however, velocity appeared to be the more meaningful parameter.

21852. Bullis, W. M.; Nyyssonen, D. **Optical linewidth measurements on photomasks and wafers,** Chapter 7 in *VLSI Electron.: Microstruct. Sci.* **3,** 301-346 (Jan. 1982).

Key words: integrated circuits; linewidth; microelectronics; micrometrology; optical metrology; optical microscopy; photomasks; silicon; VLSI.

This chapter discusses the origins of systematic errors in optical linewidth measurement systems, outlines advances in modeling the linewidth measurement process including imaging in the optical microscope, describes a primary linewidth measurement system in use at the National Bureau of Standards (NBS), and discusses the use of primary measurements to calibrate less accurate systems conventionally used for linewidth measurements. Although emphasis is placed on measurements of patterns on antireflective (AR) chromium photomasks in transmitted light, measurements on other types of materials including see-through photomasks and wafers are also discussed.

21853. Swaffield, J. A.; Bridge, S.; Galowin, L. S. **Mathematical modelling of time dependent wave attenuation and discrete solid body transport in gravity driven partially filled pipe flows,** *Proc. 4th Int. Conf. Finite Elements in Water Resources, Hannover, Germany, June 21-25, 1982,* 11 pages (Springer-Verlag Berlin, Heidelberg, New York, 1982).

Key words: drains; partially filled pipe flow; plumbing; solid transport in pipes; unsteady pipe flow.

The method of characteristics is applied to solve the unsteady partially filled pipe flow equations applying to the flow in building drainage systems. Wave attenuation, together with the propagation of steep fronted waves and the transport of discrete solids, is modelled and comparisons drawn with experimental investigations undertaken with representative pipe size and flow loading values.

21854. Hsu, N. N.; Proctor, T. M., Jr.; Blessing, G. V. **An analytical approach to reference samples for ultrasonic residual stress measurement,** *J. Test. Eval.* **10,** No. 5, 230-234 (Sept. 1982).

Key words: acoustic measurement; longitudinal waves; residual stress; stress state.

While residual stress measurements using ultrasonic techniques have been under development for some time, practical applications are still limited. One of the difficulties is the lack of suitable reference samples for instrument calibration. This paper specifically addresses the question of how to produce a known stress-state reference sample, and ultrasonically determine its zero stress state. The approach was to design and construct a sample possessing residual stresses that can be deduced from established theory. A shrink-fit ring-plug assembly was fabricated from carefully screened aluminum bar stock, forming a disk suitable for both longitudinal and shear wave calibration. Here we report results using longitudinal waves.

21855. Fish, R. H.; Tannous, R. S.; Walker, W.; Weiss, C. S.; Brinckman, F. E. **Organometallic geochemistry. Isolation and identification of organoarsenic compounds from Green River Formation oil shale,** *J. Chem. Soc., Chem. Commun.* **9,** 490-492 (Jan. 18, 1983).

Key words: arsenate; atomic absorption detector; biogeochemistry; catecholate derivatives; gas chromatography-mass spectrometry; Green River Formation; high performance liquid chromatography; methylarsonic acid; oil shale; organometallic geochemistry; phenyarsonic acid; speciation.

A Green River Formation oil shale sample was crushed and extracted with refluxing methanol and analysed by high performance liquid chromatography in combination with graphite furnace atomic absorption detection (h.p.l.c.-g.f.a.a.) to provide evidence for the presence of methyl- and phenyl-arsonic acids and the arsenate ion; further evidence for the acids' identification was provided by derivatization with 3-methylcatechol to form the corresponding five-co-ordinate organoarsenic catecholates followed by capillary column gas chromatography-electron impact mass spectrometry (g.c.-e.i.m.s.) analysis.

21856. Van Vechten, D.; Holdeman, L. B.; Soulen, R. J., Jr.; Toots, J. **The superconductive energy gaps of thin-film $AuAl_2$ and $AuIn_2$,** *J. Low Temp. Phys.* **51,** Nos. 3/4, 329-346 (May 1983).

Key words: $AuAl_2$; $AuIn_2$; energy gap; superconductivity; thin films; tunneling.

Thin films of the intermetallic compounds $AuAl_2$ and $AuIn_2$ were prepared and used as electrodes in $AuAl_2$/oxide/Al, Al/oxide/$AuIn_2$, or $AuAl_2$/oxide/$AuIn_2$ tunnel junctions. The tunnel barriers were produced by rf sputter oxidation. The temperature dependence of the energy gaps of the $AuAl_2$ and $AuIn_2$ films was measured and found to agree well with BCS theory.

21857. Swaffield, J. A.; Bridge, S.; Galowin, L. S. **Unsteady flow in long drainage systems,** *Build. Res. Pract.* **11,** No. 1, 48-59 (Jan.-Feb. 1983).

Key words: drains; partially filled pipe flow; plumbing; solid transport in pipes; unsteady pipe flow; wave attenuation.

The effect of flow attenuation on drainage design is identified and is shown to be modelled by the partially filled unsteady pipe flow equations. Numerical solutions to these equations are presented and validated against laboratory testing at flow rates appropriate to installed drainage systems. Application of the method to both steep fronted waves and solids moving through the pipe system are also presented.

21858. Mahajan, B. M.; Liu, S. T. **Initial results from the NBS passive solar test facility,** *Proc. ASME Solar Energy Division Fifth Annu. Conf., Orlando, FL, Apr. 18-20, 1983,* pp. 109-115 (The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, Apr. 1983).

Key words: hybrid; passive; performance; solar; storage; thermal test.

The National Bureau of Standards (NBS), under the sponsorship of the U.S. Department of Energy (DoE), has constructed a passive/hybrid solar test facility for the purpose of acquiring carefully measured performance data for various passive subsystems under

different experimental conditions. The test facility contains several types of generic passive solar features, such as a direct gain system, a collector/storage wall, and clerestory windows. Such carefully measured data are needed both for: (1) assessing the adequacy of performance monitoring procedures for passive heating and cooling systems, and (2) validation of passive solar analysis/design tools. Performance data have been acquired from the initial testing of the direct gain system under two different experimental conditions.

This paper briefly describes the test facility, instrumentation, experimental conditions for the initial tests and planned experimental work. The paper contains representative results from the initial test data. The performance of the concrete floor as the thermal storage medium, the occurrence of overheating, and the thermal comfort conditions within the cell are discussed.

21859. Gerstenberg, H.; Hubbell, J. H. **Comparison of experimental with theoretical photon attenuation cross sections between 10 eV and 100 GeV,** *Nucl. Data Sci. Technol.,* pp. 1007-1009 (1983).

Key words: attenuation coefficient; critical evaluation; cross sections; data base; photons; x rays.

A computerized photon attenuation data base has been developed by the NBS Photon and Charged Particle Data Center for the photon energy range 10 eV to 100 GeV and for elements, with $Z=1$ to 94. An example of use of this data base in the critical evaluation of a theory-based data-set is presented.

21860. Sonnefeld, W. J.; Zoller, W. H.; May, W. E.; Wise, S. A. **On-line multidimensional liquid chromatographic determination of polynuclear aromatic hydrocarbons in complex samples,** *Anal. Chem.* **54,** 723-727 (Apr. 1982).

Key words: high performance liquid chromatography (HPLC); multidimensional; polycyclic aromatic hydrocarbon (PAH); polycyclic organic material.

A method is described for the on-line coupling of a normal-phase high-performance liquid chromatographic (HPLC) system to a reversed-phased HPLC system. The method employs a diamine column for on-column concentration of a selected fraction from a normal-phase aminosilane column followed by a solvent exchange procedure and gradient elution focusing of the analyte species onto a reversed-phase octadecylsilane column. No loss of analyte of chromatographic resolution is observed by using this method. Several chromatographic packing materials were investigated for use as on-column concentrators of polynuclear aromatic hydrocarbons (PAH) from normal-phase chromatographic systems. The validity of this approach was verified by determining the concentration of several PAH in Standard Reference Material (SRM) 1580—"Organics in Shale Oil."

21861. Sniegoski, L. T.; White V, E. **Syntheses of 1-dodecyl-d_{25} phosphate,** *J. Labelled Comp. Radiopharm.* **XX,** No. 2, 303-309 (1983).

Key words: deuterium labeling; gas chromatography; mass spectrometry; synthesis; 1-dodecyl-d_{25} phosphate.

1-Dodecyl-d_{25} phosphate was prepared from commercially available 1-dodecanol-d_{26}. The 1-dodecanol-d_{26} reacted with diphenyl phosphorochloridate to produce 1-dodecyl-d_{25} diphenyl phosphate, which was reduced with hydrogen in the presence of Adams catalyst to give a 58.9 percent yield of 1-dodecyl-d_{25} phosphate with 99.4 atom percent deuterium.

21862. Hemmati, H.; Bergquist, J. C.; Itano, W. M. **Generation of continuous-wave 194-nm radiation by sum-frequency mixing in an external ring cavity,** *Opt. Lett.* **8,** No. 2, 73-75 (Feb. 1983).

Key words: cw UV generation; Hg^+; potassium pentaborate (KB5); spectroscopy; sum frequency mixing; UV lasers.

Several microwatts of tunable cw radiation near 194 nm in a linewidth of less than 2 MHz have been generated by sum-frequency mixing the radiation from a frequency-doubled argon-ion laser with the radiation from a ring dye laser in a crystal of potassium pentaborate. An external ring cavity resonant with the dye laser gives an enhancement factor of about 14 in the sum-frequency-generated radiation power. The Doppler-limited absorption spectrum of the $6s$ $^2S_{1/2}$–$6p$ $^2P_{1/2}$ first resonance line of natural Hg II has been resolved, and the vacuum wave number for the mass-202 isotope has been measured to be 51485.904(20) cm^{-1}.

21863. Hoer, C. A. **Choosing line lengths for calibrating network analyzers,** *IEEE Trans. Microwave Theory Tech.* **31,** No. 1, 76-78 (Jan. 1983).

Key words: calibration; network analyzer; transmission line.

Equations, examples, and a table are given to help choose the best length for a precision transmission line which is used in some methods for calibrating a network analyzer. One line will cover a frequency range of about 10:1. Two lines will cover a range of about 65:1.

21864. Jennings, D. A.; Pollock, C. R.; Petersen, F. R.; Drullinger, R. E.; Evenson, K. M.; Wells, J. S.; Hall, J. L.; Layer, H. P. **Direct frequency measurement of the I_2-stabilized He-Ne 473-THz (633-nm) laser,** *Opt. Lett.* **8,** No. 3, 136-138 (Mar. 1983).

Key words: frequency; I_2; laser; standards; visible region.

The absolute frequency of the 473-THz He-Ne laser (633 nm), stabilized on the g or i hyperfine component of the $^{127}I_2$ 11–5 $R(127)$ transition, was measured by comparing its frequency with a known frequency synthesized by summing the radiation from three lasers in a He-Ne plasma. The three lasers were (1) the 88-THz CH_4-stabilized He-Ne laser (3.39 μm), (2) a 125-THz color-center laser (2.39 μm) with its frequency referenced to the $R_{II}(26)$ $^{13}C^{18}O_2$ laser, and (3) the 260-THz He-Ne laser (1.15 μm) referenced to an I_2-stabilized dye laser at 520 THz (576 nm). The measured frequencies are 473 612 340.492 and 473 612 214.789 MHz for the g and i hyperfine components, respectively, with a total uncertainty of 1.6 parts in 10^{10}. The frequency of the i component adjusted to the operating conditions recommended by the Bureau International des Poids et Mesures is 473 612 214.830±0.074 MHz.

21865. Pollock, C. R.; Jennings, D. A.; Petersen, F. R.; Wells, J. S.; Drullinger, R. E.; Beaty, E. C.; Evenson, K. M. **Direct frequency measurements of transitions at 520 THz (576 nm) in iodine and 260 THz (1.15 μm) in neon,** *Opt. Lett.* **8,** No. 3, 133-135 (Mar. 1983).

Key words: CO_2 laser; color center laser; He-Ne laser; I_2 transition; mim point contact diode; neon Lamb-dip.

The o hyperfine component of the $^{127}I_2$ 17–1 $P(62)$ transition at 520 THz (576 nm) in iodine was measured with respect to the CH_4-stabilized 88-THz He-Ne laser. A 26-THz CO_2 laser, a color-center laser at 130 THz, and a He-Ne laser at 260 THz were used as transfer oscillators. The measured I_2 frequency was 520 206 808.547 MHz with a total fractional uncertainty of 1.6×10^{-10}. The 1.15-μm ^{20}Ne Lamb-dip-stabilized laser frequency was 260 103 249.26 MHz with a total fractional uncertainty of 3.1×10^{-10}.

21866. Oldham, N. M. **A 50-ppm ac reference standard which spans 1 Hz to 50 kHz,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 176-179 (Mar. 1983).

Key words: ac standard; binary inductive divider; digital sinewave generator; digital-to-analog converter; programmable ac source; rms standard; waveform synthesizer.

A digital sinewave generator which spans 1 Hz to 50 kHz is described. The rms amplitude is characterized by an internal thermal converter and corrected by a microcomputer to an uncertainty of 50 ppm. Amplitude is programmable from 0 to 7.07 V rms.

21867. Allan, D. W.; Alley, C. O., Jr.; Decher, R.; Vessot, R. F. C.; Winkler, G. **Shuttle experiment to demonstrate high-accuracy global time and frequency transfer,** *IEEE Trans. Geosci. Remote Sensing GE-20,* No. 3, 321-325 (July 1982).

Key words: frequency; hydrogen masers; international time comparisons; primary frequency standards; shuttle; synchronization; TAI.

The concept of a high-accuracy global time and frequency transfer system is discused. A hydrogen maser clock onboard a space vehicle combined with a microwave Doppler cancellation system can provide direct frequency transfer with an accuracy of 10^{-14} and time transfer accurate to 1 ns. The addition of short pulse laser techniques provides

subnanosecond time transfer accuracy which can be used to calibrate the microwave system.

21868. Phelps, A. V. **Transport data for the modeling of electrical breakdown and discharges,** *Proc. NATO Advanced Study Institute Electrical Breakdown and Discharge on Gases: Fundamental Processes and Breakdown, Les Arcs, France, June 28-July 10, 1981,* E. K. Kunhardt and L. H. Leussen, eds., pp. 109-132 (Plenum Press, New York, 1983).

Key words: atoms; discharges; electrical breakdown; electrons; excited atoms; gases; ions; modeling; molecules.

This is a review of transport data available for use in the modeling of electrical breakdown and discharges. Section II contains the discussion of electron transport and reaction rate coefficient data. Ion transport and reaction rates are considered in Section III. Section IV contains a discussion of radiation transport and photoionization. Finally in Section V we summarize data concerned with excited atoms and molecules. Note that in this paper we have attempted to provide the reader with enough references to get started and have not attempted to list all of the important, relevant papers.

21869. Linsky, J. L. **Cool luminous stars,** (Proc. Meet. COSPAR Advances Space Research, Ottawa, Canada, May 22-29, 1982), *Adv. Space Res.* **2,** No. 9, 249-260 (Pergamon Press, Oxford, OX3 OBW, England, 1983).

Key words: binary stars; magnetic fields; nonradiative heating; stellar chromospheres; stellar coronae; stellar winds; ultraviolet spectra.

A broad theme emerging from *IUE* and *Einstein* observations of cool stars is that magnetic fields control the structure and energy balance of the outer atmospheres of these stars. I summarize the phenomena associated with magnetic fields in the Sun and show that similar phenomena occur in cool luminous stars. High dispersion spectra are providing unique information concerning densities, atmospheric extension, and emission line widths. A recent unanticipated discovery is that the transition lines are redshifted (an antiwind) in β Dra (G2 Ib) and perhaps other stars, which I interpret as indicating downflows in closed magnetic flux tubes as are seen in the solar flux tubes above sunspots. Finally, I classify the G and K giants and supergiants into three groups—active stars, quiet stars, and hybrid stars—depending on whether their atmospheres are dominated by closed magnetic flux tubes, open field geometries, or a predominately open geometry with a few closed flux tubes embedded.

21870. Leone, S. R. **Infrared fluorescence: A versatile probe of state-selected chemical dynamics,** *Acc. Chem. Res.* **16,** No. 1, 88-95 (Feb. 1983).

Key words: energy transfer; fluorescence; infrared; laser.

The state-of-the-art in infrared detection skills has clearly advanced in the last ten years. Improvements in fabrication of large area detectors and in amplifier electronics now make it possible to detect emissions that are 10–100 times weaker than before. Similarly the response time of these sensitive detection systems has been improved an order of magnitude or more. Coupling such detectors with other new tools, such as powerful lasers, has qualitatively changed the types of experiments that are possible. Impressive new experiments can be carried out on all kinds of phenomena which were previously accessible only by more classical techniques. In this account, examples will be given in which state-of-the-art infrared fluorescence is used to study a broad spectrum of problems in chemical dynamics. The examples range from the simplest possible breaking of a molecular bond, called photofragmentation dynamics, to the complexities of laser-initiated chemical chain reactions. Several other examples will be given on the subtle competition between reactive and inelastic collision events, on intramolecular energy randominization, studies of ion-molecule reaction dynamics, and surface reaction phenomena. In many cases the application of state-resolved infrared fluorescence provides powerful new insights into important remaining problems in chemical dynamics.

21871. Galowin, L. S.; Winter, F. **Upgrading old plumbing vent systems,** *Build. Res. Pract.* **11,** No. 1, 22-35 (Jan.-Feb. 1983).

Key words: modifications for plumbing; plumbing; rehabilitation; vents in plumbing.

Rehabilitation, modernization, or renovation of existing buildings, as a resource to be conserved or recycled and reused, frequently imposes increased loads on the plumbing water supply and drainage system. The requirement for venting in U.S. practice is intended to prevent trap seal loss from exceeding values prescribed in model plumbing codes. The vent piping in older buildings may be marginal for retrofit under current requirements with the same or increased numbers of fixtures and devices installed into the plumbing system.

An experimental laboratory investigation of "circulation loop" modification to the drain-waste-vent (DWV) system to relieve the marginal performance of existing installations is reported. The experimental evaluations of the performance of the modified system and a conventional system were undertaken for a variety of wastewater load simulated conditions with various plumbing fixtures and multistory soil stack loads. The performance parameters considered were evaluation of trap seal failures and siphonic action of the water closets. Also, the dynamic responses to pressure excursions and air flow rate distributions in the branches were measured. Both systems were tested to the limiting condition for single-stack performance over a range of air flow variations into the soil and vent stack.

The circulation loop system was found to level out a portion of the soil stack pressure distributions to provide benefits in reducing trap seal failures and reduced siphonic action failures of water closets. With vent valves open, both conventional and modified loop systems provided satisfactory venting. Acceptable performance with installation of additional sanitary fixture waste loads was demonstrated by the circulation loop. Additional research requirements were identified for sizing the circulation loop vent connection fitting, and further testing with small regulated air flows into the vent stack to establish marginal performance limits.

21872. Dizdaroglu, M.; Gajewski, E.; Simic, M. G.; Krutzsch, H. C. **Identification of some OH radical-induced products of lysozyme,** *Int. J. Radiat. Biol.* **43,** No. 2, 185-193 (1983).

Key words: capillary gas chromatography; mass spectrometry; OH radicals; radiation-induced damage; radiolytic products; trimethylsilylation.

OH radical reactions with lysozyme in γ-irradiated N_2O saturated aqueous solutions caused formation of *allo*-threonine, α-amino-n-butyric acid, *o*- and *m*-tyrosines, and 2- and 3-hydroxytyrosines. These identified radiolytic products were characterized by capillary gas chromatography-mass spectrometry as their trimethylsilyl derivatives after HCl-hydrolysis of irradiated lysozyme. Their initial *G*-values were also determined using gas chromatography. The possible use of these radiolytic products as monitors of radiation-induced damage to proteins and the sites of attack are also discussed.

21873. Brennan, J. A.; Takano, A. **A preliminary report on the evaluation of selected ultrasonic and gyroscopic flowmeters at cryogenic temperatures,** *Proc. 9th Int. Cryogenic Engineering Conf., Kobe, Japan, May 11-14, 1982,* K. Yasukochi and H. Nagano, eds., pp. 655-658 (Butterworth and Company Ltd., Guildford, Surrey UK, 1982).

Key words: cryogenic; flow measurement; flowmeters; gyroscopic; liquid nitrogen; ultrasonic.

Several ultrasonic and gyroscopic flowmeters were tested on the cryogenic flow facility at the National Bureau of Standards (NBS) in Boulder, Colorado. Meters were evaluated using liquid nitrogen with flow rates ranging from 0.13 to 2.25 L/s for small meters and from 1.45 to 13.1 L/s for a larger meter, with pressures ranging from 0.41 to 0.80 MPa and with temperatures ranging from 79 to 91 K. Results of the test showed flowmeters evaluated have, with one exception, their applicability to cryogenic service with appropriate consideration of their characteristics at low temperatures.

21874. Ramaker, D. E. **Comparison of photon stimulated dissociation of gas phase and chemisorbed CO,** *J. Chem. Phys.* **78,** No. 6, Pt. 1, 2998-3013 (Mar. 15, 1983).

Key words: bound state resonances; carbon monoxide; chemisorbed CO; (e,2e) and (e,e+ion) coincidence spectroscopy; electron stimulated desorption; photon stimulated desorption.

Theoretical interpretation of electron-electron and electron-ion coincidence data for CO in the gas phase indicates one hole, two hole, and two hole–one electron excited states (e.g., the $3\sigma^{-1}$, $5\sigma^{-2}$, and $5\sigma^{-2}$ 6σ states) contribute to molecular dissociation. Detailed comparison with O^+ ion yield data for photon stimulated desorption from CO/Ru(001) at both valence and core level excitation energies reveals many similarities but also significant adsorbate-substrate interaction effects; the most important are due to charge transfer from the substrate which screens the core or valence holes in the adsorbate. Appreciation of the competitive decay rates of the excited states is critical to an understanding of which excited states of either CO gas or the CO/metal system may be expected to lead to dissociation. Resonant decay to the continuum and Auger decay are important decay mechanisms in both systems. Adsorbate-adsorbate interactions on the surface are seen to provide an additional decay mechanism. The excited states responsible for O^+, CO^+, and CO desorption from the surface are assigned for each of the threshold energies. The two hole–one electron states are the most important for desorption from the surface.

21875. Domen, S. R. **A polystyrene-water calorimeter,** *Int. J. Appl. Radiat. Isot. Tech. Note* **34,** No. 3, pp. 643-644 (1983).

Key words: absorbed dose; calorimeter; heat defect; polystyrene; thermistor; water.

A new type of calorimeter is described for the measurement of absorbed dose in polystyrene, which is reported (for some irradiation conditions) to have a heat defect of less than one percent. This calorimeter provides another investigative tool for comparison with absorbed dose measurements in water, which is the standard reference material.

21876. Patterson, C. W.; Pine, A. S. **Doppler-limited spectrum and analysis of the $3\nu_3$ manifold of SiF_4,** *J. Mol. Spectrosc.* **96,** 404-421 (1982).

Key words: anharmonicity; Doppler-limited spectrum; infrared absorption; overtone band; silicon tetrafluoride; tunable difference-frequency laser.

The two infrared-active vibrational bands of the $3\nu_3$ manifold of SiF_4 were recorded at $T\sim155$ K with Doppler-limited resolution using a tunable laser difference-frequency spectrometer. Although all branches of the $l=1$ band were seen, only portions of the P branch of the weaker $l=3$ band were recorded. Some 192 lines with $J\leqslant36$ have been fitted to a model Hamiltonian which allows the $l=1$ and $l=3$ bands to interact. This analysis allows us to determine the effective harmonic frequency, ω_3^0, and the three anharmonic coefficients X_{33}, G_{33}, and T_{33} with high precision, so that the vibrational levels in the $n\nu_3$ ladder can be predicted accurately for several values of n. In contrast with SF_6, the l basis is found to be the best representation for the vibrational sublevels.

21877. Berger, P. W. **National libraries—National necessities,** *Agri. Libr. Inf. Notes* **9,** No. 1-2, (National Agricultural Library U.S. Department of Agriculture, Beltsville, MD 20705, Jan./Feb. 1983).

Key words: library networks; National Agricultural Library; National libraries; National Libraries Advocacy Council.

A discussion of survival strategies for the three U.S. National Libraries during periods of fiscal reduction and restraint.

21878. Kessler, E. G., Jr.; Deslattes, R. D. **Utilization of MeV Van de Graaff electrons to produce characteristic X-rays for precision measurements,** (Proc. 7th Conf. Application Accelerators Research Industry, Denton, TX, Nov. 8-10, 1982), *IEEE Trans. Nucl. Sci.* **NS-30,** No. 2, 991-994 (Apr. 1983).

Key words: characteristic x-rays; precision measurements; standard x-ray wavelengths; theoretical energy level calculations; Van de Graaff accelerator.

Precision systematic studies of characteristic X-rays for elements spaced throughout the periodic table require intense convenient sources. Such sources are available from existing electron accelerators (e.g., Van de Graaff) operating in the one to several MeV region. Our studies of K series X-rays from the mid to high Z are favored by electron energies in the 2.5 MeV region where one encounters near maximum yield. We chose an angle of observation of approximately 120° to the direction of the electron beam to reduce background from bremsstrahlung. The target chamber has facilities for water cooled solid and gas samples. We chose thicknesses of the solids near ~0.5 of the electron range while the gases are contained in a high pressure (2×10^6 Pa) thin window cell.

The X-ray wavelengths are measured using a two-axis flat crystal transmission spectrometer. The angle measuring capability of the spectrometer is a few tenths of a milli arcsec which permits wavelength measurements with an uncertainty less than 1 ppm. However for X-ray lines (as contrasted with γ-ray lines) the accuracy is limited to 3 to 5 ppm by the intrinsic line width. Measurements on a number of elements from Z=47 to 92 have been completed. These serve as tests of recent theoretical calculations and as wavelength standards in the 20 to 100 keV region.

21879. Debenham, P. H.; Penner, S.; Ayres, R. L.; Cutler, R. I.; Lindstrom, E. R.; Mohr, D. L.; Rose, J. E.; Wilson, M. A. D.; Yoder, N. R.; Young, L. M.; Martin, R. E.; Mitra, A.; Potter, J. M.; Stokes, R. H.; Tallerico, P. J.; Wilkerson, L. **Progress on the NBS-LANL CW microtron,** (Proc. 7th Conf. Application Accelerators in Research and Industry, Denton, TX, Nov. 8-10, 1982), *IEEE Trans. Nucl. Sci.* **NS-30,** No. 2, 1391-1395 (Apr. 1983).

Key words: accelerators; beam optics and magnets; beam recirculation; electron accelerators; feasibility; racetrack microtron (RIM).

The NBS-LANL racetrack microtron (RTM) currently under construction at the National Bureau of Standards is a demonstration accelerator to determine the feasibility of, and to develop the technology necessary for building high-energy, high-current, continuous beam (CW) electron accelerators using beam recirculation through room temperature rf accelerating structures. Parameters of the RTM are: injection energy—5 MeV; energy gain per pass—12 MeV; number of passes—15 or 16; final beam energy—185–197 MeV; maximum current—550 μA; rf frequency—2380 MHz. At present, the electron gun and 100 keV beam transport line are operational, and most other major subsystems are in the construction or installation phase. Exceptions are the rf structure (under development), the 5 MeV beam transport line (in engineering design), and the extraction beam line (in conceptual design). Our studies of the original candidate accelerating structure, the disk-and-washer, have led to the discovery of beam steering modes which render this structure unsuitable for the RTM without at least substantial further development beyond the scope of the project. The most promising alternate for meeting the design goal of CW operation at 1.5 MeV/m is the side-coupled structure. A shunt impedance of 80 MΩ/m has been measured in a test section of side-coupled structure at 2380 MHz, adequate cooling has been designed, and a 2.7 m long section of this design is under construction. The electron optics of the RTM have been studied in detail. Compact end magnets have been designed to provide a magnetic field of the required uniformity ($\Delta B/B\leqslant2\times10^{-4}$), and are currently under construction. The RTM will be operated with a distributed control system which is currently functioning at the local control level. Our schedule calls for completion of the accelerator in 1984, followed by a year of detailed beam studies.

21880. Wortendyke, D. R.; Seitz, N. B.; Spies, K. P.; Crow, E. L.; Grubb, D. S. **User-oriented performance measurements on the ARPANET: The testing of a proposed Federal Standard,** *NTIA Report 82-112,* 293 pages (U.S. Department of Commerce, National Telecommunications and Information Administration, Institute for Telecommunication Sciences, 325 Broadway, Boulder, CO 80303, Nov. 1982).

Key words: ARPANET; data communication performance measurement; data communication service; Federal Standard 1043; network performance; user-oriented data communication.

This report presents the results of a trial implementation of a newly developed data communication performance measurement standard. In this experiment, a prototype data communication performance measurement system was developed in accordance with specifications defined in the standard. The system was used to assess the data communication service provided to a typical pair of ARPANET end users (host computer application programs). These user-oriented measurements differ from earlier ARPANET measurements in that the host computer operating systems and network control programs

are regarded as providers of an end-to-end data communication service, rather than as users of the IMP/TIP subnetwork.

Results of the experiment will be useful in three ways. First, the prototype performance measurement system developed in this experiment will serve as a model for future implementations of the standard. Second, the experience of implementing the measurement standard identified a number of ways in which that standard (and a companion parameter definition standard) could be improved. These improvements will be incorporated in future revisions to the standards. Finally, the user-oriented performance values measured in this experiment will assist communication system planners in allocating end-to-end performance requirements to subsystems.

21881. Blackburn, D. L.; Berning, D. W. **Power MOSFET temperature measurements,** *Proc. 1982 IEEE Power Electronics Specialists Conf. (PESC), Cambridge, MA, June 14-17, 1982,* pp. 400-407 (McGregor & Werner Inc., 6411 Chillum Place, N. W., Washington, DC 20012, June 1982).

Key words: electrical and thermal properties; power MOSFETs; semiconductor device; temperature; temperature-sensitive electrical parameters.

Three temperature-sensitive electrical parameters are compared as thermometers for power MOSFET devices. The parameters are the forward drain-body diode voltage, the source-gate voltage, and the on-resistance. The results are also compared with temperatures measured with an infrared microradiometer. The procedure, apparatus, and circuits required to use each of the parameters as a thermometer are described. Some general considerations for measuring the temperature of power semiconductor devices are also discussed. Each parameter is found to be satisfactory for measuring the temperature of power MOSFETs. The source-gate voltage measures a temperature nearest to the peak device temperature, and the drain-body diode voltage shows the least variation in calibration from device to device.

21882. Domen, S. R. **Theory, performance, and measured results with an improved absorbed dose water calorimeter,** *Proc. Symp. Electron Dosimetry ARC Therapy, Madison, WI, Sept. 10-11, 1981,* pp. 89-102 (American Institute of Physics, Inc., 335 East 45th Street, New York, NY 10017, 1982).

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

The feasibility of this calorimeter is mainly the result of the low thermal diffusivity of water that retards a temperature change at a point along a temperature profile. The temperature change is sensed by two calibrated thermistors sandwiched between two polyethylene films that electrically insulate the thermistors from water. The product of the temperature rise and the specific heat of water gives the combined effect of the absorbed dose and any heat defect. Temperature drifts are quickly controlled by making slight changes in electrical power dissipated in the water. Compared to solid-bodied calorimeters requiring vacuum systems, it is easy to construct, to get into operation, and to operate.

Tests indicated the absence of water convection. Measurements in a cobalt-60 γ-ray beam showed no significant difference after agitating distilled water with nitrogen or oxygen. Similar and reproducible results were obtained with use of water that had a wide range of impurities. Effects of some chemicals added to water were studied. Absorbed dose rates near 18 mGy/s were measured to an imprecision of about 0.6 percent (standard deviation) for a single run. Up to 45 three-minute irradiation runs were made in a day. The measured absorbed dose rate was 3.5 percent higher than that determined from measurements with a graphite calorimeter. Theoretical and further experimental investigations are in progress.

21883. Lentner, K. J.; Flach, D. R. **An automatic system for AC/DC calibration,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 51-56 (Mar. 1983).

Key words: ac/dc difference; ac voltage measurement; automation; calibration; metrology; thermal voltage converter.

An automatic ac/dc difference calibration system using direct measurement of thermoelement EMFs is described. The system operates over a frequency range from 20 Hz to 100 kHz, covering the voltage range from 0.5 V to 1 kV. For all voltages, the total uncertainty (including the uncertainty of the specific reference thermal converters used) is 50 ppm at frequencies from 20 Hz to 20 kHz, inclusive, and 100 ppm at higher frequencies up to 100 kHz. In addition to ac/dc difference testing, the system can be used to measure some important characteristics of thermoelements, as well as to calibrate ac voltage calibrators and precision voltmeters. Results of intercomparisons between the new system and the manual NBS calibration system, using single-range, coaxial-type, thermal voltage converters as transfer standards, are reported. The results indicate that the ac/dc differences measured are accurate to well within the combined total uncertainty limits of the two systems.

21884. Jones, D. W.; Musiol, K.; Wiese, W. L. **Stark widths and shifts for some Ar I 4s-4p transitions,** *Spec. Line Shapes* **2,** 125-136 (1983).

Key words: argon; argon I emission spectra; atomic line broadening; Stark shifts; Stark widths; systematic trends; transition array regularities.

We have measured the Stark widths and shifts of 13 lines of the Ar I 4s-4p transition array in emission with a wall-stabilized arc source. The electron density and temperature have been determined from the line profile of the hydrogen line H_β, using the well-known Stark broadening technique and assuming local thermodynamic equilibrium. For the diagnostic measurements a trace of hydrogen was added to the plasma. Furthermore, for the study of the strong 4s-4p argon lines, nitrogen gas was used as the principal plasma component, with only a small admixture of argon, in order to minimize self-absorption effects. The principal results for the Ar I Stark widths, i.e., the full widths at half maximum intensity, and Stark shifts are presented in several tables.

21885. Guildner, L. A.; Thomas, W. **The measurement of thermodynamic temperature,** *Proc. Sixth Int. Symp. Temperature, Its Measurement Control Science Industry, Washington, DC, Mar. 15-18, 1982,* **5,** 9-19 (American Institute of Physics, 335 East 45th street, New York, NY 10017, 1982).

Key words: acoustic thermometry; gas thermometry; noise thermometry; thermodynamic temperature.

The thermometers with which thermodynamic temperatures can be accurately realized are discussed and results are cited over the range from 2 mK to 1336 K. The deviations of scales from the most accurate realizations of thermodynamic temperatures are presented. Improvements have increased the accuracy of gas thermometry, which is still the most accurate means of determining thermodynamic temperatures from ca 2.5 to 1337 K, but improvements in other techniques have increased their accuracy to nearly the same level. At the extremes of the temperature range, both high and low, techniques other than gas thermometry provide more accurate thermodynamic temperatures.

21886. Reed, D. A.; Scanlan, R. H. **Time series analysis of cooling tower wind loading,** *J. Struct. Eng.* **109,** No. 2, 538-554 (Feb. 1983).

Key words: concrete structures; cooling towers; turbulence; wind loads.

This paper considers full-scale wind velocity and wind pressure time series data collected on two cooling towers. ARIMA time series models are shown to describe these data adequately. The advantage of using these models is that they provide a convenient method for loading simulation. Transfer function models in the time domain relating input wind velocity to output wind pressure-difference at three circumferential tower locations are presented and discussed.

21887. Schafft, H. A. **Measurements for commercial photovoltaics: A status report,** *Sol. Cells* **7,** No. 1-2, 23-46 (Nov. 1982).

Key words: equipment; measurements; modules; photovoltaics; quality assurance; silicon characterization; simulators (solar); solar cells; solar data; spectral response; standards.

The first part of this report discusses how reliable measurements play an important role along the chain of supplier–user links that make up the photovoltaics industry and its customers. Such measurements provide accurate information on materials, fabrication processes, product characterization and product needs on which sound decisions can be made to optimize the performance of processes

and products. They are also indispensable for effective communication in the marketplace. The second part reviews the results of visits to industry to identify measurements-related issues that affect the expeditious development and application of photovoltaics. The results are organized into nine categories: (1) silicon characterization; (2) quality assurance; (3) electrical measurements of solar cells and modules (including accuracy and reproducibility of measurements, spectral response, reference cells and simulators and spectra distribution); (4) solar data; (5) interactions with customers; (6) measurement equipment; (7) module certification; (8) standards; (9) role of government. The third part of the report provides an overview of measurement and standards development activities. The intent of this is to promote an awareness of such work to encourage thereby greater participation and also timely use of the results of this work.

21888. Saloman, E. B.; Ebner, S. C.; Hughey, L. R. **Vacuum ultraviolet and extreme ultraviolet radiometry using synchrotron radiation at the National Bureau of Standards,** *Opt. Eng.* **21,** No. 5, 951-956 (Sept.-Oct. 1982).

Key words: absolute radiometric source; calibration chamber; extreme ultraviolet radiometry; high efficiency photodiodes; practical photodiodes; radiometric standard detectors; single electron counting; spectrometer calibrations; synchrotron radiation; vacuum ultraviolet radiometry.

Synchrotron radiation is a source of continuum radiation ranging from the x-ray or soft x-ray region (depending on machine energy) to beyond the visible region. The amount of radiation emitted is a calculable function of machine operating parameters. This makes it possible to use synchrotron radiation from electron synchrotrons and electron storage rings as an absolute source particularly in the vacuum ultraviolet (VUV) and soft x-ray regions where other standards are difficult to find. At the National Bureau of Standards (NBS), an electron storage ring (SURF-II) has been used to calibrate spectrometers and photometers used in solar and aeronomy research and in fusion plasma diagnostics. A large chamber has recently been completed to facilitate such calibrations. The radiation incident on these spectrometers can be calculated to uncertainties of 3%. A technique to exactly determine the number of electrons orbiting in the ring is currently being developed to reduce this uncertainty. Detector calibrations between 5 to 55 nm (50 to 550 Å) are routinely carried out at SURF-II, and transfer standard detectors with 6 to 10% uncertainties over the range of 5 to 254 nm (50 to 2540 Å) are supplied. Special studies of "practical," high efficiency, and disposable photodiodes have been made by NBS in collaboration with other groups.

21889. Dannacher, J.; Rosenstock, H. M.; Buff, R.; Parr, A. C.; Stockbauer, R. L.; Bombach, R.; Stadelmann, J. P. **Benchmark measurement of iodobenzene ion fragmentation rates,** *Chem. Phys.* **75,** 23-35 (1983).

Key words: coincidence; fragmentation; heat of formation; iodobenzene; ion; phenyl; photoionization; rate.

The unimolecular fragmentation rate of iodobenzene ion has been studied by variable residence time photoelectron-photoion coincidence techniques. The techniques employed variable wavelength with threshold photoelectron detection and fixed (58.4 nm) wavelength with variable energy photoelectron detection, respectively. Residence times of 1.0 ± 0.25 or 5.9 ± 0.3 and 21 ± 1 or 57 ± 1 μs were employed. The four sets of measurements were independently analyzed using exact counting of harmonic oscillator states, taking into account the appropriate (and different) apparatus functions and the thermal energy distributions of the parent ions. The resulting rate-energy dependences and fragmentation threshold values were in excellent agreement with one another. The best-fit rate-energy dependence is proposed as a benchmark for calibration of future rate-energy measurements. The resulting $\Delta H^0_{f0}(C_6H_5^+)=1133\pm5$ kJ mol is in excellent agreement with earlier results based on a somewhat simpler method of analysis of chlorobenzene and bromobenzene fragmentation rates. Some remaining uncertainties regarding the transition-state model are discussed.

21890. Powell, C. J. **The contribution of surface analysis and surface science to technology,** *Aust. J. Phys.* **35,** 769-775 (1982).

Key words: interface characterization; surface analysis; surface characterization; surface science; technology.

Surface science is a rapidly growing field offering many scientific and technological challenges. New experimental and theoretical tools have been developed which can be used to probe, at a fundamental atomic and molecular level, the physics and chemistry of complex processes at solid surfaces. Surface characterization, particularly surface analysis, is now an integral part of many technologies and industries (e.g., catalysis, coatings, corrosion, semiconductor devices, computer, automobile and communications) for many different applications (e.g., failure analysis, quality control, process and device development). Characterization of surface properties and processes is similarly important in many areas of public concern (e.g., energy and environment). The concepts and techniques found useful for surface characterization are currently being extended to the characterization of solid–solid, solid–liquid and solid–gas interfaces. It is therefore expected that there will be significant developments in interface science and additional opportunities for technological applications in the coming decade.

21891. Schoenwetter, H. K. **High-accuracy settling time measurements,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 22-27 (Mar. 1983).

Key words: D/A converter; error band; flat pulse generator; operational amplifier; settling error; settling time measurements.

Methods are described for measuring the settling times and other dynamic characteristics of voltage and current output D/A converters (DAC's), operational amplifiers, and precision voltage step generators. Circuits are described for measuring voltage-output device settling times as short as 1 μs to within a settling error of ±2 ppm, and current-output device settling times as short as 40 ns to within a settling error of ±0.012 percent.

21892. Yap, W. T.; Schaffer, R.; Hertz, H. S.; White V, E.; Welch, M. J. **On the difference between using linear and non-linear models in bracketing procedures in isotope dilution mass spectrometry,** *Biomed. Mass Spectrom.* **10,** 262-264 (1983).

Key words: bracketing; isotope dilution; mass spectrometry intensity ratio; nonlinear interpolation; weight ratio.

We examine the difference between a linear and a nonlinear model for the calculation of analyte concentration by interpolation between standards in isotope dilution/mass spectrometry. Equations are developed for calculating this difference for various increments of the bracketing intensity ratios and for various compositions of the sample; graphs are also presented to depict this difference for these various conditions. As an illustration, the result for a series of measurements on urea are presented and discussed.

21893. Sanders, D. M.; Farabaugh, E. N.; Haller, W. K. **Glassy optical coatings by multisource evaporation,** (Proc. SPIE Technical Symp. East '82, Thin Film Technologies and Special Applications, Arlington, VA, May 4-7, 1982), *Soc. Photo Opt. Instrum. Eng.* **346,** 31-48 (Society of Photo-Optical Instrumentation Engineers, Box 10, Bellingham, WA, 1982).

Key words: ceramic coatings; glassy; MgO; SiO_2; thin films; ZrO_2.

In this presentation, the concepts of bulk glass formation are discussed in light of their possible application to the production of glassy thin films for optical applications. Specifically, the systems ZrO_2–SiO_2 and ZrO_2–MgO were explored using electron beam coevaporation for the film production. The films so produced were characterized using x-ray diffraction and scanning electron microscopy. It was found that while coevaporation of a traditional bulk glass former (SiO_2) to ZrO_2 was more effective in producing an amorphous mixture coating, other dopants (MgO) could also achieve the same end if used in higher concentrations.

21894. Lynn, J. W.; Erwin, R. W.; Rhyne, J. J.; Chen, H. S. **Ferromagnetic and spin glass behavior near the critical concentration in amorphous $(Fe_xNi_{100-x})_{75}Gl_{25}$,** *J. Magn. Magn. Mater.* **31-34,** 1397-1398 (1983).

Key words: amorphous magnet; ferromagnetism; frustration; percolation; spin freezing; spin-glass transition.

The magnetic properties of amorphous $(Fe_xNi_{100-x})_{75}P_{16}B_6Al_3$ have been investigated above the critical concentration ($x=17$) for long range order via neutron scattering. For $x=30$ the spin wave stiffness parameter D first increases with decreasing temperature, but then decreases at lower temperatures as the spin glass state is approached. Accompanied by the decrease in D is an increase in the spin wave linewidths.

21895. Nelson, H. E. **An approach to enhancing the value of professional judgment in the derivation of performance criteria,** *Proc. 3d ASTM/CIB/RILEM Symp. Performance Concept in Building, Lisbon, Portugal, Mar. 29-Apr. 2, 1982,* **1,** pp. 55-61 (Laboratorio Nacional de Engenharia Civil, Lisbon, Portugal, 1982).

Key words: fires; fire safety; health care facilities; life safety; performance criteria.

The Center for Fire Research of the U.S. National Bureau of Standards has developed an evaluation system for determining the risk to life from fire in health care facilities. The system was based on a cyclical approach designed to enhance the judgmental decisions of engineering professionals. The focus of the approach was on achieving consensus regarding the impact of each variable on life safety and ensuring that all aspects of safety were simultaneously satisfied. The use of this system in field investigations as well as computer applications is also discussed.

21896. Hougen, J. T.; DeKoven, B. M. **The application of extended permutation-inversion groups to internal rotation of a symmetric rotor top in a symmetric or asymmetric rotor molecule,** *J. Mol. Spectrosc.* **98,** 375-391 (1983).

Key words: asymmetric tops; extended groups; internal rotation; permutation-inversion groups; symmetric tops.

By applying the concept of extended groups to the internal rotation problem in molecules with unequal halves, it has proved possible to construct a consistent formalism involving groups which correspond to very high, but finite multiples of the original Longuet-Higgins permutation-inversion group of the molecule. This formalism thus bridges the gap between the infinite extended groups used for linear molecules and the double groups used for molecules with two identical coaxial rotors. For the example of CF_3NO considered explicitly in this paper, with permutation-inversion group isomorphic to C_{3v}, the extended group is found to be isomorphic to $C_{3m,v}$, where m is an integer obtained from the rational number p/m which equals within experimental error the ratio π of top and molecule moments-of-inertia frequently introduced in discussions of the internal rotation problem. The extended group formalism can be used to rederive in an interesting fashion many results already well known from theoretical discussions in the earlier infrared and microwave literature, and shows promise for the treatment of as yet unsolved problems in molecules exhibiting internal rotation.

21897. Rossiter, W. J.; Mathey, R. G. **A methodology for developing tests to aid service-life prediction of single-ply roofing membranes,** *Proc. NBS/NRCA 7th Conf. Roofing Technology, Gaithersburg, MD, Apr. 14-15, 1983,* pp. 4-11 (NRCA, 8600 Berwyn Mawr Ave., Chicago, IL 60631, 1983).

Key words: durability prediction; membrane; methodology roofing service life; service-life testing; single-ply membranes.

The rapid growth in the use of single-ply roofing membranes has created a need for performance standards which include requirements and tests for evaluating their service life. A methodology is described for developing tests for aiding service-life prediction of single-ply membranes. The methodology is based on ASTM practice for developing short-term tests to aid in the prediction of the service life of building materials and components. The ASTM practice outlines a sequence of steps to be taken which are applicable to aid in predicting the service life of membrane materials. A summary of the ASTM practice is given and examples of the application of many of its steps to single-ply roofing systems are presented. Service-life prediction investigations are complex and have limitations. It is expected that the development of short-term tests according to the ASTM practice will lead to increased confidence in service-life predictions.

21898. Tilford, C. R. **Reliability of high vacuum measurements,** *J. Vac. Sci. Technol. A* **1,** No. 2, 152-162 (June 1983).

Key words: ion gauges; molecular drag gauge; pump speed; spinning rotor gauge; vacuum gauges; vacuum measurements; vacuum standards.

In order to allow the users of vacuum measurements to assess the reliability of their measurements, the current state of high-vacuum standards and gauging is reviewed. The discussion includes several types of high-vacuum primary standards currently in use, an assessment of probable errors for several types of hot filament ion gauges, user-controlled factors that may serve to increase the errors, and the information available to date on the performance of a commercially available molecular drag gauge. Examples are given of the introduction of additional errors by the improper application of vacuum gauges.

21899. Schmidt, J. W.; Moldover, M. R. **First-order wetting transition at a liquid-vapor interface,** *J. Chem. Phys.* **79,** No. 1, 379-387 (July 1, 1983).

Key words: first-order wetting transition at T_w; fluids; interface; phase transition; surface tension; wetting; wetting temperature.

In certain binary solutions the lower of the two liquid phases forms a layer which intrudes between the upper liquid phase and the vapor. We find that such intruding layers form above binary solutions of a fluorocarbon (C_7F_{14}) and an alcohol (i-C_3H_7OH). As the temperature of C_7F_{14}–i-C_3H_7OH solutions is increased, the intruding layer abruptly appears at a characteristic wetting temperature $T_w=311$ K. This temperature is well below the consolute temperature (363 K). At temperatures slightly above T_w the intruding layer's thickness (measured by ellipsometry) is several hundred angstroms and its variation with temperature is extremely weak. Below T_w, the layer's thickness may be zero and is no greater than 20 Å when a naive slab model is used to interpret the data. Below T_w, three-phase contact can occur between the vapor and both the upper and the lower liquid phases. Our measurements show that one of the angles (θ) which characterizes this three-phase contact has a very simple temperature dependence: $\cos\theta=1-0.8(T_w-T)/T_w$. Thus, both the temperature dependence of the layer's thickness and the temperature dependence of the three-phase contact are consistent with a first-order wetting transition at T_w. The thickness of the intruding layer has been monitored as the solutions approach equilibrium. Below T_w the behavior is complex; however, a feature does appear which suggests a nucleation-like event is required for the layer to vanish. Phenomenological theories of the first-order wetting transition predict that a discontinuity in the temperature derivative of σ occurs at T_w where σ is the macroscopic surface tension between the upper liquid phase and the vapor phase. From our data we estimate that this discontinuity is very small: -0.009 dyn cm^{-1} K^{-1}. A first-order wetting transition is predicted by approximate theories which use long-ranged interatomic potentials (e.g., inverse sixth power attractions), provided that the range of the potential between unlike species is longer than the range of the potentials between like species. We find that the thickness of the intruding layer d depends quite weakly on L in the vicinity of a first-order wetting transition. (L is the height spanned by the upper liquid phase.) This feature is in contrast with earlier ellipsometric measurements of the thickness of intruding layers which showed that $d \propto L^{-1/3}$ in different binary mixtures away from wetting transitions.

21900. McCulloh, K. E. **Calibration of molecular drag vacuum gages,** *J. Vac. Sci. Technol. A* **1,** No. 2, 168-171 (June 1983).

Key words: calibration; high vacuum; molecular drag gage; orifice flow; pressure sensor; primary standard; spinning-ball gage; spinning-rotor gage; vacuum gage.

In spinning-ball molecular drag gages, the logarithm of the rotational frequency varies linearly with the time integral of the applied pressure under conditions of free molecular motion. An orifice flow standard for calibrating these devices has been developed that passes a measured quantity of gas through the calibration chamber in typically 30 min. The time integral of the calibration pressure can be calculated with an estimated uncertainty less than 1%. A number of gage balls operated in conjunction with three controllers have been calibrated for N_2, Ar, and He using this system. Conditions

and procedures affecting the performance characteristics of these gages have been investigated, including magnetization of the ball, baking and other conditioning of its surface, and degradation of gas purity by surface contaminants in an unbaked flow system.

21901. Kagann, R. H.; Maki, A. G. **Infrared absorption intensities of nitrous acid (HONO) fundamental bands,** *J. Quant. Spectrosc. Radiat. Transfer* **30,** No. 1, 37-44 (1983).

Key words: gas phase nitrous acid; infrared absorption intensities; infrared band strengths.

A Fourier transform spectrometer with a resolution of 0.06 cm^{-1} was used to measure the absorption intensities of the four in-plane fundamental bands (ν_1,ν_2, ν_3 and ν_4) of *trans*-nitrous acid (HONO) and three of the in-plane fundamental bands (ν_1, ν_2 and ν_4) of *cis*-nitrous acid. The equilibrium constants for the reactions $NO+NO_2+H_2O \rightleftharpoons 2HONO$, $NO+NO_2 \rightleftharpoons N_2O_3$, and $2NO_2 \rightleftharpoons N_2O_4$ were used to determine the partial pressure of HONO in the gas mixture in the absorption cell. Interferences from overlapping absorptions of NO_2, H_2O and other species were digitally subtracted from the spectra.

21902. Pierce, D. T.; Celotta, R. J.; Unguris, J. **Spin polarized electron scattering studies of surface magnetism,** *J. Magn. Magn. Mater.* **31-34,** 869-873 (1983).

Key words: electron spin polarization; surface magnetism; surface magnons.

The asymmetry in the scattered intensity of an electron beam with spins polarized parallel or antiparallel to the target magnetization provides a sensitive measure of the magnetization of the outer few atomic layers of the target surface. We discuss the spin dependent scattering process itself as well as results, such as surface hysteresis curves, the temperature dependence of the magnetization, and data for magnetic structure determination, which illustrate the kind of information that can be obtained about the magnetic properties of ferromagnetic surfaces.

21903. Brinckman, F. E.; Jackson, J. A.; Blair, W. R.; Olson, G. J.; Iverson, W. P. **Ultratrace speciation and biogenesis of methyltin transport species in estuarine waters,** Paper in *Trace Metals in Sea Water,* C. S. Wong, E. Boyle, K. W. Bruland, J. D. Burton, and E. D. Goldberg, eds., pp. 39-72 (Plenum Publ. Corp., New York, NY, 1983).

Key words: atomic absorption detector; biomethylation; Chesapeake Bay; estuarine organotin transport; flame photometric detector; gas chromatography; kinetics; liquid chromatography; methyltin hydrides; purge and trap sampling; redox; tetramethyltin.

Environmental tin, widely dispersed at low concentrations in waters, sediments, and biota, is shown to be a bioactive element susceptible to methylation and even hydridization by marine bacteria. The redox cycle of tin in natural waters is poorly understood and recent advances in tin-specific molecular characterization fail to speciate Sn(II) and Sn(IV) reliably. Nonetheless, such rapid developments in speciation methodology now permit growing numbers of studies of organotin distributions in aquatic systems, raising the question of the "natural" biogeochemical flux of methylstannanes in relation to increased anthropogenic organotin influx from industry and shipping. New methods for direct speciation of aquated or involatile organotins by liquid chromatography are compared with advances in purge-and-trap sampling of volatile or hydrophobic organotins speciated by gas chromatography. The work in our laboratory indicates that effective models for estuarine formation and transport may ultimately be developed, but that basic roadblocks to progress stem from inadequate descriptive aqueous organometallic chemistry and knowledge of critical kinetic parameters for the lifetimes of key organotin species in sea water, occuring at sub-nanomolar concentrations.

21904. Hummer, D. G. **Radiative transfer problems in planetary nebulae,** *Proc. IAU Symp. No. 103, Planetary Nebulae, London, England, Aug. 1982,* D. R. Flower, ed., pp. 211-218 (Reidel, Dordrecht, The Netherlands, 1983).

Key words: planetary nebulae; radiative transfer; ultraviolet radiation.

In view of the enormous importance of the UV observations of planetary nebulae made possible by the IUE, this review will concentrate primarily on the formation of resonance lines in nebulae; an important special case is that of He II Lyα and its role in the Bowen mechanism. Special attention is given to the effects of dust on the line and continuum formation.

21905. Barnes, J. A.; Tryon, P. V.; Allan, D. W.; Jones, R. H. **Stochastic models for atomic clocks,** (Proc. Fourteenth Annu. Precise Time Time Interval (PTTI) Applications Planning Meet., Greenbelt, MD, Nov. 30-Dec. 2, 1982), *NASA Conf. Publ. 2265,* pp. 295-306 (NASA Goddard Space Flight Center, Greenbelt, MD, 1983).

Key words: Allan variance; atomic clocks; clock modeling; clock noise; clocks; clock stability; frequency drift; maximum likelihood; oscillators; power law spectra; techniques.

Most workers in the field of atomic clocks encounter frequency and time instabilities which can be characterized (or modelled) as random fluctuations. These random fluctuations typically display a power spectral density which varies as a power-law over some significant range of (Fourier) frequencies (e.g., $S_y(f)=h_2f^2$, where Y denotes the normalized, instantaneous frequency and f denotes the Fourier frequency). Typical oscillators and/or clocks may have regions where one specific power-law predominates and other regions where other power-laws predominate. In general, various combinations of five different power-laws seem to be adequate to describe almost all observed random behavior in atomic clocks. The five types are: White phase modulation, $S_y(f)=h_2f^2$; Flicker phase modulation, $S_y(f)=h_1f^1$; White frequency modulation, $S_y(f)=h_0f^0$; Flicker frequency modulation, $S_y(f)=h_{-1}f^{-1}$; Random Walk frequency modulation, $S_y(f)=h_{-2}f^{-2}$. In addition to the random components, oscillators and clocks often show systematic, (i.e., deterministic) trends such as offsets in frequency and time, as well as linear drifts in frequency.

For the atomic clocks used in the NBS Time Scales, an adequate model is the superposition of white FM, random walk FM, and linear frequency drift for times longer than about one minute. The model has been tested on several clocks using maximum likelihood techniques for parameter estimation and the residuals have been "acceptably random." Conventional diagnostics indicate that additional model elements contribute no significant improvement to the model even at the expense of the added model complexity.

21906. Spencer, L. V. **Types of nuclear disaster and their radiation environment,** *Proc. NCRP Symp. Control of Exposure to the Public to Ionizing Radiation in the Event of Accident or Attack, Reston, VA, Apr. 27-29, 1981,* pp. 4-7 (NCRP, P.O. Box 30175, Washington, DC 20014, 1982).

Key words: civil protection; nuclear accident; nuclear attack; radiation disaster; radiation hazards; reactor accident.

This paper, together with the purpose statement, introduces the published proceedings of NCRP-sponsored Symposium on civil protection from radiation generated in nuclear accidents or attacks. The bulk of the material consists of a summary and rearrangement of contents of a report prepared by P. Dolan for participants in the Symposium, which listed data for multiweapon and single weapon attacks, core melt and no core melt reactor accidents, weapons and spent fuel reactor transportation accidents, and transoceanic fallout from a multiweapon attack. Characteristics of the carrier, the source, the hazard, the radiations, countermeasures, and dosimetry are given.

21907. Frohnsdorff, G.; Masters, L. W. **The meaning of durability and durability prediction,** *Proc. 1st Int. Conf. Durability Building Materials Components, Ottawa, Canada, Aug. 21-23, 1978,* pp. 17-30 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, 1980).

Key words: accelerated tests; building components; building materials; durability; durability prediction; recommended practice; service life.

The concept of durability is not well defined. The term durability is often used to imply the possession of qualities associated with long-life. In some standards for building components, it is nonquantitative and implies that design requirements are likely to be exceeded for the design service life or some other specified period. The new ASTM Recommended Practice for Developing Short-Term Accelerated Tests for Prediction of the Service Life of Building Components and Materials (E 632–78), is outlined. The application of the recommended practice to service life prediction is illustrated by an example for work being planned on protective coatings for steel.

21908. Beehler, R. E. **GOES satellite time code dissemination,** (Proc. Fourteenth Annu. Precise Time Time Interval (PTTI) Applications Planning Meet., Greenbelt, MD, Nov. 30-Dec. 2, 1982), *NASA Conf. Publ. 2265,* pp. 57-82 (NASA Goddard Space Flight Center, Greenbelt, MD, 1983).

Key words: GOES satellites; satellite time dissemination; time codes; time and frequency coordination; time and frequency dissemination; time and frequency measurement.

The National Bureau of Standards, in cooperation with the National Oceanic and Atmospheric Administration (NOAA), has been disseminating a time code referenced to UTC(NBS) via two of NOAA's geostationary GOES satellites since 1975. A review of the GOES time code system, the performance achieved to date, and some potential improvements in the future will be discussed.

The disseminated time code is originated from a triply redundant set of atomic standards, time code generators and related equipment maintained by NBS at NOAA's Wallops Island, VA satellite control facility. It is relayed by two GOES satellites located at 75°W and 135°W longitude on a continuous basis to users within North and South America (with overlapping coverage) and well out into the Atlantic and Pacific ocean areas. Downlink frequencies are near 468 MHz. The signals from both satellites are monitored and controlled from the NBS labs at Boulder, CO with additional monitoring input from geographically separated receivers in Washington, DC and Hawaii. Received time code accuracies are typically better than 1 ms if the user only applies a constant correction to compensate approximately for his geographical location or better than 100 μs if manual or automatic corrections are applied for path delay using satellite position data encoded into the GOES time code signals.

Performance experience with the received time codes for periods ranging from several years to one day is discussed. Results are also presented for simultaneous, common-view reception by co-located receivers and by receivers separated by several thousand kilometers.

Based on the general acceptance of the GOES time code, NBS and NOAA have recently extended their formal Memorandum-of-Agreement to continue the GOES time code operations for at least an additional five-year period.

21909. Lechner, J. A. **Statistical evaluation of blood alcohol measurements,** *Interim Report DOT-HS-806 193,* 28 pages (Available from the National Technical Information Service, Springfield, VA 22161, Dec. 1982).

Key words: accuracy; blood alcohol; clinical laboratory; reliability; statistical analysis; validity.

The U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA) has instituted a voluntary program to evaluate the proficiency of laboratories measuring the amount of alcohol in blood. In this report, data from that program are examined, and the variability of those measurements assessed. Differences between labs, between dates for the same lab, and between samples on the same date are quantified. Differences in overall bias for the six different periods (covering two years) are noted. A few of the roughly 120 labs participating were observed to perform considerably less well than the others.

21910. Peterlin, A. **Mechanical and transport properties of drawn semicrystalline polymers,** Chapter 3 in *Strength Stiffness of Polymers,* A. E. Zachariades and R. S. Porter, eds., pp. 97-127 (M. Dekker, New York and Toronto, 1983).

Key words: annealing; diffusivity; drawn semicrystalline polymers; elastic modulus; fracture; microholes; radical formation; strength.

The microfibrillar model of the fibrous structure assuming highly aligned microfibrillar bundles with intra- and interfibrillar ttm explains well the data observed on the elastic modulus, strength, density and transport properties of drawn semicrystalline polymers as drawn and after annealing with free and fixed ends. Most of the checks were made on linear PE and PP, to a minor extent on nylon 6 and PET. In spite of the fact that most of the correlations are formulated in a more qualitative manner that one would like one must not forget that a quantitative formulation will be only possible after more data become available on the number of tie molecules of the dimensions of microfibrils and fibrils and their change with the draw ratio and temperature of drawing or annealing. The same applies to their dependence on the morphology, the molecular weight, and molecular weight distribution of the initial material. As the situation presently is, one has no reliable method for the exact determination of any of those quantities.

21911. Behrens, J. W.; Johnson, R. G.; Schrack, R. A. **Neutron transmission measurements to determine isotopic content of spent fuel,** *Proc. Trans. Am. Nucl. Soc. Annu. Meet., 1983, Detroit, MI,* **44,** 204-205 (American Nuclear Society, Inc., La Grange Park, IL 60525, 1983).

Key words: eV energy range; linac; neutron transmission measurements; nondestructive assay; spent nuclear fuel; time-of-flight.

The National Bureau of Standards (NBS) has completed neutron transmission measurements on spent nuclear fuel. The measurements were conducted using the NBS Linac as a pulsed-neutron source and a ^{6}Li glass detector located 20 m from the neutron-producing target. The energy range of interest was from 0.8 to 45 eV, determined using the time-of-flight technique. From our data, we have identified resonances from 11 actinide isotopes and five fission products. Analysis of the resulting transmission dips gives a quantitative determination of isotopic content.

21912. Santoro, R. J.; Dobbins, R. A.; Semerjian, H. G. **Interpretation of optical measurements of soot in flames,** (Proc. AIAA 18th Thermophysics Conf., Montreal, Canada, June 1-3, 1983), Paper *AIAA-83-1516,* 12 pages (American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, NY 10104, 1983).

Key words: diffusion flames; laser diagnostics; light scattering; particle measurements; refractive index; soot formation.

The mean cross sections for directional scattering and extinction are calculated for absorbing spheres obeying the log normal size distribution function using Mie theory. These properties are used to calculate the dissymmetry ratios, the scattering-extinction ratios, and the depolarization ratios for polydispersions of specified complex refractive index. The use of this information to deduce particle volume fraction, the various mean sizes and the width of the distribution, and the particle number concentration is discussed.

Optical observations of agglomerated soot in flames in our laboratory and elsewhere are reviewed. The incompatibility of these observations with the Mie theory for polydispersions of absorbing spheres noted by D'Alessio et al. is confirmed. It is concluded that this conflict arises because the loosely packed, low density agglomerates have an effective refractive index that is significantly reduced below that of the particulate material. The downward scaling of the refractive index in the manner suggested in the past for macroscopic aggregates of soot material with distributed finite void spaces alleviates the incompatibilities. When the particles display the characteristics of Mie scattering, it is possible to determine the soot volume fraction, the width of the distribution function and various mean diameters, the agglomerate number concentration, and the effective refractive index of the soot agglomerates from certain optical observations. The solution for the soot properties is recovered from the observed data by the minimization of an aggregate relative error of the observations using a method for the least squares minimization of nonlinear functions. Illustrative examples based on recent observations in a laminar ethene/air diffusion flame are provided.

21913. Rosasco, G. J.; Lempert, W.; Hurst, W. S.; Fein, A. **Line interference effects in the vibrational Q-branch spectra of N_2 and CO,** *Chem. Phys. Lett.* **97,** No. 4-5, 435-440 (May 27, 1983).

Key words: CO; CW stimulated Raman spectroscopy; line broadening; line mixing; N_2; Q-branch Raman spectra; relaxation matrix theory.

Self-broadened ($\simeq$20–200 kPa) Q-branch spectra are measured by high-resolution cw-stimulated Raman spectroscopy. Line overlap in these spectra is described using a relaxation matrix formalism and a first-order (in density) solution to the resulting equation is used to fit the data. The parameters of this model are analyzed in terms of rates of rotational energy transfer.

21914. Braun, E.; Krasny, J. F.; Peacock, R. D.; Paabo, M.; Smith, G. F.; Stolte, A. **Cigarette ignition of upholstered chairs,** *J. Consumer Prod. Flammability* **9,** No. 4, 167-183 (Dec. 1982).

Key words: cigarettes; cotton batting; fabrics; flammability; ignition; polyester batting; polyurethane foam; pyrolysis products; smoldering; toxicity; upholstered furniture.

The cigarette-initiated smoldering behavior of six upholstered chairs in a small, closed test room was analyzed in detail. The CO, CO_2, and total hydrocarbon concentrations, oxygen depletion, temperature rise, smoke obscuration, and weight loss were recorded. All chairs were covered with medium to heavy weight, cellulosic (cotton or rayon) fabric. Two chairs were commercial, varying in fabric construction, filling materials, and configuration. Four experimental chairs were constructed for this project. They had identical cover fabrics and configurations, but varied widely in filling materials.

Potentially hazardous conditions caused by poor visibility and high concentration of pyrolysis products occurred in all six chair burns, regardless of whether the chairs only smoldered during the test period or whether they first smoldered and then burst into flames. Smoke development which would make escape difficult generally occurred before the flaming of the chairs and before the maximum CO and CO_2 concentrations, oxygen depletion, and temperature were reached.

The chairs which smoldered only contained polyester batting under the cover fabric in the area where the cigarette was placed, those which first smoldered and then burst into flames contained polyurethane foam or cotton batting. The rate of pyrolysis product release was lower during smoldering of the chairs which eventually burst into flames than that of the chairs which smoldered during the whole test period. However, this rate increased rapidly when flaming occurred.

21915. Brown, W. E.; Chow, L. C. **Surface equilibria of sparingly soluble crystals,** *Colloids Surf.* 7, 67-80 (1983).

Key words: crystal; electrochemical; equilibrium; Gouy-Chapman; hydroxyapatite; phase rule; stoichiometric; surfaces.

The chemical interactions between an ionic solid, its interfacial compartments, and a saturated solution are of major interest in surface chemistry. We divide the chemical reactions into two types: (1) "stoichiometric" reactions involving crystal growth-dissolution occurring at kink sites, and (2) "electrochemical" reactions involving random impingement and ejection of ions at crystal faces. The stoichiometric reaction (a) is controlled by the composition and structure of the inner lattice, (b) is the genesis of the solubility product constant and the isotherm in the phase diagram, (c) provides the thermodynamic communication between the bulk solution and the inner lattice, and (d) is unaffected by Galvani potentials. The electrochemical model (a) is non-stoichiometric, (b) does not generate a solubility product nor a solubility isotherm, (c) provides the thermodynamic communication between the bulk solution and (1) the outer layer of the crystal and (2) points within the Gouy-Chapman layer, (d) responds to Galvani potential differences, (e) probably is not a true dissolution-precipitation reaction, but instead is a mechanism for adjusting the compositions of the crystal surfaces to satisfy equilibrium conditions imposed by the stoichiometric reactions, and (f) provides information about chemical potentials of surface ions.

Transport of neutral "Gibbsian" components as such across the phase boundary appears not to represent an actual mechanism, but instead derives from the electrochemical equations. According to this model, equilibrium is not attained between inner lattice and outer layer via solid-state reactions, but only through the aqueous phase. This model has major implications regarding the mechanism by which specific ion electrodes function.

21916. Mountain, R. D.; Basu, P. K. **Molecular dynamics study of homogeneous nucleation for liquid rubidium,** *J. Chem. Phys.* **78,** No. 12, 7318-7322 (June 15, 1983).

Key words: liquid rubidium; liquid state; local order in liquids; metastable liquid; molecular dynamics; nucleation.

Molecular dynamics has been used to study the dependence of homogeneous nucleation of the crystal on the rate with which the liquid is quenched, the initial state of the liquid and on the depth of the quench. A total of 54 simulations of quenching for a liquid rubidium system were performed and the dependence on these quantities of the time required for the onset of nucleation, the rate with which nucleation proceeds and the symmetry of the resulting crystal were determined. With the exception of the onset times for slow quenches, the results show an element of randomness in that the growth rates and the development of bcc or fcc structures do not correlate with quench rates, etc. For slow quench rates, the onset times show the *C*-shaped profile found experimentally in time-temperature trajectory studies of nucleation in strongly supercooled liquids.

21917. DeCandia, F.; Perullo, A.; Vittoria, V.; Peterlin, A. **Mechanical and transport properties of drawn low pressure low density polyethylene,** *J. Appl. Polym. Sci.* **28,** 1815-1817 (1983).

Key words: axial elastic modulus; density; diffusion; drawing; polyethylene; sorption.

The new low density polyethylene obtained under low pressure in the reactor has a great many side branches which are short in contrast to the material obtained at high pressure of the reactor with a few very long branches. The mechanical and transport properties shift a little from those of the usual low density material towards those of the linear polyethylene.

21918. Casella, R. C. **Theory of excitation bands of hydrogen in bcc metals and of their observation by neutron scattering,** *Phys. Rev. B* **27,** No. 10, 5943-5954 (May 15, 1983).

Key words: band theory; hydrogen in metals; muons in metals; neutron scattering; theory of band widths; theory of cross sections.

I consider the possibility that the excited-state oscillator wave functions of dilute hydrogen in bcc metals overlap sufficiently with nearest-neighbor occupancy sites so as to produce hydrogenic energy bands, analogous to electronic energy bands in narrow-band semiconductors. The theory is motivated by the experiments of Magerl *et al.* as well as the earlier observation of ground-state tunnel splitting by Wipf *et al.*, demonstrating quantum coherence in the motion of the hydrogen, despite the necessity of correlated motion by the surrounding metal atoms. Because of the latter complication, the relevant overlap integrals are not calculated from first principles. The band structures are given for the first (nondegenerate) and second (doubly degenerate) excitations ω_I and ω_{II} of the local oscillators, *modulo* a few irreducible overlap integrals, which are then determined by comparison with experiment. The fact that the experimental bandwidths for inelastic neutron scattering from dilute hydrogen in V, Nb, and Ta satisfy $\Gamma(V)>\Gamma(Nb)>\Gamma(Ta)$ at room temperature (Rush, Magerl, and Rowe) finds a natural explanation in the theory. It is shown that the ω_I and ω_{II} bandwidths satisfy $\Delta E_{II}/\Delta E_I=(H_{II}/H_I)Y$, where H_I and H_{II} are irreducible overlap integrals and Y is an (almost) universal constant for H in bcc metals, determined (essentially) by the geometry of the tetrahedrally coordinated hydrogen occupancy sites. On the basis of the band structure that I obtain, I estimate that $Y\simeq 3/4$. Based upon physical reasoning, the relation $(H_{II}/H_I)=(\omega_{II}/\omega_I)^2$ is proposed. Given the (model-consistent) empirical result, $\omega_{II}/\omega_I\simeq 2^{1/2}$, this leads to the prediction $\Delta E_{II}/\Delta E_I\simeq 3/2$, to be compared with the neutron-measured ratios $\Gamma_{II}/\Gamma_I=1.3$ and 2.0 for dilute hydrogen trapped at O and N impurities in Nb metal at $T=4$ and 10 K, respectively. The variation in Γ_{II}/Γ_I is attributed to perturbations of the intrinsic hydrogen bands by the trapping impurities, which are necessary for low-temperature observation, if one is to prevent coagulation of the hydrogen atoms into the ϵ phase of NbH. The differential cross section for inelastic neutron scattering from hydrogen in band states is related theoretically to that for H in local oscillator states. With appropriate rescaling, the band structure that I obtain for hydrogen can also be applied to the case of trapped

positive muons in bcc metals.

21919. Cooper, L. Y. **A concept for estimating Available Safe Egress Time in fires,** *Fire Safety J.* **5,** No. 2, 135-144 (1983).

Key words: combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits.

Available Safe Egress Time (ASET) in enclosure fires is defined as the time between fire detection and the onset of conditions which are hazardous to continued human occupancy. A general technique for estimating this time interval is introduced. A description of hazard development is presented. This description identifies the variables of fire growth which are significant to life safety. A conceptual engineering model which simulates these variables is formulated. Because of the primary focus on life safety, as compared with property protection or structural integrity per se, the suggested modeling includes significant simplifying assumptions which would not be otherwise justified. The concepts developed in this paper provide a rational basis for the use of a mathematical model and user oriented computer program, presented in other works, to actually carry out ASET calculations for compartments of fire origin.

21920. Cowan, P. L.; Hastings, J. B.; Jach, T.; Kirkland, J. P. **A UHV compatible two-crystal monochromator for synchrotron radiation,** *Nucl. Instrum. Methods* **208,** Nos. 1-3, 349-353 (Apr. 15, 1983).

Key words: monochromator; synchrotron; UHV; x ray.

For obvious reasons, monochromatic synchrotron radiation studies at soft X-ray energies require that the monochromator be ultra-high vacuum compatible. We will describe the design, testing and performance of a linkage based, two-crystal, non-dispersive monochromator for use at synchrotrons. The use of a mechanical linkage reduces the degrees of freedom and minimized the number of motion feedthroughs into the vacuum. The linkage chosen maintains a constant output beam position, and assures that the second crystal is always properly positioned. Pertinent design features include direct angular encoding and a feedback-controlled correction system to eliminate the effects of mechanical imperfections.

21921. Bean, V. E. **Fixed points for pressure metrology,** Chapter 3 in *High Pressure Measurement Techniques,* pp. 93-124 (Elsevier Science Publ. Co., Inc., New York, NY 10017, 1983).

Key words: fixed points; metrology; phase transitions; pressure; pressure measurement; pressure scale.

This is Chapter 3 of the reference book *Practical High Pressure Measurement*, G. N. Peggs, Editor. The chapter is a review of the experimental research on high pressure fixed points and contains a summary table of "best" values. An appendix contains a list of phase transitions that have not yet been carefully characterized but may have potential as fixed points in the future. 134 references.

21922. Cavanagh, R. R.; King, D. S. **Internal energy distributions in thermally desorbed molecules, (Summary Abstract),** *J. Vac. Sci. Technol. A* **1,** No. 2, 1267-1268 (Apr.-June 1983).

Key words: angular flux; desorption; Doppler; laser; oxide; rotational levels; Ruthenium; temperature.

Laser excited fluorescence has been employed to examine the quantum state populations of NO thermally desorbed from clean and oxidized Ru surfaces. The rotational and spin populations observed are found to be Boltzmann, yet the observed rotational temperature varies from being equivalent to the surface temperature, to being 50% less than the surface temperature depending on the details of sample preparation. Laser Doppler Spectroscopy has also been applied to the thermally desorbed NO. These measurements provide information on both the angular flux distribution and the spread in translational kinetic energy.

21923. McKnight, R. H.; Kotter, F. R. **A facility to produce uniform space charge for evaluating ion measuring instruments,** *IEEE Trans. Power Appar. Syst.* **PAS-102,** No. 7, 2349-2357 (July 1983).

Key words: electrostatic potential; high efficiency air particulate (HEPA) filters; ion counters; ion density; measurement; net space charge.

A low-speed wind tunnel containing space charge has been constructed and evaluated. The facility is used for testing the performance of ion counters and net space charge measuring devices. Depending on location within the system, space charge densities range from $2\text{–}7\times10^{-8}$ C/m^3. The space charge is spatially uniform within $\pm5\%$ over more than 90% of the cross sectional area of the test volume, but decreases by approximately 20% between two positions separated by 1 m. Ion densities achieved in this system are comparable to those found near high-voltage dc transmission lines but are free from the accompanying large electric fields.

21924. Deslattes, R. D. **X-ray fluorescence spectroscopy,** *Nucl. Instrum. Methods* **208,** Nos. 1-3, 655-658 (1983).

Key words: emission spectra; synchrotron radiation; threshold; x ray.

This is a general review of X-ray emission spectroscopy using sychrotron radiation from storage ring sources. Applications thus far have been to chemical analysis and to use of emission as a probe of absorption in dilute samples. One class of application combines the use of high resolution primary monochromator with a secondary spectrometer also having high resolution. This combination permits detailed examination of some complex inner shell which perturb both emission and absorption spectra.

21925. Jach, T.; Cowan, P. L. **PIN diodes as detectors in the energy region 500 eV-10 keV,** *Nucl. Instrum. Methods* **208,** Nos. 1-3, 423-425 (1983).

Key words: PIN diode; radiation detector; x rays.

PIN diodes offer several advantages over ion chambers in signal-to-noise ratio, size, and ultra-high vacuum compatibility. We have evaluated several commercially available PIN diodes, suitable for use in the X-ray region 500 eV$\leqslant E\leqslant$10 keV, using both brehmsstrahlung and characteristic lines from X-ray tubes between 1.29 and 8.9 keV. We present data on response functions, noise levels, and linearity of response.

21926. Christensen, R. G.; White V, E.; Meiselman, S.; Hertz, H. S. **Quantitative trace analysis by reversed-phase liquid chromatography-mass spectrometry,** *J. Chromatogr.* **271,** 61-70 (1983).

Key words: liquid chromatography/mass spectrometry (LC/MS); preconcentration; trace analysis; ultrasonic.

In order to overcome difficulties in spraying aqueous solvents into the vacuum of a mass spectrometer, an ultrasonic spraying device has been constructed. The vibration is achieved by means of magnetostriction in the nickel inlet tube itself. Applications to aliphatic acid determination in a shale oil process water and to determination of valproic acid, an anti-convulsant, in human serum (SRM 1599) are presented.

21927. Berger, P. W. **The New Federalism: How it is changing the library profession in the United States,** Article in *The Bowker Annual of Library and Book Trade Information, 28th Edition,* pp. 36-41 (R. R. Bowker Co., New York, NY, 1983).

Key words: contracting-out; library-information service; OMB; OPM; personnel standards.

Article describes the potential impacts on librarianship of both the Office of Personnel Management's (OPM) proposed new standards for library and information service workers and the Office of Management and Budget's (OMB) proposed new version to its Circular No. A-76.

21928. Agarwal, G. S. **Phase conjugate optics,** *Curr. Sci. (Golden Jubilee Issue)* **52,** No. 5, 193-198 (Mar. 5, 1983).

Key words: phase conjugacy; scattering.

A brief review of some of the important developments in the relatively new field of phase conjugate optics is presented.

21929. Drever, R. W. P.; Hall, J. L.; Kowalski, F. V.; Hough, J.; Ford, G. M.; Munley, A. J.; Ward, H. **Laser phase and frequency stabilization using an optical resonator,** *Appl. Phys. B* **31,** 97-105 (1983).

Key words: laser spectroscopy; laser stabilization; precision measurement.

We describe a new and highly effective optical frequency discriminator and laser stabilization system based on signals reflected from a stable Fabry-Perot reference interferometer. High sensitivity for detection of resonance information is achieved by optical heterodyne detection with sidebands produced by rf phase modulation. Physical, optical, and electronic aspects of this discriminator/laser frequency stabilization system are considered in detail. We show that a high-speed domain exists in which the system responds to the phase (rather than frequency) change of the laser; thus with suitable design the servo loop bandwidth is not limited by the cavity response time. We report diagnostic experiments in which a dye laser and gas laser were independently locked to one stable cavity. Because of the precautions employed, the observed sub-100 Hz beat line width shows that the lasers were this stable. Applications of this system of laser stabilization include precision laser spectroscopy and interferometric gravity-wave detectors.

21930. May, W. E.; Wasik, S. P.; Miller, M. M.; Tewari, Y. B.; Brown-Thomas, J. M.; Goldberg, R. N. **Solution thermodynamics of some slightly soluble hydrocarbons in water,** *J. Chem. Eng. Data* **28,** 197-200 (1983).

Key words: anthracene; benz(a)anthracene; benz(a)pyrene; benzene; chromatography; chrysene; enthalpy; fluoranthene; fluorene; generator column; Gibbs energy; heat capacity; hexylbenzene; naphthalene; phenanthrane; pyrene; triphenylene; water; 1-methylphananthrene; 2-methylanthracene.

This paper summarizes a series of measurements of the solubilities of 14 hydrocarbons in water at temperatures ranging from 275 to 304 K using a generator-column-high-pressure liquid-chromatographic method. The compounds investigated were benzo[*a*]pyrene, benz[*a*]anthracene, anthracene, hexylbenzene, benzene, chrysene, pyrene, triphenylene, fluoranthene, 1-methylphenanthrene, 2-methylanthracene, phenanthrene, fluorene, and naphthalene. We have calculated values of $\Delta G°$, $\Delta H°$, and $\Delta C_p°$ at 298.15 K for the processes compound(liquid or solid)=compound(aqueous) using the model of Clarke and Glew. We have also calculated these same thermodynamic parameters from the information available on these compounds in the literature.

21931. Morgan, T. J. **Atomic Physics of Negative Ions: A report on the U.S.-Mexico joint workshop,** *Comments At. Mol. Phys.* **12,** No. 5-6, 319-326 (1983).

Key words: chemical physics; heating and fueling fusion plasmas; negative hydrogen ion beams; negative ions; plasma physics.

A workshop on the Atomic Physics of Negative Ions was held recently in Galindo, Mexico. Forty physicists from six countries participated, and twenty-six invited presentations reviewed the field. This report summarizes the motivation for such a workshop and outlines some of the highlights.

21932. Mann, W. B. **Standards, traceability and regulations,** (Proc. 1981 Am. Nuclear Soc. Annu. Meet., Miami, FL, June 9, 1981), Paper in *Critical Reviews on Nuclear Energy,* pp. 1-2, (1981).

Key words: intercomparisons of radioactivity standards; measurements-assurance programs; regulations; standards (radioactivity reference); traceability of radioactivity standards.

This paper reviews the development of measurements-assurance programs in the field of radioactivity to meet various regulatory and licensing requirements in the United States.

21933. Parr, A. C.; Southworth, S. H.; Dehmer, J. L.; Holland, D. M. P. **Photoelectron spectrometer for high resolution angular resolved studies,** *Nucl. Instrum. Methods* **208,** Nos. 1-3, 767-770 (Apr. 15, 1983).

Key words: asymmetry parameters; autoionization; electron kinetic energy; photoelectron spectrometer; photoionization; polarization.

We report on a new electron spectrometer system designed for use on storage ring light sources. The system features a large (76 cm diameter×92 cm long) triply magnetically shielded vacuum chamber and two 10.2 cm mean radius hemispherical electron energy analyzers. One of the analyzers is fixed and the other is rotatable through about 150°. The chamber is pumped by a cryopump and a turbomolecular pump combination so as to enable experiments with a variety of gases under different conditions. The light detection includes both a direct beam monitor and polarization analyzer. The electron detection is accomplished with either a continuous channel electron multiplier or with multichannel arrays used as area detectors.

21934. Allis, W. P. **On the divergence of the Legendre expansion of the electron velocity distribution,** *Proc. NATO Advanced Study Institute Electrical Breakdown Discharge on Gases: Fundamental Processes and Breakdown, Les Arcs, France, June 28-July 10, 1981,* E. K. Kunhardt and L. H. Luessen, eds., pp. 187-205 (Plenum Press, New York, 1983).

Key words: Boltzmann equation; divergence; electron velocity distribution; Legendre expansion.

We consider the velocity distribution of free electrons in a gas of stationary molecules subjected to an electric field E=-ma/e but with no density gradients. We first discuss the distribution $\phi(\vec{v})$ when the electrons disappear, by attachment or recombination, at each collision, and then introduce the scattered-in electrons as a separate source function S(v,f) to evaluate the full distribution $f(\vec{v})$. It will be seen that the functions ϕ are a recognizable part of the function f. They describe the collision-less "streaming" of the fast electrons in front of the swarm which gain energy from the field and effectively disappear on collision, whereas the bulk of the distribution is determined by the balance between energy gained from the field and lost to recoil or inelastic collisions.

21935. Peterlin, A. **Transport of small molecules in Polymers,** Chapter 2 in *Controlled Drug Delivery. Vol. I: Basic Concepts,* Stephen D. Bruck, ed., pp. 15-51 (CRC Press, Inc., Boca Raton, FL, 1983).

Key words: biological membranes; crystalline polymers; diffusion; drawn polymers; fractional free volume; NMR (spin echo, pulsed magnetic gradient); permeability; sorption.

The article is intended to survey the field treated in the book "Controlled Drug Delivery" edited by S. D. Bruck. It covers the transport properties of the half space, plane, cylindrical and spherical membrane. A chapter is devoted to biological membranes which may be approximated by a trilayer membrane. The crystalline structure requires some modifications due to the fact that the transport takes place through the amorphous component while the crystalline lamellae act as obstacles to the transport. The theory of the transport properties is based on the fractional free volume concept. The measurements are partially based on the sorption transient and on the steady state transport. The sorption may be followed by the weight gain or loss and by the optical absorption. The diffusivity is deduced from the sorption, steady state transport and from the decay of the spin echo in a pulsed magnetic gradient NMR.

21936. McLaughlin, W. L. **Radiation processing dosimetry,** *Radiat. Phys. Chem.* **21,** No. 4, 359-366 (1983).

Key words: absorbed dose; calorimetry; charge deposition; dose distributions; dosimetry; electron beams; gamma radiation quality control; radiation processing; radiation spectra; radiochromic dyes.

Measurements of ionizing radiation quantities of intense photon and electron radiations are used to establish quality control of industrial radiation processes. The most important quantity is absorbed dose as determined through traceability of routine dosimetry to calorimetry or standard chemical dosimetry. Some crucial concerns of dosimetry are: (1) Calculations and measurements of radiation energy depositions; (2) improved radiation interaction data in condensed media; (3) radiation scattering behavior for different substances and spectral distributions; (4) secondary radiation phenomena at boundaries and in dielectrics; (5) environmental effects on dosimetry response and analysis.

21937. McLaughlin, W. L.; Simic, M. G.; Miller, A. **Dosimetry by means of the radiation reduction of hemin in aprotic solvents,** *Proc. 3d Int. Symp. Nucl. Chemistry, University of Mexico, Dec. 8-10, 1980,*

A. N. Mendoza and G. Albarran, eds., 195-201 (Center de Estudio Nucleares, Universidad Nacional Autonoma de, A. P. 70-543, Deleg. Coyoacan, 04510 Mexico, D. F., Dec. 1982).

Key words: aprotic solvents; dimethyl sulfoxide; dosimetry; gamma radiation hemin; ion porphyrins; N,N-dimethyl formamide; radiation chemistry; radiation dosimetry; radiation reduction.

Iron (III) porphyrins when dissolved in certain polar organic solvents are reduced by ionizing radiation. This results in a stable shift of both the Soret (B) and visible (Q) absorption bands, as long as the solution is maintained in a deaerated state, thus affording a means of radiation dosimetry. For hemin chloride in dimethyl sulfoxide or N,N-dimethyl formamide, increases in optical absorption at maximum absorption wavelengths of the reduced species give a reproducible response and an accurate means of dosimetry in the dose ranges: 10^{-1}–10^{2} Gy at 422 nm for 10 μM concentration and 10^{2}–10^{4} Gy at 554 nm for 100 μM concentration. The Soret band shift (402 nm to 422 nm) provides linear optical density increase with dose with a yield of reduced Fe(II) species: $G = 4.2(100\ eV)^{-1}$.

21938. Berger, M. J. **On the spatial correlation of ionization events in water,** *Proc. 7th Symp. Microdosimetry, Oxford, United Kingdom, Sept. 7-12, 1980,* pp. 521-531 (Harwood Academic Publ. Ltd., P.O. Box 786, Cooper Station, New York, NY 10003, 1981).

Key words: beta particles; electrons; gamma rays; microdosimetry; relative biological effectiveness; restricted ionization yield; track structure; x rays.

The spatial correlation of ionizations in water from various low-LET radiations is discussed in terms of a restricted ionization yield. This quantity is defined as the number of ionizations per 100 eV which are preceded by another ionization on the track within a distance s or closer. For large values of s the restricted ionization yield goes over into the usual total ionization yield. Restricted ionization yields have been computed for various separation distances **s**, ranging from less than 1 nm to 1000 nm, for monoenergetic electrons with energies up to 1 MeV. These results have in turn been used to obtain restricted yields for monoenergetic photons, x-ray spectra and tritium beta rays. Whereas the total ionization yield is almost the same for various low-LET radiations, the restricted yield depends markedly on the radiation quality. For small and moderate separation distances it can become almost 2 times larger for 1-keV than for 1-MeV electrons, and 1.5 times larger for low-energy x rays and tritium beta rays than for cobalt-60 gamma rays. These yield ratios may provide a partial explanation for observed differences in radiobiological effectiveness between various low-LET radiations.

21939. Bizau, J. M.; Wuilleumier, F.; Dhez, P.; Ederer, D. L.; Picque, J. L.; LeGouet, J. L.; Koch, P. **Observation of ionization of laser excited sodium atoms by synchrotron radiation,** (Proc. Conf. Laser Techniques Extreme Ultraviolet Spectroscopy, Boulder, CO, Mar. 8-12, 1982), Paper in *Laser Techniques for Extreme Ultraviolet Spectroscopy* **90,** No. 2, 331-346 (American Institute of Physics, New York, NY, 1982).

Key words: autoionization; excited states; lasers; photoelectron spectroscopy; photoionization; synchrotron radiation.

In a triple, orthogonal crossed beam experiment, we have studied photoionization of excited Na atoms. A cw ring dye laser (few W/cm^2) locked to the D_1 or D_2 absorption lines excited up to 20% of the 10^{13} cm^{-3} ground state atoms to Na($3p\ ^2P_{3/2}$). Monochromatized synchrotron radiation from the ACO storage ring provided the photoionizing radiation. A cylindrical mirror electron spectrometer was used to measure photoelectron spectra. First measurements of the $2p^6 3p \rightarrow 2p^5 3p\epsilon l$ photoionization were obtained. Decay of autoionizing resonances to the $2p^5 3p$ ionic channel were also observed.

21940. Yin, L. I.; Trombka, J. I.; Ruitberg, A. P.; Seltzer, S. M. **A small, battery-operated fluoroscopic system: Lixiscope with x-ray generator,** *Mater. Eval.* **41,** No. 7, 844-848 (June 1983).

Key words: battery-operated fluoroscopic system; fluoroscopic image; Lixiscope; x-ray generator.

A small, battery-operated x-ray generator has been developed to be used as part of a small-format fluoroscopic system, the Lixiscope (Low Intensity X-ray Imaging Scope). The x-ray generator consists of a grounded rod-anode x-ray tube with a 0.2 mm focal spot and a specially designed, battery-operated, 0 to −80 kV high-voltage supply. Total power consumption is about 10 W. The fine focal spot, in conjunction with the continuously variable x-ray intensity and spectral distribution, helps to extend both the versatility and the performance of the Lixiscope toward a much wider range of terrestrial and spacecraft applications. The complete fluoroscopic system is described, and some examples of possible applications are shown.

21941. Butrymowicz, D. B. **Diffusion rate data and mass transport phenomena for copper systems, Part II, INCRA Monograph VIII; The metallurgy of copper,** *Book: Diffusion Rate Data and Mass Transport Phenomena for Copper Systems, Part II,* 750 pages (International Copper Research Assoc., Inc. 708 Third Avenue, New York, NY 10017, 1982).

Key words: alloys; compilation; copper; data; diffusion; kinetics; mass transport; metallurgy; metals; migration; monograph; review.

A survey, comparison and critical analysis is presented of data compiled from the scientific literature concerning diffusion in copper alloy systems involving elements in Group IIB (Zn, Cd, Hg), Group IIIA (B, Al, Ga, In, Tl), Group IVA (C, Si, Ge, Sn, Pb), Group VIA (O, S, Se, Te), Group VIIA (F, Cl, Br, I), and Group VIIIA (Ge, Kr, Xe). Here the term "copper alloy system" is interpreted in the broadest sense. For example, the review of diffusion in the Cu-M system reports all diffusion situations which involve both copper and element M, including diffusion of M in Cu or in any alloy containing Cu; and diffusion of any element in any alloy containing both Cu and M. Topics include volume diffusion, grain boundary diffusion, tracer diffusion, alloy interdiffusion, electromigration, thermomigration, strain-enhanced diffusion and diffusion in molten metals. An extensive bibliography is presented along with figures, tabular presentation of data, and discussion of results.

21942. Mountain, R. D.; Basu, P. K. **Temperature dependence of the dynamic structure factor and the stability of a supercooled liquid: A molecular-dynamics study of liquid rubidium,** *Phys. Rev. A* **28,** No. 1, 370-372 (July 1983).

Key words: computer simulation; liquid state physics; liquid structure; metastable liquid; molecular dynamics; self-diffusion.

A molecular-dynamics study of the temperature dependence of the dynamic structure factor for liquid rubidium was made in order to clarify the role of density fluctuations in determining the stability limit of the supercooled liquid. Neutron scattering measurements on supercooled liquid gallium and on supercooled mixtures of lead and tin have led to conflicting interpretations of the temperature variation of the dynamic structure factor. The molecular-dynamics results for supercooled liquid rubidium indicate that the temperature variation of the dynamic structure factor correlates with the self-diffusion coefficient. By reexamining the data for liquid gallium we show that the experimental and the molecular-dynamics results can be given a common interpretation and that the density fluctuations are not an indicator of the limit of stability of a supercooled liquid.

21943. Kirkpatrick, D.; Horlick, J. **Proficiency testing for thermal insulation materials in the National Voluntary Laboratory Accreditation Program,** (Proc. 17th Int. Conf. Thermal Conductivity, National Bureau of Standards, Gaithersburg, MD, June 15-19, 1981), *Thermal Conductivity 17,* J. G. Hust, ed., pp. 497-506 (Plenum Publ. Corp., 1983).

Key words: accreditation; flammability; laboratory accreditation; National Voluntary Accreditation Program (NVLAP); proficiency testing; test methods; thermal insulation materials.

The National Voluntary Laboratory Accreditation Program (NVLAP) is administered by the U.S. Department of Commerce to accredit testing laboratories upon request. Accreditation is currently available for laboratories that test carpet, thermal insulation materials, and freshly mixed field concrete. Decisions to accredit laboratories are based on evaluations conducted by the National Bureau of Standards that include questionnaires, on-site assessments, and

proficiency testing.

This paper discusses the design and operation of the first two years of the proficiency testing portion of the evaluation of laboratories that test thermal insulation materials.

21944. Gross, J. G. **Application of the performance concept to rehabilitation—Field application and evaluation, Final Report.** *Proc. 3d ASTM/CIB/RILEM Symp. Performance Concept in Building, Lisbon, Portugal, Mar. 29-Apr. 2, 1982,* **2,** Section III.2, 227-231 (Laboratorio Nacional de Engenharia Civil Avenido do Brasil, 1799 Lisboa Codex, Portugal, 1982).

Key words: economic methods; evaluation guides; performance concept; regulations; rehabilitation; research; research needs; test methods.

This paper summarizes the Session III.2 *Application of the Performance Concept to Rehabilitation*, "Field Application and Evaluation," of the 3rd ASTM/CIB/RILEM Symposium on the *Performance Concept in Building*, held in Lisbon, Portugal, March 29, 30, 31, and April 1 and 2, 1982. Provided is a session summary with identified research and technical needs to facilitate the application of the performance concept to rehabilitation of existing buildings.

21945. Gross, J. G. **Application of the performance concept to rehabilitation—Field application and evaluation,** *Proc. 3d ASTM/CIB/RILEM Symp. Performance Concept in Building, Lisbon, Portugal, Mar. 29-Apr. 2, 1982,* **2,** Section III.2, 205-218 (Laboratorio Nacional de Engenharia Civil Avenido do Brasil, 1799 Lisboa Codex, Portugal, 1982).

Key words: building; evaluation; performance; rehab; research; test methods.

This report presents the author's review of five papers presented to Section III, *Application of the Performance Concept to Rehabilitation*, Group III.2, Field Application and Evaluation, of the Third International Symposium on the *Performance Concept in Building*, sponsored by ASTM, CIB, and RILEM. Discussed is the need for and the importance of pre-rehabilitation evaluation for the success of any rehab project. Summarized is the need for evaluation research in the area of the physical sciences, engineering, economics, and user needs.

21946. Lowney, J. R.; Larrabee, R. D.; Thurber, W. R. **The relationship between deep-level measurements and lifetime in devices,** (Proc. 1983 Custom Integrated Circuits Conf., Genesee Plaza/Holiday Inn, Rochester, NY, May 23-25, 1983), *IEEE Cat. No. 83CH1859-8,* pp. 152-156 (Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, 1983).

Key words: deep-level measurements; generation current; lifetime; minority-carrier lifetime; recombination centers; silicon.

The minority-carrier lifetime in silicon devices affects performance by influencing such lifetime-related quantities as switching times, storage times, and reverse-leakage currents. A computer program has been developed to model the behavior of deep-level recombination centers that control the minority-carrier lifetime. The input parameters that characterize the deep levels can be measured by capacitive-transient techniques coupled with a measurement of the low-injection-level lifetime. These parameters can be used for deep-level identification and diagnostic purposes and, as input to the program, for predicting lifetime under different injection-level conditions. This technique of deep-level characterization is illustrated for n^+p and p^+n diodes containing deep levels from intentionally added platinum.

21947. Baylies, W. A.; Scace, R. I.; Vieweg-Gutberlet, F. **International standards for semiconductor materials,** *Am. Soc. Test. Mater. Standard. News,* pp. 21-23 (May 1983).

Key words: international standardization; semiconductors; silicon; standards; test methods.

Semiconductor silicon is an internationally traded commodity which requires sophisticated characterization procedures for producer's quality control and purchaser's incoming inspection tests. International coordination at the technical committee level, being pursued by ASTM Committee F-1 on Electronics, to create a technically consistent set of test methods throughout the world is described. Some further topics for international collaboration in test method development are also mentioned.

21948. Siebert, B. R. L.; Caswell, R. S.; Coyne, J. J. **Calculations of quality factors for fast neutrons in materials composed of H, C, N and O,** (Proc. Eighth Symp. Microdosimetry, Julich, West Germany, Sept. 27-Oct. 1, 1982), Paper in *Radiation Protection,* J. Booz and H. G. Ebert, eds., pp. 1131-1140 (Commission of the European Communities, Luxembourg, 1983).

Key words: carbon; hydrogen; microdosimetry; neutron dosimetry; nitrogen; oxygen; quality factors.

Microdosimetric measurements in neutron or mixed neutron-gamma fields allow the determination of the absorbed dose and the mean quality factor. Various methods for extracting the mean quality factor from measured dose distributions in LET have been proposed and the use of these techniques for radiation protection has been suggested.

The aim of this paper is to show that the mean quality factor for neutrons in tissue can be calculated in a good approximation directly from initial recoil energy spectra. Tables are given which make it possible to compute quality factors for monoenergetic neutrons from 11 meV to 20 MeV in any tissue-simulating material composed of H, C, N and O. The calculations are based on water as slowing down medium. The quality of this approximation is discussed.

21949. Schaefer, A. R.; Zalewski, E. F.; Geist, J. **Silicon detector nonlinearity and related effects,** *Appl. Opt.* **22,** No. 8, 1232-1236 (Apr. 15, 1983).

Key words: nonlinearity; nonuniformity; quantum efficiency; recombination loss; reverse bias; silicon photodiode; supralinearity.

An explanation is put forth for the observed nonlinearity in the red spectral region of the response of silicon photodiodes. Experiments are described to support the explanation; and the results, implications, and precautions indicated for the use of these diodes are given. Correlation of nonlinearity with spatial nonuniformity of response is demonstrated.

21950. Jacox, M. E. **The reaction of F atoms with CH_3SH. Vibrational spectroscopy and photochemistry of CH_3S and CH_2SH hydrogen-bonded to HF,** *Can. J. Chem.* **61,** No. 5, 1036-1043 (1983).

Key words: CH_2SH; CH_3S; CH_3SH; F-atom reaction; HF complex; hydrogen bonding; infrared spectrum; isotopic substitution; matrix isolation; photodecomposition.

When the products of the reaction between F atoms formed in a microwave discharge and methanethiol are frozen in a large excess of argon at 14 K, prominent absorptions of isolated and hydrogen-bonded HF appear, indicating that hydrogen abstraction occurs both in the deposition beam and in the solid. Secondary F-atom reactions play only a minor role. Studies of the partially deuterium-substituted methanethiols support the assignment of peaks at 3515 and 3672 cm^{-1} to the HF-stretching modes of HF hydrogen-bonded to CH_3S and CH_2SH, respectively, and indicate that CH_2SH is formed with enough excess energy to surmount the barrier for rearrangement to CHH_3S. Although ground-state rearrangement of the thermochemically more stable isomer, CH_3S, to CH_2SH was not observed, when the sample was excited by radiation in the spectral region of a known electronic transition of CH_3S, isomerization to CH_2SH resulted. The present experiments cannot distinguish between direct isomerization and formation of CH_2SH by the cage recombination of CH_2S+H. Although peaks attributable to CH_3S isolated in solid argon are weak, the experiments provide some support for a recent assignment of vibrational fundamentals of CD_3S, based on photodetachment studies. A prominent, structured absorption at 424 cm^{-1} is assigned to the H_2CS "umbrella" deformation of CH_2SH, consistent with a recent *ab initio* calculation. The photodecomposition threshold of CH_2SH lies between 260 and 280 nm.

21951. Berger, M. J.; Seltzer, S. M. **Mean excitation energies for use in Bethe's stopping power formula,** (Proc. Seminar Charge States Dynamic Screening Swift Ions Solids, East-West Center, Honolulu, HI, Jan. 25-29, 1982), *Report CONF-820131,* pp. 57-74 (Jan. 1983).

Key words: Bragg additivity; dielectric-response function; mean excitation energies; oscillator-strength distributions; shell corrections; stopping power.

A review has been made of the mean excitation energies that can be derived from the analysis of stopping-power and range measurements, and from semi-empirical dipole oscillator-strength distributions for gases and dielectric-response functions for solids. On the basis of this review, mean excitation energies have been selected for 43 elemental substances and 54 compounds. Additivity rules have also been considered which allow one to estimate the mean excitation energies for compounds for which no direct data are available. These additivity rules are based on the use of mean excitation energies for atomic constituents which, to a certain extent, take into account the effects of chemical binding and physical aggregation.

21952. Brenner, D.; Treado, M. J. **Guide to electronic facsimile systems,** *NIJ Standard-201-83,* 40 pages (U.S. Department of Justice, Office of Development, Testing, and Dissemination, National Institute of Justice, Washington, DC, Jan. 1983).

Key words: communications interface; facsimile equipment; image quality; law enforcement; printer; receiver; transmitter; user guide.

This guide presents the basic concepts of facsimile transmission and reception. It discusses the types of equipment available and how each is used. Image quality, operating procedures, data transmission, the facsimile/communications equipment interface, and law enforcement uses are among the topics discussed. Also included is a section on equipment selection criteria and a discussion of image quality on a noisy radio channel. References, an annotated bibliography and a list of facsimile equipment manufacturers are also provided.

21953. Hockey, B. J. **Crack healing in brittle materials,** *Proc. Fracture Mechanics Ceramics,* R. C. Bradt, A. G. Evans, D. P. H. Hasselman, and F. F. Lange, eds., **6,** 637-658 (Plenum Publ. Corp., New York, 1983).

Key words: brittle materials; crack healing; dislocations; impact; indentation; stacking faults; transmission electron microscopy.

Transmission electron microscopy has been used to examine cracks produced in Al_2O_3, SiC, Si, and Ge by room temperature indentation or solid particle impact. While most cracks are dislocation-free, a small but significant fraction ($\simeq$25%) are found to end in a network of dislocations. In this paper, the nature and origin of these dislocations is investigated, and it is concluded that they are interfacial mismatch dislocations which form as a result of spontaneous crack healing.

Unlike dislocation structures resulting from slip, these dislocation networks exhibit no preferred orientation dependence. Instead, they join continuously with cracks of arbitrary orientation and morphology, and thus clearly define extended portions of the residual crack interface. These dislocation networks, moreover, are generally composed of widely separated partial dislocation segments, so that much of the defined area is faulted. In Al_2O_3, the unique nature of these configurations of partial dislocations and faults is confirmed by diffraction contrast analyses. In addition, observations illustrating the spontaneous formation of high energy stacking fault ribbons during apparent beam-induced crack closure in Al_2O_3 are provided.

The retention of such energetically unfavorable lattice defects in these materials is explained on the basis of a two-stage model describing the formation and subsequent relaxation of interfacial mismatch dislocations during imperfect crack healing.

21954. Domen, S. R. **A temperature-drift balancer for calorimetry,** *Int. J. Appl. Radiat. Isot.* **34,** No. 6, 927-928 (1983).

Key words: absorbed dose; calorimeter; resistance-capacitance circuit; temperature-drift balancer.

Calorimeters used in radiation measurements often suffer from errors due to thermal drifts at positions of the heat sensors in a Wheatstone bridge. A simple resistance-capacitance circuit can be connected across a Wheatstone bridge in order to balance recorder pen drifts due to gradually changing temperature gradients that often occur in calorimeters.

21955. Goodman, L. J.; Coyne, J. J.; Zoetelief, J.; Broerse, J. J.; McDonald, J. C. **Dosimetry of a lightly encapsulated ^{252}Cf source,** *Radiat. Prot. Dos.* 4, No. 2, 91-96 (1983).

Key words: californium-252; dosimetry; encapsulation; neutrons.

For use in calibrating various neutron detectors, the National Bureau of Standards employs several strong ^{252}Cf sources specially fabricated in light encapsulation. Measurements of the neutron and gamma ray tissue kerma rates in free air produced by one of these sources (~2 mg) were performed with tissue-equivalent ionisation chambers, a magnesium walled argon filled ionisation chamber, and miniature Geiger-Müller gamma-ray dosemeters. The kerma rates were also calculated from accurate measurements of the neutron emission rate of the source. The neutron kerma rates obtained using the tissue-equivalent chambers and the Geiger-Müller dosemeters were nearly 40% higher than the calculated values. Additional measurements made with a tissue-equivalent proportional counter, with simulated greater encapsulation material around the source, and with aluminum absorbers revealed that this discrepancy was due to the emission of photons or electrons with low penetration which the Geiger-Müller dosemeter did not detect.

21956. Kelly, W. R.; Fassett, J. D. **Determination of picogram quantities of uranium in biological tissues by isotope dilution thermal ionization mass spectrometry with ion counting detection,** *Analyt. Chem.* **55,** No. 7, 1040-1044 (1983).

Key words: bovine liver; ion counting; isotope dilution; mass spectrometry; thermal ionization; trace determination; uranium.

A procedure has been developed for the determination of picogram quantities of U in biological matrices by isotope dilution mass spectrometry that uses artifically produced ^{233}U (SRM 955) as the isotopic spike. The U is chemically purified by anion exchange chromatography and then loaded onto a single anion exchange bead. The bead is loaded into the mass spectrometer and provides a point source for the emission of U^+ ions with an ionization efficiency of 0.2%. One-hundred picograms of U can be measured with a precision of better than 0.5% (2*s*). At these levels the chemical blank is the limiting source of error. For this quantity of U the blank correction and its associated uncertainty were typically 4% and 2%, respectively. The procedure was applied to the determination of U in SRM 1577a, bovine liver, which was found to have a mean concentration of 709$\pm$13 pg of U/g (*ts*, 95% confidence limit), the lowest certified U concentration of any biological SRM.

21957. Jones, D. W.; Musiol, K.; Wiese, W. L. **Regularities of Stark widths and shifts in an Ar I transition array,** *Proc. XI Symp. Physics Ionized Gases,* G. Pichler, ed., pp. 457-464 (Institute of Physics of the University, Zagreb, Yugoslavia, 1982).

Key words: neutral argon; plasma spectroscopy; regularities; Stark shifts; Stark widths; transition array.

A study of the Stark width and shifts for lines of the Ar I 4s–4p transition array has been carried out with a wall stabilized arc. Systematic variations of the widths and shifts have been found, which are correlated with the excitation energies of the upper level.

21958. Davidson, R. M.; White V, E.; Margolis, S. A.; Coxon, B. **Synthesis of nitrogen-15-labeled 2-amino(glycofurano)oxazolines *via* glycosylamine intermediates,** *Carbohydr. Res.* **116,** 239-254 (1983).

Key words: glycofuranosyl 2″-amino oxazolines; glycosylamine intermediates; nitrogen-15.

A new, efficient synthesis of doubly ^{15}N-labeled 2-amino-oxazoline derivatives of pentoses and hexoses has been delineated that involves treatment either of unprotected or *O*-isopropylidenated glycosylamines with cyanamide-$^{15}N_2$ in methanol to give 2-amino(glycofurano)oxazolines-$^{15}N_2$. A probable mechanism for these reactions is presented. These techniques provide a practical means by which a variety of stable or radioactive isotopes can be introduced into any of several known, clinically significant pyrimidine anhydronucleosides, such as 2,2′-anhydro (1-β-D-arabinofuranosylcytosine)(cyclo-C).

21959. Schima, F. J.; Hoppes, D. D. **Tables for cascade-summing corrections in gamma-ray spectrometry,** *Int. J. Appl. Radiat. Isot.* **34,** No. 8, 1109-1114 (1983).

Key words: cascade sum; gamma-ray detector; peak efficiency; sum coincidence; sum correction coefficient; total efficiency.

Calculations of the spectral distortion caused by the simultaneous detection of cascade radiations in gamma-ray spectrometry involve terms containing the relative probability for the coincident emission of the radiations involved. Here we present tables of these probabilities ("summing coefficients") for the most probable gamma rays of some frequently encountered radionuclides, to be combined with measured full-energy-peak or total efficiencies of a particular system to calculate emission rates that would be measured without cascade summing.

21960. Kirkpatrick, D.; Horlick, J. **Proficiency testing—An essential element of laboratory accreditation,** *Am. Soc. Test. Mater. Stand. News,* pp. 14-17, 48 (Dec. 1980).

Key words: carpet testing; laboratory accreditation; laboratory evaluation; laboratory performance evaluation; proficiency testing; thermal insulation materials testing.

The National Voluntary Laboratory Accreditation Program (NVLAP) is administered by the Department of Commerce to accredit testing laboratories upon request. Accreditation is currently available for laboratories that test carpet, thermal insulation materials, and freshly mixed field concrete. Decisions to accredit laboratories are based on an evaluation conducted by the National Bureau of Standards which includes questionnaires, on-site examination, and proficiency testing.

It was recognized early that while questionnaires and site visits could provide valuable insight into a laboratory's ability, a true measure of it's capability could only be determined through proficiency testing.

This paper discusses the design and operation of the proficiency portion of the approach used in evaluating laboratories that test thermal insulation materials and carpets.

21961. Snell, J. E. **Hazard assessment—Challenge to fire science,** *J. Fire Sci.* **1,** 4-8 (Jan./Feb. 1983).

Key words: combustion products toxicity; fire safety; toxic hazard assessment; toxicity test methods.

This article discusses technical issues relevant to development of practical guidance for fire protection engineers and code officials on assessing the toxic hazard of combustion products from fires. Also, an approach for developing a toxic hazard assessment methodology over the next three years is outlined, and major additional research needs are noted to stimulate discussion and assistance for planned NBS work in this area.

21962. Guillot, B.; Birnbaum, G. **Theoretical study of the far infrared absorption spectrum of dense nitrogen,** *J. Chem. Phys.* **79,** No. 2, 686-691 (July 15, 1983).

Key words: far infrared; induced absorption; liquid; molecular band shape; theoretical spectrum.

The far infrared absorption spectrum of dense nitrogen is calculated by assuming that the induction mechanism is quadrupolar and that the intermolecular potential is predominantly isotropic. The profile is then described as the convolution of a translational spectrum and a rotational spectrum. The latter expresses the free rotations of the molecules, whereas the former, calculated from the Zwanzig-Mori theory of Brownian motion, is characterized by two translational modes, a diffusive low frequency mode and an oscillatory high frequency mode. The translational spectrum is found to be responsible for the density dependence of the absorption spectrum, contributing significantly to the profile at high densities and for all frequencies. The parameters of the theory are analytically given and the influence on the profile of a small anisotropy in the intermolecular potential is estimated by a perturbation approach.

21963. Watson, R. E.; Bennett, L. H.; Davenport, J. W. **Ionic character of polar crystals: An extended Mulliken scheme for electronegativities,** *Phys. Rev. B* **27,** No. 10, 6428-6438 (May 15, 1983).

Key words: atomic energy levels; charge transfer; electronegativity; insulators; metal compounds; semiconductors; transition.

The total energy of an atom can be expressed in terms of the charge q on the atom as $E(q)=E(0)+\alpha q+\beta q^2+\gamma q^3$. It is shown that the expected charge transfer q, which brings the intra-atomic energy of the atoms to a minimum, between otherwise isolated noninteracting atoms, is proportional to the difference in the α's of the consitituent elements, i.e., $q=c\Delta\alpha$. Thus α provides a well-defined electronegativity scale, and if the third-order term γq^3 may be neglected, then $\alpha=\Phi_m$, which is the original Mulliken scale. The quadratic term βq^2 acts to oppose charge transfer, and therefore the coefficient c, relating q to $\Delta\alpha$, depends on what elements are involved and on their relative concentration in a well-defined manner. This implies an asymmetry in charge transfer with concentration. Spectroscopic data indicate that γ, though small, is not negligible and, in such a case Φ_m is not a proper electronegativity. The extended Mulliken scheme, involving α and β, is relevant to the energetics of charge transfer and hence to the ionic character of insulating and semiconducting compounds. It allows simple baseline estimates to be made of such character. Other factors contribute to charge transfer and some of the complications associated with transition-metal compound formation are explored.

21964. Richter, D.; Rush, J. J.; Rowe, J. M. **Localized modes and hydrogen trapping in niobium with substitutional impurities,** *Phys. Rev. B* **27,** No. 10, 6227-6233 (May 15, 1983).

Key words: defects; hydrogen in metals; neutron scattering; phonon; trap; vibrational spectroscopy.

The trapping of hydrogen by the substitutional impurities Ti and Cr in Nb has been investigated by neutron inelastic scattering measurements of hydrogen vibration spectra as a function of temperature. In the case of Ti, the hydrogen is in a trap which is deep enough to prevent precipitation into the hydride phase at low temperatures. In the trapped state, the hydrogen occupies a tetrahedral site which is likely to be a neighbor of the Ti impurity. The higher-energy vibrational-mode peak is shifted down by ≈ 10 meV and broadened somewhat with respect to that in pure niobium. In the case of Cr impurities the trap is shallower, and precipitation to the hydride phase is not inhibited at low temperatures. By studying the detailed behavior of the temperature dependence of the vibrational line shapes for dissolved, trapped, and precipitated H, a binding energy at the Cr trap of 105 ± 10 meV has been derived.

21965. Geist, J.; Wang, C. S. **New calculations of the quantum yield of silicon in the near ultraviolet,** *Phys. Rev. B* **27,** No. 8, 4841-4847 (Apr. 15, 1983).

Key words: impact ionization; quantum yield; silicon.

The rigorous expression for the quantum yield for electron-hole pair production was simplified using assumptions inspired by Kane's random-k approximation and by recent results of Alig, Bloom, and Struck. The resulting approximation was intuitively satisfying. It required integration with respect to kinetic energy of the product of the joint distribution of the photogenerated electrons and holes and the average number of electron-hole pairs created by the cascade of impact ionizations initiated by a carrier with a given kinetic energy. The first quantity in the integrand was calculated from a self-consistent, first-principles band structure for silicon; the second was obtained from results of Alig, Bloom, and Struck. The results agreed reasonably well with recent experimental measurements of the quantum yield of silicon in the ultraviolet.

21966. Geist, J.; Gladden, W. K. **Transition rate for impact ionization in the approximation of a parabolic band structure,** *Phys. Rev. B* **27,** No. 8, 4833-4840 (Apr. 15, 1983).

Key words: Auger scattering; impact ionization; random-k approximation; semiconductors; silicon.

Recently, Alig, Bloom, and Struck have reported a simple model of ionization scattering in semiconductors and insulators. Their model is based upon the random-k approximation to the transition rate for impact ionization, and upon a generic band structure with only two

free parameters to describe all materials. The present paper describes the first step in an attempt to understand in detail why such a simple model works so well. The random-k approximation to the transition rate for impact ionization is tested on a highly symmetric band-structure model for which most of the dimensions of the twelve-dimensional transition-rate integral can be treated analytically. The difference near threshold between the random-k approximation and the rigorous result can be much larger than indicated by Kane's Monte Carlo integration for the silicon band structure, but this difference seems to be unimportant in practical problems where impact ionization competes with phonon emission.

21967. Reader, J. **$3s^2$–$3s3p$ and $3s3p$–$3s3d$ transitions in magnesiumlike ions from Sr^{26+} to Rh^{33+},** *J. Opt. Soc. Am.* **73,** No. 6, 796-799 (June 1983).

Key words: energy levels; krypton; molybdenum; niobium; rhodium; ruthenium; spectra; strontium; yttrium; zirconium.

The $3s^2\ {}^1S_0$–$3s3p\ {}^1P_1$, $3s3p\ {}^1P_1$–$3s3d\ {}^1D_2$, and $3s3p\ {}^3P_2$–$3s3d\ {}^3D_3$ transitions in seven Mg-like ions from Sr^{26+} to Rh^{33+} were observed with a laser-produced plasma and a 2.2-m grazing-incidence spectrograph. The wavelengths of the $3s^2\ {}^1S_0$–$3s3p\ {}^1P_1$ transition are compared with tokamak observations and with theoretical values obtained with the relativistic random phase approximation.

21968. Phillips, W. E.; Lowney, J. R. **Analysis of nonexponential transient capacitance in silicon diodes heavily doped with platinum,** *J. Appl. Phys.* **54,** No. 5, 2786-2791 (May 1983).

Key words: capacitance transient; deep-level measurements; platinum; semiconductor characterization; silicon.

An analysis having improved rigor has been made of the capacitance transient due to thermal emission from charged defect centers in a semiconductor depletion region. This analysis extends the range of applicability of capacitance-transient defect characterization techniques to nonexponential transient conditions which occur in diodes with trap densities of the same order as the net shallow dopant density or in diodes with somewhat smaller trap densities when defect centers are charged initially in only a part of the depletion region. An example of the improvement is shown for three silicon diodes heavily doped with platinum.

21969. Huennekens, J.; Gallagher, A. **Radiation diffusion and saturation in optically thick Na vapor,** *Phys. Rev. A* **28,** No. 1, 238-247 (July 1983).

Key words: radiation diffusion; saturation; sodium.

We have measured the time-dependent fluorescence of the sodium D lines following pulsed excitation of one D line, in the presence of radiation trapping with optical depths k_0L of $\sim$10 to 2000. When collisional coupling of the $3P_{1/2}$ and $3P_{3/2}$ levels and different radiative-escape probabilities for each D line are taken into account, we obtain excellent agreement with Holstein's theory for the effective radiative decay rates in the Doppler region ($k_0L \sim 10$–300) and in the redistributed Lorentzian region ($k_0L > 1000$). For k_0L between these two regions, we observe an abrupt transition between the two limiting formulas. The buildup rate of the sensitized fluorescence signal also yields a $3P_{3/2} \rightarrow 3P_{1/2}$ excitation transfer cross section in agreement with our previously reported cw measurement. Additionally, we have measured the dependence of the $3P$ fluorescence on laser power and beam diameter, and we explain the observed approach to saturation. We suggest that the previously reported "anomalous" approaches to saturation may be explained in terms of the laser beam burning through the optically thick vapor. Laser-beam spatial intensity variations and self-focusing also contribute to fluorescence signals that deviate from the usual single-atom saturation behavior.

21970. El-Behay, A. Z.; McLaughlin, W. L. **Dose distribution mapping in intense γ-ray fields using dye film dosimetry,** *Int. J. Appl. Radiat. Isot.* **33,** 684-687 (1982).

Key words: cobalt-60; depth dose; dose distribution; dose mapping; dye films; film dosimetry; gamma radiation; isodose; radiation sterilization; radiochromic dyes; triphenyl methane dyes.

The radiochromic dye film dosimeters of 50 μm thickness were used to map isodose curves inside products contained in aluminum boxes of wall thickness 1.5 mm, which are typically irradiated for sterilization of medical products in the large ^{60}Co irradiation facility of Egypt. Reproducibility of the absorbed dose readings using this dosimetry system was calculated to be within less than 2.5%. The value of the uniformity ratio inside the product material contained in these boxes was measured to be 1.28 ± 0.06, which is less than the value for the usual cardboard boxes used in radiation processing. The isodose curves obtained for the aluminum cases are also more widely spaced than those obtained for the cardboard boxes alone. Such large aluminum boxes are recommended, therefore, as containers for cardboard boxes of products being processed in large γ-radiation facilities.

21971. El-Assy, N. B.; Roushdy, H. M.; Rageh, M.; McLaughlin, H. L.; Levine, H. **Gamma-ray dosimetry using pararosaniline cyanide in dimethyl sulfoxide solutions,** *Int. J. Appl. Radiat. Isot.* **33,** 641-645 (1982).

Key words: dimethyl sulfoxide; gamma radiation; hexahydroxyethyl pararosaniline cyanide; leucocyanide dyes; liquid chemical dosimetry; pararosaniline cyanide; radiation processing; radiochromic dosimetry.

A chemical radiochromic dosimeter using pararosaniline cyanide in dimethyl sulfoxide can be used over a wide absorbed dose range. Experiments show that the dosimeter has a main optical absorption maximum at 554 nm, which is 5 nm higher than that of other polar solvents. Millimolar solutions of leucodye containing small amounts of carboxylic acid or nitrobenzene show a linear response for absorbed doses up to 11.75 kGy. The yield of dye is linear with concentration up to 5 mM. At that concentration the upper limit of linear response range can be extended to about 40 kGy. The lower dose limit for 50 mM concentration of the dye precursor hexahydroxyethyl pararosaniline ($\lambda_{max} = 608$ nm) is about 3 Gy, with $\pm 5\%$ SD at a 95% confidence level, when using a 5 cm pathlength cell. Dye formation yield varies not only with concentration of the leucocyanide, but also with type of oxidizing agent and temperature during irradiation. The latter parameter is especially critical, as dimethyl sulfoxide freezes at 17°C. The effect of storage temperature on the color produced after irradiation at different dose levels was also studied.

21972. Lu, T. M.; Wang, G. C. **Reconstructed domains on a stepped W(100) surface,** *Surf. Sci.* **107,** 139-147 (1981).

Key words: antiphase domains; instrument response function; low energy electron diffraction; reconstructed domains; step edge inhibition; stepped surface; Tungsten (100).

A model calculation is carried out for the scattering of low energy electron diffraction from reconstructed $(\sqrt{2} \times \sqrt{2})$R45° domains on a stepped W(100) surface. The existence of monotonically increasing steps causes the integral order beams to split and the separation of the splitting oscillates with the incident electron energy. We show that due to the existence of an antiphase relationship among the randomly nucleated reconstructed domains, the half-order beams neither split nor oscillate with the incident electron energy. This nonsplitting of half order beams is in agreement with the observation by Debe and King (DK). We also show that the measured intensity profile of a half order beam is equal to the signal intensity profile from the individual finite size domains convoluted with the instrument response function. This gives a simple way to evaluate the reconstructed domain size quantitatively. From the angular distribution of the half-order beam intensity we deduce that the reconstructed domains are somewhat round in shape, instead of the "long strips" proposed by DK. Also, the long range inhibition (20 Å) of the reconstruction near the step edge suggested by DK does not necessarily follow from our analysis. As a matter of fact, there is evidence showing that the inhibition (if it exists at all) can be short range in nature. Our suggestion is in agreement with the observation of the reconstructed W(100) surface by Melmed, Tung, Graham and Smith using FIM technique.

21973. Coriell, S. R.; Boisvert, R. F.; Mickalonis, J. I.; Glicksmann, M. E. **Morphological and convective instabilities during soldification,** *Adv. Space Res.* **3,** No. 5, 95-101 (1983).

Key words: cylinder; helical instability; hydrodynamic stability;

interfacial stability; solidification; succinonitrile.

The stability of the flow between two vertical, infinite, rigid, coaxial cylinders held at different temperatures is analyzed by linear stability theory. For a Prandtl number of 22.8 and a radius ratio of 0.02, the flow is unstable to an axisymmetric perturbation at a critical Grashof number of 2150; the wave speed of the instability is comparable to the maximum velocity of the unperturbed flow. When the rigid outer cylinder-fluid interface is replaced by a crystal-melt interface which can change shape, two new modes of instability occur at lower Grashof numbers. There is an asymmetric instability with a critical Grashof number of 180 and an axisymmetric instability with a critical Grashof number of 460; for both of these modes the wave speed of the instability is several orders of magnitude smaller than the unperturbed flow velocity.

These calculations were motivated by and are in general agreement with our recent experiments on succinonitrile. A long vertical cylindrical sample of succinonitrile was heated by an electrical current through a coaxial vertical wire so that a vertical melt annulus formed between the coaxial heater and the surrounding crystal-melt interface. Above a critical Grashof number of circa 200, a helical crystal-melt interface formed which rotated steadily about the cylinder axis; the wave speed was several orders of magnitude less than the base flow velocity.

21974. Alvarez, R. **NBS standard reference materials certified for arsenic,** *Proc. Symp. Arsenic, Arsenic Panel of Chemical Manufacturers Association and National Bureau of Standards, Gaithersburg, MD, Nov. 4-6, 1981,* pp. 112-121 (Van Nostrand Reinhold Co., Inc., 135 West 50th Street, New York, NY 10020, 1983).

Key words: arsenic; chemical analysis; chemical composition; environment; epidemiology; foods; fossil fuels; glass; materials; nutrition; quality control; standard reference materials.

The accurate determination of arsenic concentrations is difficult but necessary to establish sound scientific data bases for industrial, environmental, epidemiological, and nutritional investigations. Interlaboratory studies, in which identical samples have been analyzed, frequently show unacceptably large variations among laboratories. This is true not only when different methods are used but even when the same method is used. One method of establishing the reliability of analytical data for arsenic is through the use of chemical composition Standard Reference Materials issued by NBS. SRM's are used worldwide to calibrate instrumentation, validate experimental data, develop methods of known accuracy, and to refer experimental data to a common base. The first such materials, issued by NBS in 1906, were cast irons certified for chemical composition. Today there are approximately 1000 different SRM's. Examples of SRM's certified for arsenic in the industrial category are: four glasses (two certified for As_2O_3 and As_2O_5), cast irons, low-alloy steels, and unalloyed copper ; in the environmental category are: two coals, a coal fly ash, urban particulate matter collected from the atmosphere, sediments, plant materials, and water; and in the nutritional category are: oyster tissue, bovine liver, and rice flour. In addition, a high-purity arsenic trioxide SRM is being renewed. These SRM's have been developed as a result of demonstrated needs by individuals, industry, professional societies, trade associations, government agencies, and academia.

21975. Alber, G.; Zoller, P. **Spin polarization by selective laser-induced interference,** *Phys. Rev. A* **27,** No. 3, 1713-1716 (Mar. 1983).

Key words: autoionizing-like states; multiphoton ionization; resonant multiphoton ionization; spin polarization.

States behaving like autoionizing states can be selectively induced by laser radiation into one of the continuum spin channels in the photoionization of polarized excited alkali atoms. As a result of destructive or constructive interference between the direct ionization channel and those introduced by the dressing laser radiation, the cross section of this specific spin component is completely suppressed or enhanced, while leaving the other spin channel unaffected. The q parameter which determines the line shape of the Fano-type resonance can be resonantly tuned as a function of the dressing laser frequency.

21976. Brinckman, F. E.; Olson, G. J.; Iverson, W. P. **The production and fate of volatile molecular species in the environment: Metals and metalloids,** (Proc. Dahlem Konferenzen 1982, Berlin, May 2-8, 1982), Paper in *Atmospheric Chemistry,* E. D. Goldberg, ed., pp. 231-249 (Springer-Verlag, Berlin, Heidelberg, New York, 1982).

Key words: air-water transport; anoxic environments; atmosphere; biomethylation; chemical rates; hydrides; lifetimes; metal(loid)s; microorganisms; molecular geometry; organometal(loid)s; surface microlayer.

Forms of volatile environmental metal(loid)s cannot be predicted from thermodynamic considerations of redox conditions. In their transport to and from the atmosphere, they may be degraded, sorbed, or regenerated by both chemical and biological events at rates largely unknown, though measurable. Trapping and escape of these elements at ubiquitous aquatic surface microlayers can now be reconciled with new progress in correlating molecular geometries with air-water transport and the biogeochemistry of microenvironments.

21977. Birnbaum, G.; Vest, C. M. **Holographic nondestructive evaluation: Status and future,** *Int. Adv. Nondestruct. Test.* **9,** 257-282 (1983).

Key words: industrial application; inspection of tires; nondestructive evaluation; optical holography; real-time holography.

The results and conclusions of an extensive review of the literature and practice of holographic nondestructive evaluation are reported. Although this technique has several technically unique features, and has been shown to be a feasible nondestructive testing technique in a very large number of laboratory investigations, its commercial application is rare. A counter example is its prevalent use in testing of aircraft and heavy equipment tires. The status of the technique is reviewed, recent and potential technical advances are enumerated, and suggestions of activities which would enable full realization and evaluation of the potential of holographic NDE in the future are made.

21978. Roszman, L. J.; Weiss, A. W. **Effects of configuration interaction on dielectronic recombination of Fe(XXIV),** *J. Quant. Spectrosc. Radiat. Transfer* **30,** No. 1, 67-71 (1983).

Key words: autoionization; configuration interaction; dielectronic recombination; ionization balance; iron; plasma.

The rate of dielectronic recombination for Fe^{23+} has been computed in the non-relativistic approximation, with and without configuration interaction. All possible doubly excited states with $n=3$–6, and $l=0$–4 were included in the calculation. The rate of recombination for this manifold of states was found to be insensitive to the effects of configuration interaction, although contributions from any given LS symmetry were changed by as much as 40%.

21979. Treado, M. J. **Mobile digital equipment,** *NIJ Standard-0215.00,* 20 pages (U.S. Department of Justice, Washington, DC, May 1983).

Key words: digital device; digital equipment; equipment standard; law enforcement; mobile data transmission; mobile terminal; voice channel.

This document establishes minimum performance requirements and test methods for evaluating mobile digital equipment. It addresses characteristics such as message duration, information throughput, error sensitivity, and display readability. An FM transceiver interface is prescribed and an alphanumeric keyboard layout is suggested. Tests are prescribed at temperature, humidity, and vibration environmental extremes in addition to those conducted at ambient conditions. The principal terms and definitions needed to use the standard are included, as is a listing of the primary items of test equipment needed to perform the required measurments. The standard is intended for use by law enforcement agencies and other interested parties in the selection and procurement of digital devices used in vehicles.

21980. Wiese, W. L. **Recent developments in atomic transition probabilities,** (Proc. Trans. Int. Astronomical Union, Patras, Greece, Aug. 17-26, 1982), Paper in *Highlights of Astronomy,* **6,** 795-799 (1983).

Key words: astrophysical applications; atomic transition probabilities; data review; experiment—theory comparisons; large-scale calculations; oscillator strengths.

Recent developments in atomic transition probabilities have been reviewed and developments of special interest to astrophysical applications have been emphasized. The remarkable progress with regard to higher accuracy of the data is demonstrated by a few representative cases. Since large sets of data are often needed for modeling studies of stellar spectra, large-scale calculational work has been reviewed in some detail and the reliability of the theoretical results has been tested by various comparisons with the best laboratory data. It is seen that large random errors still occur for many transitions of low or moderate strength.

21981. Wiese, W. L. **Atomic transition probabilities and lifetimes of argon,** (Proc. XI Int. Symp. Ionized Gases, Dubrovnik, Yugoslavia, Aug. 23-27, 1982), Paper in *The Physics of Ionized Gases,* pp. 435-456 (Institute of Physics of the University, Zagreb, Yugoslavia, Dec. 1982).

Key words: atomic lifetime; atomic transition probability; critical review; emission spectroscopy assessment; neutral argon; singly ionized argon.

Numerous emission experiments and atomic lifetime measurements have been carried out on the prominent spectral lines of Ar I and Ar II. Differences between various sets of data have remained surprisingly large, often outside the mutually estimated error limits. A critical analysis is undertaken, which points to several very definite causes of the disagreements. With appropriate corrections, the data can be made significantly more consistent.

21982. Wasik, S. P.; Miller, M. M.; Tewari, Y. B.; May, W. E.; Sonnefeld, W. J.; DeVoe, H.; Zoller, W. H. **Determination of the vapor pressure, aqueous solubility, and octanol/water partition coefficient of hydrophobic substances by coupled generator column/liquid chromatographic methods,** *Residue Rev.* **85,** 29-42 (1983).

Key words: aqueous solubility; generator column; HPLC; octanol-water partition coefficient; vapor pressure.

A dynamic coupled column liquid chromatographic method for measuring the aqueous solubility, octanol-water partition coefficient and vapor pressure of hydrophobic compounds is presented. Several organic compound classes are amenable to this technique. The useful concentration range by these methods for aqueous solubility is 1.6 to 10^{-10} M, for octanol-water partition coefficient is 4 to 10^{7}, and for vapor pressures is 10 to 10^{-6} pascals. The precision and accuracy of the method are in good agreement with literature values. The measurement of these three physical properties is critically discussed.

21983. Waclawski, B. J. **A UHV gasket removal tool,** *J. Vac. Sci. Technol. A* **1,** No. 1, 99-100 (Jan.-Mar. 1983).

Key words: gasket remover; ultrahigh vacuum; vacuum techniques.

This note describes a safe, effective tool for removing copper gaskets from ultrahigh vacuum flanges. Use of the tool practically reduces to zero the chance of damaging the flange sealing surface, because all motion of the tool is away from the flange face, and force is required for gasket removal. In addition, the pliers maintain a positive grip on the gasket, keeping it from dropping onto delicate parts of any apparatus attached to the flange.

21984. Sanchez, I. C. **Liquids: Surface tension, compressibility, and invariants,** *J. Chem. Phys.* **79,** No. 1, 405-415 (July 1, 1983).

Key words: correlation length; critical exponents; direct correlation function; invariants; isothermal compressibility; Lennard-Jones potential; noble elements; organics; polymer liquids; square gradient theory; surface tension.

A new equation has been derived which relates the surface tension (σ) to a liquid's isothermal compressibility (κ) and mass density (ρ). The derivation is based on a generalized square-gradient approximation for the free energy density of a nonuniform fluid. The equation is $\sigma(\kappa/\rho)^{1/2}=A_0^{1/2}=$constant in the normal liquid range. Except for water, A_0 is temperature independent for a variety of inorganic, organic, and polymer liquids. Among 50 nonpolar and polar organic liquids, including hydrogen bonding liquids, $A_0^{1/2}$ appears to be an invariant with a value of $2.78\pm0.13\times10^{-4}$(erg cm^2/g)$^{1/2}$. Among the diatomic elements (except hydrogen), $A_0^{1/2}$ is an invariant with a value of 1.8×10^{-4}. Among the heavy noble elements, $A_0^{1/2}$ is an invariant with a value of 1.36×10^{-4}. For the quantum noble elements helium and neon, $A_0^{1/2}=1.0\times10^{-4}$. The constant A_0 is shown to be proportional to a second moment of a direct correlation function. A semiempirical formula has been derived for A_0 relating it to the parameters ϵ_0 and σ_0 that characterize the pair interaction potential. For a Lennard-Jones 6-12 potential, it is shown that $A_0^{1/2}=0.26(\epsilon_0\sigma_0^2/M)^{1/2}$, where M is molecular weight. This result combined with the experimental evaluations of A_0 implies that the parameter combination $(\epsilon_0\sigma_0^2/M)$ is an invariant for certain classes of molecules. It appears that this surprising observation has never been made before; its physical implications remain unclear.

21985. Reader, J. **$5s^25p^4$–$5s5p^5$ transitions in Cs IV, Ba V, and La VI,** *J. Opt. Soc. Am.* **73,** No. 3, 349-352 (Mar. 1983).

Key words: barium; cesium; energy levels; ions; lanthanum; sliding spark; spectrum; vacuum ultraviolet.

The $5s^25p^4$–$5s5p^5$ transitions of Cs IV, Ba V, and La VI were observed with a sliding spark discharge and a 10.7-m normal-incidence spectrograph. The region of observation was 539–1282 Å. The energy parameters derived from least-squares fits to the experimental levels are compared with Hartree-Fock (HF) calculations. The fitted/HF ratios for the $5s^25p^4$ configurations of the ions Te I-La VI are compared with the fitted/HF ratios for the $4s^24p^4$ configurations of the ions Se I-Mo IX.

21986. Pierce, D. T.; Celotta, R. J. **New insights from electron spin polarization studies of surfaces,** *J. Vac. Sci. Technol. A* **1,** No. 2, 1119-1124 (Apr.-June 1983).

Key words: electron spin polarization; photoemission; polarized electron scattering; surface magnetism.

Examples of recent investigations in several laboratories, where measurement of effects due to electron spin polarization provided new insight into surface phenomena, will be reviewed. The results to be discussed include the use of spin dependent electron scattering to determine the surface potential barrier, the magnetic critical behavior of a semi-infinite solid, and the low temperature surface magnetization. Examples from spin-polarized photoemission include studies of the nature of the resonant 6 eV satellite in Ni and of oxygen-induced magnetism in a Cr(100) surface. The use of angle-resolved spin-polarized inverse photoelectron spectroscopy to obtain information on spin dependent band structure of unoccupied states will also be described. The rapid growth of measurements involving electron spin polarization, where previously only electron energy or momentum was measured, is explained by the development of new experimental techniques like the GaAs spin-polarized electron source and advances in spin polarization detectors.

21987. Rhyne, J. J.; Koon, N. C. **Spin dynamics of $HoAl_2$,** *J. Magn. Magn. Mater.* **31-34,** 608-610 (1983).

Key words: crystal fields; Laves-phase compounds; magnetism; neutron scattering; rare earth compounds; spin waves.

Inelastic neutron scattering has been used to examine the spin excitations at 4 K in a single crystal of the cubic Laves-phase compound $HoAl_2$ along $[q,q,0]$, $[q,0,0]$, $[q,q,q]$ propagation directions. Three pair of acoustic and optic modes are observed in Brillouin zones centered at (220) and (002). Crystal field and exchange parameters consistent with those found for other RAl_2 compounds were determined by an RPA pseudo-boson analysis.

21988. Wiederhorn, S. M.; Hockey, B. J. **Effect of material parameters on the erosion resistance of brittle materials,** *J. Mater. Sci.* **18,** 766-780 (1983).

Key words: erosion data; linear regression; materials; plastic deformation.

Erosion data are compared with two theories that have been suggested to explain the erosive behaviour of solids. A dimensional analysis is applied to the variables that are important to erosion, and a multivariate, linear regression analysis is used to fit the data to the dimensional analysis. The results of the linear regression analyses are compared with the two theories in order to evaluate the applicability of these theories to erosion. Although semi-quantitative agreement of the data with the theories is obtained, some discrepancies are apparent. In particular, the dependence of erosion rate on hardness and critical stress intensity factor is greater than predicted by either of the two theories. These discrepancies are attributed primarily to microstructural aspects of erosion that are not modelled by either of the theories.

21989. Dizdaroglu, M.; Simic, M. G.; Rioux, F.; St-Pierre, S. **Separation of diastereomers and analogues of neurotensin by anion-exchange high-performance liquid chromatography,** *J. Chromatogr.* **245,** 158-162 (1982).

Key words: anion-exchange chromatography; biological activity; diasteromer; neurotensin; peptide hormone.

Diastereomers and analogues of neurotensin were separated by anion-exchange high-performance liquid chromatography using a triethylammonium acetate buffer and acetonitrile as the eluent. Recoveries were over 90% as determined by comparative amino acid analysis. A strong effect of temperature on retention was observed. The buffer used is volatile and thus facilitates an easy isolation of separated peptides for further use.

21990. Tsai, D. H.; Trevino, S. F. **Molecular dynamical studies of the dissociation of a diatomic molecular crystal. I. Energy exchange in rapid exothermic reactions,** *J. Chem. Phys.* **79,** No. 4, 1684-1697 (Aug. 15, 1983).

Key words: activation energy; caging; chemical dynamics; diatomic crystal; energy exchange; equilibrium; exothermic reaction; hot spots; mechanisms of dissociation; model study; molecular dynamics; reaction rates.

We discuss the results of a study of the exothermic dissociation of a model diatomic molecular crystal. Our main purpose is to investigate the dynamics of energy transport and energy sharing in this system during the dissociation process. The crystal was prepared in a metastable molecular form, in thermal equilibrium at a low initial temperature and pressure. When we heated the system to a higher temperature, at constant volume, we observed thermally initiated dissociations which progressed rapidly to completion. During the dissociation process, we found that the sharing of the potential energy released by the metastable molecules with the rest of the system, and the sharing of the kinetic energy of the dissociated fragments with the kinetic energy of the molecules in the translational degrees of freedom, were rather efficient. But the intra- and intermolecular exchange of the kinetic energy among the various degrees of freedom, viz., translation-rotation, translation-vibration, and rotation-vibration was inefficient. Dissociation would occur in one of the regions of high local kinetic energy density, after a molecule in that region has acquired sufficient vibrational energy to break apart, and when the "caging" effect was favorable to allow the molecule to dissociate. From such a reaction site, and there may be others, the reaction would spread to a neighboring site, and continue this way until all the molecules became dissociated. The induction time showed an approximately logarithmic dependence on the inverse of the temperature of the system after heating. But during the process of rapid dissociation, both the potential energy and the kinetic energy of the system underwent rapid changes, and thermal equilibrium was not reached *until the end of the process.*

21991. Martin, W. C.; Sansonetti, C. J. **Improved measurement of the ^{4}He I 3^1D–3^3D separation: Confirmation of predicted mass-polarization isotopic shift.** *Phys. Rev. A* **28,** No. 1, 500-504 (1983).

Key words: atomic energy levels; atomic spectra; atomic theory; helium; isotope shifts; spectral series.

From new measurements of the ^{4}He $1s2p$–$1s3d$ lines, we have determined the 3^1D_2–3^3D_2 separation to be 102 459(15) MHz. The corresponding nonrelativistic $1s3d$ singlet-triplet separation is 102 196(15) MHz, as compared with the value 102 116(5) MHz previously determined for the equivalent ^{3}He separation. The difference of 80(16) MHz agrees with the predicted isotopic difference of these separations, the main contribution being a mass-polarization difference of 79 MHz as recently calculated by Drake. The experimental difference for $1s3d$ is consistent with the rough trend of such isotopic differences of 1 *snd* singlet-triplet separations determined in previous experiments. We infer that mass-polarization shifts probably contribute significantly to the previously observed differences, at least up to $n \simeq 8$.

21992. Linsky, J. L. **The quiescent chromospheres and transition regions of active dwarf stars: What are we learning from recent observations and models?,** *Proc. IAU Colloq. #71, Activity in Red Dwarf Stars, Catania, Sicily, Aug. 10-13, 1982,* P. B. Byrne and M. Rodono, eds., pp. 39-60 (Reidel Publ. Co., 1983).

Key words: chromospheric activity; late-type dwarfs; transition regions.

I will review the rapid progress in our understanding of active dwarf stars, which has been stimulated by recent *IUE, Einstein,* and ground-based observations, by asking a series of questions. The most fundamental question is the extent to which magnetic fields control nonflare phenomena in these stars. There are a number of aspects to this question: (1) What is the evidence for large scale magnetic structures similar to solar plages in these stars and how does a plage system differ from a quiescent spectrum? (2) Can the enhanced heating in these stars be explained by solar-like magnetic flux tubes? (3) What roles do systematic flows play in active dwarf atmospheres? (4) What is the relation between heating rates in different layers of these stars? (5) By what mechanisms are active dwarf chromospheres and transition regions heated? (6) What are semiempirical models telling us about active dwarf stars? Recent observations are permitting us to begin to answer these questions.

21993. Mann, W. B. **An international reference material for radiocarbon dating,** *Radiocarbon* **25,** No. 2, 519-527 (1983).

Key words: carbon-14 international standard for dating; contemporary carbon-14 dating standard reference material; international radiocarbon-dating standard.

In August 1980, the National Bureau of Standards (NBS) issued, in the form of oxalic acid, a new International Reference Material of contemporary ^{14}C for use in radiocarbon dating laboratories. This reference material was to replace the 1975 oxalic-acid standard, supplies of which had been practically exhausted in 1978. The preparation of the new oxalic-acid standard was described in a preliminary report, as were, also, the results then available for the activity-concentration ratio of the new to the old standard obtained by a number of leading international laboratories.

With the recent completion of the analysis of all results submitted by the participating laboratories, NBS plans to issue these recently calibrated samples of oxalic acid as an NBS Standard Reference Material. There is, however, no significant difference in the reported value of its activity concentration, relative to that of the 1957 standard, from that given provisionally in 1980.

Subsequent to our report (Cavallo and Mann, 1980) a further measurement of relative activity concentration was reported by the Radiocarbon Laboratory of Peking University. Their value, and that also for δ^{13}C, is insignificantly different from the average value of the results submitted by the eleven laboratories that participated in the international comparison organized by NBS.

21994. Tighe, N. J.; Wiederhorn, S. M. **Effects of oxidation on the reliability of silicon nitride,** Paper in *Fracture Mechanics of Ceramics,* R. C. Bradt, A. G. Evans, D. P. H. Hasselman, and F. F. Lange, eds., **5,** 403-423 (Plenum Publ. Corp., New York, 1983).

Key words: creep; flaws; fracture; high temperature deformation; lifetime prediction; reliability; silicon nitride; static load; strength degradation map; strength distribution.

Oxidation at 1200°C affects the strength and reliability of hot-pressed, magnesia-doped silicon nitride by modifying the flaw population. Static load data, and microstructural examination are used to identify the new flaw populations and to describe the failure mechanisms. The analysis is displayed graphically by means of a strength degradation map which delineates specific regions for the failures due to pit formation, crack growth, cavitation, and creep rupture.

21995. Kearsley, E. A. **A basis for predicting longtime behavior from short-time tests of geothermal sealants,** *J. Test. Eval.* **11,** No. 4, 299-303 (July 1983).

Key words: aging tests (materials); degradation; elastomers; geothermal; hydrolysis; permanent set; rubber; sealers; stress relaxation.

The failure of sealants aging in geothermal downwell atmospheres is usually a result of the cumulative effects of both the forming of cross-links and their destruction in the rubbery sealant materials. Methods are discussed to distinguish between these mechanisms using measurement of stress relaxation and permanent set. Some data on oxidative aging of natural rubber are recalled as a paradigm of chemically degrading elastomers and some simple scaling laws are described which (when they can be established) are useful for predicting longtime behavior from short-time tests.

21996. Rush, J. J.; Cavanagh, R. R.; Kelley, R. D. **Summary abstract: Neutron scattering from adsorbates on platinum black,** *J. Vac. Sci. Technol. A* **1,** No. 2, 1245-1246 (June 1983).

Key words: adsorbate; catalysis; catalyst; neutron scattering; platinum; surface.

Neutron spectra have been measured for hydrogen, acetylene, and ethylene on a platinum black catalyst. Measurements are compared in some detail with electron scattering results.

21997. Symonds, B. L.; Cook, R. F.; Lawn, B. R. **Dynamic fatigue of brittle materials containing indentation line flaws,** *J. Mater. Sci.* **18,** 1306-1314 (1983).

Key words: brittle; contact damage; crack velocity; fatigue; flaws; residual stress; strength.

A study is made of the dynamic fatigue response of brittle materials containing indentation-induced line flaws. The theoretical fracture mechanics of "median" crack evolution to failure under applied tension are first developed, with special emphasis on the role of residual contact stresses. In particular, it is shown that use of fatigue curves to evaluate the exponent in an assumed power-law crack velocity function may result in systematic error, by as much as a factor of two, if proper account is not taken of this residual contact contribution. Data from strength tests on soda-lime glass bars in water, using a tungsten carbide cutting wheel to introduce the median pre-cracks, confirm the basic predictions. The results suggest that extreme care needs to be exercised when using surface with a contact history, e.g., as with machining damage, in fatigue test programmes for materials analysis.

21998. O'Connell, J. S.; Hayward, E.; Lightbody, J. W., Jr.; Maruyama, X. K.; Bosted, P.; Blomqvist, K. I.; Franklin, G.; Adler, J. O.; Hansen, K.; Schroder, B. **Total nuclear inelastic electron scattering cross sections compared to sum rule calculations,** *Phys. Rev. C* **27,** No. 6, 2492-2499 (June 1983).

Key words: Coulomb sum rule; electron scattering; excitation energy integral; Fermi gas; gamma sum; harmonic oscillator; inelastic cross section; nuclear response.

The nuclear response to 200–350 MeV electrons inelastically scattered at 20° for six nuclei ranging from $A=9$ to 181 is given. An excitation energy integral is formed and compared with three theoretical calculations of the total inelastic scattering cross section.

21999. Watson, R. E.; Bennett, L. H. **Structural maps and parameters important to alloy phase stability,** *Proc. Mater. Res. Soc. Symp., Boston, MA, Oct. 31-Nov. 4, 1982,* **19,** 99-104 (Elsevier Science Publ. Co., New York, NY, 1983).

Key words: alloys; d-band hole count; electronegativity; intermediate compound phases; phase stability; structural maps; transition.

Alloy properties are often summarized on two-dimensional maps. For instance, Darken and Gurry related the terminal solubilities of alloy systems to two coordinates (the differences in electronegativities and in atomic radii of the alloy constituents). Maps are considered here which correlate the structures in which the compounds form as well as providing some indication of whether a compound forms at some given composition in the first place. This class of map involves one coordinate which is the difference in an atomic parameter (here it will be taken to be the electronegativity) while the other is an average (in this case the d band hole count). This contrasts with Darken Gurry maps and Giessen's maps related to glass-forming ability (elsewhere in this volume) where both coordinates are differences. The situation for 50/50 transition metal alloys is reviewed and results are presented for systems off 50/50 composition.

22000. Goodman, D. A.; Bennett, L. H.; Watson, R. E. **Relative solubility trends in transition-metal alloys,** *Proc. Mater. Res. Soc. Symp., Boston, MA, Oct. 31-Nov. 4, 1982,* **19,** 43-52 (Elsevier Science Publ. Co., New York, NY, 1983).

Key words: alloy phase diagrams; alloy solubility; d-band theory; Engel-Brewer theory; relative valency rule; transition metals.

The prediction of terminal solubilities for a given metal solute and solvent is a formidable problem, and it remains a major unsolved question in metallurgy. In this paper we describe the relative solubilities of the transition metals in one another. After discussing the problem of defining an appropriate measure of solubility for the transition-metal alloys which have any intermediate phases, we present a map of relative solubilities for the transition metals. From this map, we delineate the trend which occurs. Both the Engel-Brewer theory and d-band transition-metal alloy theory are consistent with this trend.

22001. Chantikul, P.; Lawn, B. R.; Richter, H.; Freiman, S. W. **Relation between multiregion crack growth and dynamic fatigue of glass using indentation flaws,** *J. Am. Ceram. Soc.* **66,** No. 7, 515-518 (July 1983).

Key words: controlled flaws; fatigue; fracture; glass; strength; transport-control.

The influence of transport-limited kinetic crack growth on the fatigue properties of soda-lime glass was examined. Dynamic fatigue data were taken on specimens with controlled indentation flaws and were compared with the predicted response from measured crack velocity characteristics. Heptane was used as the operational test environment because of its pronounced crack velocity plateau; control tests in water served to establish a baseline reference for comparing the results. Fractographic observations using a stress wave marker technique showed a complex growth history for flaws broken in heptane compared to that for flaws broken in water. The magnitude of the predicted region II influence is too small to be detected in the dynamic fatigue results, even allowing for the relatively high degree of data reproducibility. The implications of this conclusion for lifetime predictions are discussed.

22002. Celotta, R. J.; Pierce, D. T. **Electron spin polarization measurements in atomic and surface physics,** (Proc. XI Int. Symp. Ionized Gases, Dubrovnik, Yugoslavia, Aug. 23-27, 1982), Paper in *Physics of Ionized Gases,* pp. 3-20 (Institute of Physics of the University, Zagreb, Yugoslavia, Dec. 1982).

Key words: electron spin polarization; polarized electron scattering; polarized electron sources; spin polarization detectors; surface magnetism.

Within a few years after Goudsmit and Uhlenbeck introduced the concept of electron spin to explain spectroscopic data in 1925, physicists were studying how spin polarization effects would arise in electron scattering experiments. J. R. Oppenheimer wrote to say that the possibility of exchange must be included in any calculation of electron-hydrogen scattering and Davison and Germer concluded, after an unsuccessful experiment, that it was not possible to polarize electrons by reflection in a way analogous to the way reflection polarizes light. Why then, fifty years later, are similar questions still the subject of great scientific interest? The answer is not that polarization effects in electron scattering are negligible or uninteresting, but rather that they have proven to be intractable experimentally because the production or detection of electron polarization has traditionally been inefficient and cumbersome. Recent technological developments have changed all that, however, and a new, and more promising, era of studies of electron spin polarization has begun.

22003. Uribe, R. M.; Pina, M. C.; McLaughlin, W. L. **ESR studies of polymer films containing leucodyes irradiated with ^{60}Co gamma rays,** *Proc. 3d Int. Symp. Nuclear Chemistry, University of Mexico, Mexico City, Dec. 8-10, 1980,* pp. 202-211 (Center of Nuclear Studies, University of Mexico, Mexico, D. F., Dec. 1982).

Key words: dosimetry; electron spin resonance; free radicals; gamma radiation; leucodyes; nylon; plastic films; polymer films; polyvinyl butyral; radiochromic dyes; triphenyl methane dyes.

When plastic films containing leucocyanide of triphenylmethane dyes are irradiated with large doses of ^{60}Co gamma rays, free radicals are formed that are sufficiently stable for analysis at room temperature. Preliminary studies about the effect of Co-60 gamma rays on the ESR signal of radiochromic dye films are discussed, in order to investigate practicality of this technique in dosimetry. Dose-response curves along with fading effects on irradiated films with leucodyes are presented. It is shown that by sorting out the broad Electron Spin Resonance spectrum component due to free-radical production in the polymeric host materials and the dye precursor itself, it is possible to assign differences in amplitudes and double integrated spectra to the number of spins associated with a free radical produced in the substituted triphenyl methyl radical and also in the plastic material as a whole. Methods of preparing plastic films containing triphenyl methane leucocyanides are described. Not only can dosimetry be achieved at higher doses than are normally used with spectrophotometry of these films, but also information about the radiation chemistry of dye formation can be derived.

22004. Kaufman, V.; Sugar, J.; Tech, J. L. **Analysis of the $4d^9$–$4d^8 5p$ transitions in nine-times ionized xenon** (Xe X), *J. Opt. Soc. Am.* **73,** 691-693 (1983).

Key words: energy levels; parameters; rhodium sequence; vacuum ultraviolet; wavelengths; xenon.

The $4d^9$–$4d^8 5p$ transition array of nine-times ionized xenon at 130–160 Å was photographically observed with the National Bureau of Standards 10.7-m grazing-incidence vacuum spectrograph. The spectral source was a high-voltage spark between carbon electrodes triggered by insertion of a small quantity of xenon. Forty-seven lines were classified as transitions from 34 levels of the $4d^8 5p$ configuration to the two levels of the $4d^9\ ^2D$ ground term. An excellent correlation was found between the observed and calculated relative intensities. Least-squares-fitted parameter values and their ratios to the Hartree-Fock values are given.

22005. Lightbody, J. W., Jr.; Bellicard, J. B.; Cavedon, J. M.; Frois, B.; Goutte, D.; Huet, M.; Leconte, P.; Nakada, A.; Ho, P. X.; Platchkov, S. K.; Turck-Chieze, S.; de Jager, C. W.; Lapikás, J. J.; de Witt Huberts, P. K. A. **Elastic and inelastic electron scattering from ^{50,52,54}Cr,** *Phys. Rev. C* **27,** No. 1, 113-132 (Jan. 1983).

Key words: charge distribution; configuration mixing; elastic; electron scattering; Fourier-Bessel expansion; inelastic.

Elastic and inelastic electron scattering cross sections are given for ^{50,52,54}Cr at momentum transfers between 0.15 and 2.6 fm^{-1}. Ground state charge distributions are derived from a combined analysis of these data and muonic atom data. Deduced values of the rms charge radii are given. Comparison is made between the experimental charge distributions and density dependent Hartree-Fock-Bogolyubov calculations. Inelastic scattering form factors for 2^+, 4^+, and 6^+ states up to 4 MeV excitation are given along with shell model and phenomenological model fits to those data, $B(EL)$ values, multipole dependence of effective charges, and other model parameters.

22006. Shechtman, D.; Swartzendruber, L. J. **Metastable phases in rapidly solidified aluminum-rich Al-Fe alloys,** *Proc. Mater. Res. Soc. Symp., Boston, MA, Oct. 31-Nov. 4, 1982,* pp. 265-268 (Elsevier Science Publ. Co., New York, NY, 1983).

Key words: alloy; aluminum; gamma ray; iron; microscopy; rapid solidification; resonance.

Aluminum-rich Al-Fe binary alloys up to and including Al_3Fe were prepared by melt spinning in order to study the metastable phase structure and its transformation following heat treatment. Transmission electron microscopy and nuclear gamma-ray resonance were utilized in the study. The rapidly solidified structure was found to contain up to three metastable phases. One of the phases, with a composition and a gamma-ray resonance spectrum appropriate for Al_6Fe, has either a globular or a cellular morphology upon quenching.

22007. Linsky, J. L. **The role of magnetic fields in stellar chromospheres and transition regions,** *Proc. IAU Symp. #102, Solar and Stellar Magnetic Fields: Origins and Coronal Effects, Aug. 2-6, 1982,* J. O. Stenflo, ed., pp. 313-338 (Reidel, Dordrecht, 1983).

Key words: chromospheres; coronae; late-type stars; magnetic fields; transition regions.

In this review based largely on observations with the *IUE* and *Einstein* satellites, I will summarize the different roles that magnetic fields play in controlling the structure and energy balance in the chromospheres and transition regions of late-type stars. Solar observations clearly show that magnetic flux tubes are the dominant structural element in the solar atmosphere, but the rotational modulation of plages (structures that are bright in ultraviolet emission lines) that overlie dark starspots provide strong evidence that magnetic flux tubes are the dominant structural elements in late-type stellar atmospheres as well. The wide range of radiative loss rates (and thus heating rates) observed in chromospheric and transition region emission lines also provides evidence for the importance of magnetic fields, but it is not yet clear whether the most active stars can be understood in terms of a large fractional coverage by solar-like magnetic flux tubes or whether brighter flux tubes are needed. I propose that the existence of a boundary between solar-like stars and those with little or no hot plasma, as well as the different types of G-K giants and supergiants, can be understood in terms of the fractional surface coverage by closed magnetic structures. Transition region downflows, the chromospheric heating mechanism, and the relative heating rates at different layers can be simply explained by the control of the energy balance by magnetic fields. Finally, I will intercompare models computed for active and quiet regions on the Sun with similar models computed for active and quiet stars, that is stars with intrinsically bright or weak emission lines.

22008. Olver, F. W. J.; Wilkinson, J. H. **A *posteriori* error bounds for Gaussian elimination,** *IMA J. Numer. Anal.* **2,** 377-406 (1982).

Key words: backward error analysis; floating-point arithmetic; forward error analysis; interval analysis; iterative refinement; linear algebraic equations; matrix computations; residuals.

Explicit bounds are constructed for the error in the solution of a system of linear algebraic equations obtained by Gaussian elimination using floating-point arithmetic. The bounds take account of inherent errors in the data and all abbreviations (choppings or roundings) introduced during the process of solution. The bounds are strict and agree with the estimate for the maximum error obtained by linearized perturbation theory. The formulation of the bounds avoids the need for specially directed rounding procedures in the hardware or software; in consequence the bounds can be evaluated on most existing computers. The cost of computing the bounds is comparable with the cost of computing the original solution.

22009. Seltzer, S. M.; Berger, M. J. **Procedure for calculating the radiation stopping power for electrons,** *Int. J. Appl. Radiat. Isot.* **33,** 1219-1226 (1982).

Key words: approximation formula; electron-electron bremsstrahlung; electron-nucleon bremsstrahlung; electrons; radiation stopping powers; screening corrections.

A procedure is described for calculating the radiation stopping power for electrons, i.e., the mean energy loss per unit path length due to the emission of bremsstrahlung photons. For bremsstrahlung in the field of the atomic nucleus, the cross sections used are those of Pratt and collaborators at low and intermediate energies, and those of Davies, Bethe, Maximon and Olsen at high energies. For bremsstrahlung in the field of the atomic electrons, the cross section of Haug is used. The radiation stopping powers in the energy region from 1 kev to 10 GeV have been fitted by a 9-parameter approximation formula. These parameters depend on the atomic number Z, and are given for all Z from 1 to 100.

22010. Seltzer, S. M.; Berger, M. J. **Evaluation of the collision stopping power of elements and compounds for electrons and positrons,** *Int. J. Appl. Radiat. Isot.* **33,** 1189-1218 (1983).

Key words: Bragg additivity; density effect; electrons; mean excitation energy; positrons; stopping power.

This paper gives tables of material properties needed for the evaluation of the collision stopping power for electrons and positrons according to the Bethe theory. The key quantity is the mean excitation energy of the medium, which has been derived for many materials by a critical analysis of experimental data. Also given are the density-effect parameters of the theory of Sternheimer and Peierls. The material properties are given for the elements and for 180 compounds and mixtures, and the rules are described by which they could be obtained for other materials. Tables are also given of auxiliary quantities which depend only on the kinetic energy of the incident electron. These, together with the main tables, make possible the quick-and-easy evaluation of the collision stopping power.

22011. Dodge, W. R.; Leicht, R. G.; Hayward, E.; Wolynec, E. **Electrodisintegration of ^{56}Fe, ^{59}Co, and ^{64}Zn,** *Phys. Rev. C* **24,** No. 5, 1952-1960 (Nov. 1981).

Key words: electric quadrupole; electrodisintegration; giant resonance; virtual photons.

The (e,p) and (e,α) cross sections for ^{56}Fe, ^{59}Co, and ^{64}Zn have been measured in the electron energy range 16–100 MeV. They have been analyzed using the distorted-wave Born approximation $E1$ and $E2$ virtual photon spectra. The $E1$ and $E2$ components in the proton and α channels have been obtained.

22012. Dodge, W. R.; Hayward, E.; Wolynec, E. **Experimental test of virtual photon theory,** *Phys. Rev. C* **28,** No. 1, 150-158 (July 1983).

Key words: analogue state; electric dipole; electrodisintegration; isochromat; size effects; virtual photons.

An isochromat of the $E1$ virtual photon spectrum has been measured by counting the number of ground-state protons emitted by the 16.28 MeV isobaric analog state in ^{90}Zr as a function of incident electron energy in the range 17–105 MeV. The experimental results reproduce well the distorted wave Born approximation spectra for a point Zr nucleus for electron energies up to 30 MeV. A radiator was used for electron energies of 60–100 MeV to measure the photodisintegration plus electrodisintegration cross section. These results showed that the Davies-Bethe-Maximon bremsstrahlung cross section magnitude yields the same result as the electrodisintegration results below 30 MeV where size corrections for the finite extent of the nucleus are minimal. As E_0 increases to 105 MeV the need for such corrections becomes manifest. Several such corrections are discussed. As by-products of this study the quantity $\Gamma_\gamma\Gamma_{p0}/\Gamma$ was determined to be 63.8 ± 1.9 eV or 66.1 ± 2.0 eV depending on the virtual photon spectrum used in analysis. The Γ_{p2}/Γ_{p0} ratio was also determined to be 0.58 ± 0.02. Combining these results yields for Γ_γ 100.8 ± 5.0 eV or 104.4 ± 5.2 eV.

22013. Bowers, P. F.; deJong, T. **VLA positions of OH/IR stars,** *Astron. J.* **88,** No. 5, 655-657 (May 1983).

Key words: OH maser emission; star positions; type II OH/IR stars; very large array.

Absolute positions of the 1612-MHz OH maser emission from 26 Type II OH/IR stars have been determined with the Very Large Array to an estimated positional accuracy of ±4 arcsec. Combined with earlier work, our results provide radio positions with errors <15 arcsec for all known OH/IR stars between galactic longitudes of 10° and 27°.5 with flux densities larger than 1.7 Jy.

22014. Bowman, C. D.; Johnson, R. G. **Measurements of inelastic scattering of eV neutrons,** *Proc. IPNS Symp. Neutron Scattering, Argonne National Laboratory, Argonne, IL, Aug. 12-14, 1981,* pp. 84-86 (American Institute of Physics, 335 East 45th Street, New York, NY 10017, 1982).

Key words: eV neutrons; inelastic scattering; molecular vibration; momentum transfer; neutron detection; time-of-flight.

A technique has been demonstrated for studying the inelastic scattering of eV neutrons using a pulsed white source. Measurements have been completed on benzene for incident energies in the range 1.5 to 15 eV and for q values from 13 to 120 $A^{\circ-1}$. Details of the method and possibilities for improvement and extension are presented.

22015. Costrell, L.; Dawson, W. K. **FASTBUS modular high speed data acquisition system,** *Proc. IEEE Int. Conf. Communications, ICC'82, Philadelphia, PA, June 13-17, 1982,* pp. 5C.4.1–5C.4.5 (Institute of Electrical and Electronics Engineers, 345 East 45th Street, New York, NY 10017, 1982).

Key words: control system; data acquisition system; FASTBUS; high energy physics; modular system; standard system.

FASTBUS is a flexible modular data bus system for data acquisition, data processing, and equipment control. It consists of multiple bus segments which operate independently but which can automatically and transparently link together for inter-segment communication. A bus segment may be implemented as a cable, connecting devices or as a crate backplane which can accommodate up to 25 devices. The multiplexed data and address fields are 32 bits wide. FASTBUS can operate asynchronously using a handshake protocol to reliably accommodate different speed devices without prior knowledge of their speed capabilities. It can also operate synchronously without handshake for transfer of blocks of data at maximum speed. System speed is limited solely by propagation and logic delays. For intracrate operations data transfer rates of better than 10 MHz have been obtained with ECL implementation.

FASTBUS originated in the high energy physics community but, because of its many attractive features, will find application in numerous other areas. The specification is to be produced initially as a Department of Energy document and then, with some editorial revision and possibly other minor adjustments, will be issued as IEEE Standard 960.

22016. Faller, J. E.; Zumberge, M. A.; Rinker, R. L. **The JILA absolute gravimeter,** *Proc. Ninth Int. Conf. Earth Tides, New York, NY, Aug. 17-22, 1981,* pp. 465-474 (E. Schweizerbart'sche Verlagsbuchhandlung, D-7000 Stuttgart, 1983).

Key words: absolute gravimeter; earth tides; gravity.

We have developed a new absolute gravimeter based on high speed laser interferometry which measures the acceleration of a freely falling retroreflector using sub-nanosecond timing electronics. A Rubidium frequency standard is used as the reference of time while an iodine-stabilized laser is used as the reference of length. The instrument is designed to measure g with an absolute accuracy of a few parts in 10^9 in a time measurement one half or less. The status of the instrument and results obtained with it will be discussed.

22017. Antonucci, J. M.; Toth, E. E. **Extent of polymerization of dental resins by differential scanning calorimetry,** *J. Dent. Res.* **62,** No. 2, 121-125 (Feb. 1983).

Key words: conversion; dental resins; differential scanning calorimetry; enthalpy of polymerization; free radical; polymerization; residual unsaturation.

The traditional infrared spectroscopic methods for assessing the degree of polymerization of dental monomers are often hampered by the difficulties of sample preparation and, in the case of composites, by interference from the filler component. These difficulties may be circumvented by the use of another technique, differential scanning calorimetry (DSC). In this preliminary investigation, DSC was used to ascertain the degree of vinyl polymerization of an experimental monomer system consisting of seven parts BIS-GMA and three parts TEGDMA (triethylene glycol dimethacrylate). Thermally-activated polymerizations of this monomer system were studied using benzoyl peroxide (BP) as the initiator. Both the heating rate and the concentration of BP affected the percent of reacted vinyl groups. For a BP concentration of 0.39% and heating rates of 10°/min and 2.5°/min, conversions were 73 and 38%, respectively. Chemically-activated polymerizations using BP and fast-acting amine accelerators (e.g., p-*t*-butyl-N,N-dimethylaniline) gave approximately the same results (e.g., 50% conversion) as those obtained with slower-acting promoters (e.g., ascorbyl palmitate). Experimental difficulties are encountered in observing an exotherm with the very reactive accelerators unless the other parameters (e.g., BP or inhibitor content)

involved in the reaction are adjusted accordingly. As a method for evaluating the performance of various dental monomers, initiator systems, and inhibitors, DSC has great potential utility.

22018. Clausen, K.; Rhyne, J. J.; Lebech, B.; Koon, N. C. **Temperature dependence of the spin waves in $ErFe_2$,** *J. Phys. C: Solid State Phys.* **15,** 3587-3596 (1982).

Key words: anisotropy; exchange; magnetism; magnons; neutron scattering; rare-earth compounds; spin waves.

The temperature renormalisation of the energies of the optic modes in $ErFe_2$ has been determined from room temperature up to close to the Curie temperature (547 K). It is found that the two modes, a dispersive transition-metal mode and a localised crystal-field-dominated mode, cross over at about 420 K. The experimental results have been interpreted and are well accounted for by a linear spin wave model, where the level scheme of the lowest J multiplet of the Er^{3+} site has been assumed to consist of pure J_z states with an equidistant energy spacing between the levels.

22019. Yoshida, S.; Phelps, A. V.; Pitchford, L. C. **Effect of electrons produced by ionization on calculated electron-energy distribution,** *Phys. Rev. A* **27,** No. 6, 2858-2867 (1983).

Key words: calculation; electrons; energy distribution; ionization; nitrogen.

The effects of the form of the distribution in energy of the electrons produced by ionization on electron-energy distributions and transport coefficients are investigated theoretically at high values of the ratio of the electric field to gas density, E/n. The calculations are carried out for N_2 at E/n from 100×10^{-21} to 3000×10^{-21} Vm^2 using previously determined electron-collision cross sections and secondary-electron energy distributions. As the energy of the secondary electrons and the energy lost by the higher-energy, scattered electrons is increased, the relative numbers of electrons at very low energies and at high energies in the calculated steady-state distributions decreases. These changes are accompanied by decreases in the calculated ionization coefficients, drift velocities, and mean energies and by an increase in the characteristic energy. A simplified secondary-electron energy distribution is proposed which gives distribution functions and transport coefficients in satisfactory agreement with those obtained using the published experimental distributions.

22020. Quintiere, J.; Harkleroad, M.; Walton, D. **Measurement of material flame spread properties,** *Combust. Sci. Technol.* **32,** No. 1-4, 67-89 (1983).

Key words: Douglas fir particle board; flame spread properties; ignition; performance of material in fires.

A concept was examined for measuring flame spread parameters suitable for predicting the performance of a material in fires. The study examines a radiant panel test apparatus used to measure downward and lateral flame spread, and ignition. An analysis of data from tests of Douglas fir particle board is presented. A procedure has been identified for measuring specific parameters useful in the general prediction of ignition and flame spread for complex materials.

22021. Greenberg, R. R.; Kingston, H. M. **Trace element analysis of natural water samples by neutron activation analysis with chelating resin,** *Anal. Chem.* **55,** No. 7, 1160-1165 (June 1983).

Key words: Chelex-100; chromatography; fresh water; natural water; neutron activation analysis; salt water; seawater; trace element analysis.

Procedures are described to preconcentrate the trace elements in 100, 200, or 500 mL of natural water into a solid sample of approximately half a gram by using a chelating resin. These procedures are applicable to both freshwater and seawater and leave the transition metals and other elements of interest essentially free from the alkali metals, the alkaline earth metals, and the halogens. The concentrations of 15 elements in one seawater sample have been determined by using this separation procedure coupled with the neutron activation analysis technique.

22022. Kotter, F. R.; Smith, A. N. **A study of air-gap breakdown at 28.5 kilohertz,** *IEEE Trans. Power Appar. Syst.* **PAS-102,** No. 6, 1913-1920 (June 1983).

Key words: air gap; electrical breakdown; insulator flashover; VLF antenna; voltage breakdown.

Measurements of the electrical breakdown of both quasi-uniform and highly nonuniform-field air gaps at a frequency of 28.5 kHz are reported. Gaps between a variety of electrode geometries ranged from a few centimeters to over two meters in length. Breakdown voltages significantly below the corresponding 60 Hz values were observed with electrodes for which appreciable pre-breakdown discharges occurred, and a pattern of "anomalous" flashovers at considerably lower than the normal breakdown voltages was noted with quasi-uniform field gaps. The results obtained appear to correlate well with the data found in the literature for higher frequencies but lower voltages. An annotated bibliography is included.

22023. Kahn, A. H.; Lowney, J. R. **Multiple scattering theory of the density of states in semiconductors,** *Solid State Commun.* **46,** No. 3, 229-233 (1983).

Key words: density of states; impurity bands; multiple scattering; semiconductors; silicon.

A method for calculating the electronic density of states of a semiconductor in the presence of impurity scattering is given. The approach is based on a low density multiple scattering expansion. The calculation treats the density of states of the conduction band, shifts of the band edge, and the profiles of the impurity bands. It is performed for a simple model, using a spherical well potential for the individual impurity centers, but could be extended to any scattering potential. The first impurity band forms when the potential is sufficiently strong that one center can bind an electron. The impurity bands are of finite width, have a flat upper edge, and an asymmetrically broadened tail on the low energy side.

22024. Simic, M. G. **Free radical mechanisms in autoxidation processes,** *J. Chem. Ed.* **58,** 125-131 (Feb. 1981).

Key words: antioxidants; autoxidation; free radicals; kinetics; pulse radiolysis.

Free radical processes operating in autoxidation processes in food components and biological systems as well as interactions of autoxidants were reviewed. Special emphasis was given to the spectroscopy and kinetics of transient species obtained by pulse radiolysis.

22025. Rainwater, J. C.; Moldover, M. R. **Thermodynamic models for fluid mixtures near critical conditions,** Chapter 10 in *Chem. Eng. at Supercritical Fluid,* pp. 199-219 (Ann Arbor Science Publishers, 230 Collingwood Road, P.O. Box 1425, Ann Arbor, MI 48106, 1983).

Key words: butane; critical phenomena; dew-bubble curves; liquid mixtures; methane; mixtures; nitrogen; octane; phase equilibria; thermodynamic properties; thermodynamic surface; VLE.

We use model thermodynamic potentials for correlating VLE data for mixtures in near-critical conditions. The model potentials are obtained by "interpolation" between the thermodynamic potentials of the pure components. The interpolation is carried out parallel to the critical locus using "field" variables which are ratios of fugacities. This contrasts with more conventional schemes in which "density" variables such as mole fractions play a key role. Our model potentials accurately describe the phase equilibria data in the critical region of CH_4–N_2 and C_4H_{10}–C_8H_{18}. These mixtures have coexisting phases whose compositions differ substantially from each other. Previous applications of the field variable concept to correlating critical region data have been limited to mixtures whose coexisting phases have quite similar compositions.

22026. Schwartz, R. B.; Eisenhauer, C. M.; Gilliam, D. M.; Spiegel, V.; Wasson, O. A. **NBS neutron fields for personnel dosimetry calibration,** *Proc. Trans. Am. Nucl. Soc., Las Vegas, NV, June 8-12, 1980,* pp. 621-623 (American Nuclear Society, Inc., La Grange Park, IL, 1980).

Key words: calibration; californium; dosimeter; neutron; reactor; Van de Graaff.

The National Bureau of Standards has established both monoenergetic and continuous-energy neutron fields for personnel dosimeter calibrations. These facilities have been used for a wide variety of dosimeter and instrument calibrations and tests, and this paper will largely be a discussion of the characteristics of these calibration fields.

22027. Agarwal, G. S.; Haan, S. L.; Cooper, J. **Photoemission spectra from autoionizing states under recycling conditions,** *Phys. Rev. A* **28,** No. 2, 1154-1156 (Aug. 1983).

Key words: laser-induced autoionization; photoemission spectra; photoionization; radiative decay.

Spectral features of the radiation emitted by autoionizing states in the presence of a strong laser field are calculated under the condition of multiple photon absorption and emissions. The method is based on the exact solution of the master equation for the recycled system. The decay spectra are found to exhibit sharp maxima at the laser frequency, and for large values of the Fano q value, sidebands which are reminiscent of the triplet which one finds in the context of a two-level atom.

22028. Agarwal, G. S.; ONeil, S. V. **Effect of hydrodynamic dispersion of the metal on surface plasmons and surface-enhanced phenomena in spherical geometries,** *Phys. Rev. B* **28,** No. 2, 487-493 (July 1983).

Key words: excited molecule; Green's function; hydrodynamic dispersion; spherical geometries; surface plasmons.

We investigate the effect of the hydrodynamic dispersion of the metal on various electromagnetic related surface effects in spherical geometries by calculating the general expression for the electromagnetic Green's function. The Green's function yields the multipolar polarizabilities for the metallic sphere and the dispersion relation for surface plasmons. The hydrodynamic dispersion is shown to lead to considerable shift of the surface-plasmon frequencies, which are pushed into the region in which they would not occur had the metal been characterized by the local dielectric function. The Green's function is further used to study the decay of an excited molecule near the metal surface and the molecular polarizability renormalizations. Various resonances in the decay characteristics of the excited molecule are shown to correspond to the shifted surface-plasmon frequencies.

22029. Egelhoff, W. F., Jr. **Thermochemical values for Cu-Ni surface and interface segregation deduced from core-level binding-energy shifts,** *Phys. Rev. Lett.* **50,** No. 8, 587-590 (Feb. 21, 1983).

Key words: copper; core levels; nickel; photoelectron spectroscopy; surface segregation; thermochemistry.

A new method for extracting thermochemical values of surface and interface segregation in binary alloys from shifts in core-electron binding energies is applied to the case of Cu-Ni. The results for the heat of Cu surface segregation agree well with the calculated value. In addition to providing important thermochemical values this approach provides new insights into the relative importance of the different effects contributing to segregation phenomena.

22030. Johnson, W. C. **Interaction of a dislocation with a misfitting precipitate,** *J. Appl. Phys.* **53,** No. 12, 8620-8632 (Dec. 1982).

Key words: dislocation; elasticity; inhomogeneity; interaction; precipitate; strain energy; transformation strain.

By formulating the appropriate differential equations and boundary conditions in terms of an integral equation, an expression is derived for the displacement associated with an interacting dislocation and precipitate in an infinite matrix. The technique is applicable to anisotropic systems in which the precipitate possesses a stress-free transformation strain and elastic constants different from those of the matrix phase. Approximate solutions to the integral equation are made, and stress, strain, and interaction energy calculated for straight screw and edge dislocations situated near ellipsoidal and rectangular parallelepiped elastic inhomogeneities in an isotropic matrix.

22031. Fuller, E. R.; Lawn, B. R.; Cook, R. F. **Theory of fatigue for brittle flaws originating from residual stress concentrations,** *J. Am. Ceram. Soc.* **66,** No. 5, 314-321 (May 1983).

Key words: ceramics; crack growth; fatigue; indentation flaws; residual stress.

A theory is formulated for the general fatigue response of brittle flaws which experience residual stress concentrations. The indentation crack is taken as a model flaw system for the purpose of setting up the basic fracture mechanics equations, but the essential results are expected to have a wider range of applicability in the strength characterization of ceramics. A starting fatigue differential equation is first set up by combining an appropriate stress intensity factor for point- or line-contact flaws with a power-law crack velocity function. Analytical solutions are then obtained for the case of static fatigue. The resulting relation between lifetime and failure stress is shown to have exactly the same power-law form as the conventional solution for Griffith (residual-stress-free) flaws. This "equivalence" is used as a basis for extending the results to dynamic fatigue. A comparison of these analytical solutions with numerical counterparts defines the limits of accuracy of the theoretical procedure. However, while the form of the lifetime relation remains invariant, the values of the exponent and coefficient differ significantly for flaws with and without residual stress. Accordingly, the application of conventional fatigue theory to evaluate crack velocity parameters, without due regard for the nature of the critical flaw, can lead to serious errors. Explicit conversion formulas are given for transforming "apparent" velocity parameters for indentation flaws directly into "true" parameters. The implications of these results concerning the use of the indentation method for materials evaluation are discussed.

22032. Lawn, B. R.; Hockey, B. J.; Richter, H. **Indentation analysis: Applications in the strength and wear of brittle materials,** *J. Microsc.* **130,** Pt. 3, 295-308 (June 1983).

Key words: brittle materials; controlled flaws; deformation; erosion; residual stress strength; wear.

Some recent developments in the principles and applications of indentation fracture in brittle materials are surveyed. Attention is focused on 'sharp' indenters, for which precursor 'plasticity' is an essential element of the crack development. A major consequence of this plasticity is a residual contact stress field which exerts a dominant influence on ensuing mechanical behaviour. This influence is discussed in relation to strength and wear properties of brittle ceramics. Emphasis is placed on the advantages of the indentation method as a means of producing controlled cracks for evaluating material fracture parameters and for gaining insight into flaw micromechanics.

22033. Wells, J. S.; Petersen, F. R.; Maki, A. G. **Heterodyne frequency measurements of carbonyl sulfide transitions at 26 and 51 THz. Improved OCS, $O^{13}CS$, and $OC^{34}S$ molecular constants,** *J. Mol. Spectrosc.* **98,** 404-412 (1983).

Key words: carbonyl sulfide; heterodyne frequency measurements; OCS calibration frequencies; OCS frequency measurements; OCS molecular constants; OCS overtone bonds.

Heterodyne frequency measurements were made on selected absorption features of carbonyl sulfide (OCS) near 26 THz (860 cm^{-1}) and 51 THz (1700 cm^{-1}). Frequency differences were measured between a tunable diode laser (TDL) locked to carbonyl sulfide absorption lines and either a stabilized $^{13}CO_2$ laser or a CO laser which was referred to stabilized CO_2 lasers. These measurements are combined with conventional TDL measurements and published microwave measurements to obtain new, more reliable molecular constants for OCS, $O^{13}CS$, and $OC^{34}S$. New frequency measurements are given for nine CO laser transitions between 1686 and 1726 cm^{-1}.

22034. Falk, R. A.; Stefani, G.; Camilloni, R.; Dunn, G. H.; Phaneuf, R. A.; Gregory, D. C.; Crandall, D. H. **Measured electron-impact ionization of Be-like ions: B^+, C^{2+}, N^{3+}, O^{4+},** *Phys. Rev. A* **28,** No. 1, 91-98 (July 1983).

Key words: Be sequence ions; crossed beams; electron impact ionization; experiment.

Electron-impact-ionization cross sections have been measured from threshold to about 20 times threshold for Be-like ions B^+, C^{2+}, N^{3+}, and O^{4+} with the use of the crossed-beams technique. The ion beams consist of mixtures of ions in the $2s^2\ ^1S$ ground state and the $2s2p\ ^3P_{0,1,2}$ metastable states. For B^+ and C^{2+} the metastable fractions could be changed, allowing estimates of ground-state cross sections, while for N^{3+} and O^{4+} the metastables appear to dominate the beams and the fractions could not be changed. The measured cross sections are compared with a variety of predictions. Distorted-wave calculations compare most favorably, but discrepancies up to 40% are found. The metastable-state–ground-state mixture complicates the comparisons for these beam experiments and is probably an issue for all environments where light ($Z \leqslant 15$) Be-like ions occur.

22035. Chatham, H.; Hils, D.; Robertson, R.; Gallagher, A. C. **Reactions of He^+, Ne^+, and Ar^+ with CH_4, C_2H_6, SiH_4, and Si_2H_6,** *J. Chem. Phys.* **79,** No. 3, 1301-1311 (Aug. 1983).

Key words: charge-exchange; disilane; ethane; ion-molecule reactions; methane.

The rate coefficients and product-ion distributions for the reactions of He^+ and Ar^+ with silane and disilane have been measured in a drift tube, typically for collision energies of 0.01–1 eV. The total charge-exchange rate coefficients are found to be roughly independent of E/N, or collision energy, and are about equal to the Langevin values for the reactions of He^+ with SiH_4 and C_2H_6 and Ar^+ with CH_4 and C_2H_6. The He^+ rate coefficients on CH_4 and Si_2H_6, and the Ne^+ rate coefficients on SiH_4 and Si_2H_6 are 50% to 80% of the Langevin values, while the Ar^+ rate coefficients on SiH_4 and Si_2H_6 are much smaller. Product ions tend to be hydrogen poor with very infrequent breaking of the C–C or Si–Si bonds. Furthermore, hydrogen stripping is more severe for the silanes than the alkanes. These product-ion distributions bear no resemblance to the product-ion distributions of either photoionization or electron collisional ionization.

22036. Nicholson, W. L.; Prince, E.; Buchanan, J.; Tucker, P. **A robust/resistant technique for crystal-structure refinement,** Paper in *Crystallographic Statistics—Progress and Problems,* pp. 229-263 (Indian Academy of Sciences, Madras, India, 1982).

Key words: crystal structure; data fitting; least squares; parameter estimates; robust/resistant techniques; single crystals; structure refinement.

A refinement technique is 'robust' if it works well over a broad class of error distributions in the data, and 'resistant' if it is not strongly influenced by any small subset of the data. Least squares possesses neither property. A more robust/resistant procedure is to minimize, instead of a simple sum of squared differences, a sum of terms of the form $(x^2/2)[1-(x/a)^2+(1/3)(x/a)^4]$ for $|x| \leqslant a$ and $a^2/6$ for $|x| > a$. Here $x = w^{1/2}(|F_0|-|F_c|)/s$, s is a measure of the width of the error distribution based on the results of the previous cycle, and a is a constant chosen so that extreme data do not influence the solution. This function behaves like the sum of squares for small $|x|$, but is constant for large $|x|$, so that the effect of large differences is deemphasized. A least-squares program can easily be modified to perform this more robust/resistant procedure. The modified procedure has been used in a reanalysis of the $D(+)$-tartaric acid data collected by the Single Crystal Intensity Project of the International Union of Crystallography [Abrahams, Hamilton & Mathieson (1970), *Acta Cryst.* **A26,** 1–17). The results show that the technique provides an efficient means for automatic screening of a data set for discrepant data points. It gives results in agreement with the least-squares results for good data sets. If the results do not agree with least squares it suggests systematic effects. A detailed analysis of residuals may identify the problem and help to determine whether the robust/resistant refinement is an improvement.

22037. Lynn, J. W.; Erwin, R. W.; Chen, H. S.; Rhyne, J. J. **Evolution from ferromagnetism to spin-glass behavior,** *Solid State Commun.* **46,** No. 4, 317-320 (1983).

Key words: amorphous magnet; ferromagnetism; frustration; percolation; spin freezing; spin-glass transition.

The magnetic properties of amorphous $(Fe_xNi_{100-x})_{75}P_{16}B_6Al_3$ have been investigated in the critical concentration region ($x_c \approx 17$) via neutron scattering. For $x > x_c$ a transition to ferromagnetism is first observed followed at lower temperatures by an evolution to spin-glass behavior. Associated with this low temperature state are two distinct time scales corresponding to a resolution-limited elastic peak and to excitations. The temperature dependence of the elastic component is directly related to the spin-glass order parameter and indicates that there is a region of temperature where ferromagnetism and spin-glass order coexist.

22038. Lozier, D. W. **The use of floating-point and interval arithmetic in the computation of error bounds,** *IEEE Trans. Comput.* **C-32,** No. 4, 411-417 (Apr. 1983).

Key words: arithmetic algorithms; error propagation; floating-point computation; inner-product accumulation; interval analysis; interval arithmetic; relative precision; rounding error analysis.

Three forms of interval floating-point arithmetic are defined in terms of absolute precision, relative precision, and combined absolute and relative precision. The absolute-precision form corresponds to the centered form of conventional rounded-interval arithmetic. The three forms are compared on the basis of the number of floating-point operations needed to generate error bounds for inner-product accumulation.

22039. Hardman, K.; Rhyne, J. J.; Prince, E.; Smith, H. K.; Malik, S. K.; Wallace, W. E. **Magnetic and structural properties of $Th_6Mn_{23}D_x$ and $Y_6Mn_{23}D_x$,** Article in *The Rare Earth in Modern Science and Technology* **3,** 477-478 (Plenum Press, New York, NY, 1982).

Key words: actinides; hydrides; magnetic compounds; magnetism; neutron diffraction; rare earths.

The magnetic behavior of Y_6Mn_{23} and Th_6Mn_{23} is greatly affected by the absorption of hydrogen or deuterium. Y_6Mn_{23} is a ferrimagnetic compound with $T_c = 486$ K and a magnetic moment of 13 μ_B/f.u. (formula unit). The long-range magnetic order vanishes on hydrogen absorption. In contrast, Th_6Mn_{23} is a Pauli paramagnet, while $Th_6Mn_{23}H_{30}$ exhibits long-range magnetic ordering with $T_c = 329$ K and a bulk magnetization value of 18.5 μ_B/f.u.

22040. Cohen, J. S.; Wlodawer, A. **Diffraction and NMR studies of proteins: An uneasy alliance,** *Trends Biochem. Sci.* **7,** No. 11, 389-391 (1982).

Key words: diffraction; histidine; method comparison; nuclear magnetic resonance; protein structure; ribonuclease.

Results of structural studies of proteins by diffraction and nuclear magnetic resonance have been analyzed and compared. Both techniques have been successfully used for this purpose in the past and the results obtained with each have seldom been compared. This leads to possible misinterpretations. Ribonuclease and serine proteases have been analyzed by both methods and this paper compares the results and points to the possible pitfalls in their interpretation.

22041. Carino, N. J.; Lew, H. S. **Temperature effects on strength-maturity relations of mortar,** *Am. Concr. Inst. J., Title No.* **80-17,** No. 3, 177-182 (May/June 1983).

Key words: age-strength relation; compression tests; compressive strength; concretes; cubes; curing; hydration; mortars (material); setting (hardening); temperature.

Two questions are addressed: 1) What are the quantitative effects of curing temperature on the strength-maturity relations of concrete? 2) At what age will curing temperature no longer affect the strength-maturity relation? To answer the first question, mortar cubes were cast and cured at five different temperatures from 5 to 43 C, and compression tests were performed at seven maturity values. A three-parameter equation was used to represent the strength-maturity relations, while regression analysis was used to evaluate the coefficients. It was found that the parameters in the strength-maturity function for each curing condition varied systematically with temperature.

To answer the second question, mortar cubes were cast and stored at 5 and 32 C; they were then transferred to a 23 C environment for subsequent curing. Compression tests were performed at five maturity values. Resulting data were analyzed to determine the age beyond which initial curing temperature no longer affected the strength-maturity relation. Results indicate that an alternative to the traditional

approach for computing maturity may exist which may better account for combined effects of temperature and time on the strength development of concrete.

22042. Lovesey, S. W.; Bowman, C. D.; Johnson, R. G. **Electron excitation in atoms and molecules by neutron-nucleus scattering.** *Z. Phys. B* **47,** 137-147 (1982).

Key words: atoms and molecules; center-of-mass recoil; electron excitation; neutron scattering; nonadiabatic coupling; theory.

The electronic excitation of atoms and diatomic molecules arising from neutron-nucleus scattering is examined. Both center-of-mass recoil and the coupling between electrons and nuclei arising from non-adiabatic terms neglected in the Born-Oppenheimer approximation are considered. A significant cross-section from center-of-mass recoil is predicted for single atoms for sufficiently large changes in the wavevector of the neutron. The non-adiabatic terms give rise to small cross-sections for molecules unless the spacing of the electronic states is comparable with the rotational energy constant, which is possible for transitions between excited states.

22043. Matthias, E.; Zoller, P.; Elliott, D. S.; Piltch, N. D.; Smith, S. J. **Influence of configuration mixing in intermediate states on resonant multiphoton ionization,** *Phys. Rev. Lett.* **50,** No. 24, 1914-1917 (June 1983).

Key words: angular distributions; barium; configuration mixing; experimental; multiphoton; photoionization; quantum defect theory; spectra.

Resonant three-photon ionization of Ba to a structureless continuum via 6*snd* Rydberg states was performed in the range $19 \leqslant n \leqslant 30$. It is shown that state mixing in the Rydberg states strongly affects the photoion and photoelectron yields as well as the angular distributions of photoelectrons. The experimental results are explained on the basis of a three-channel quantum-defect theory for the perturbed Rydberg series.

22044. Wagner, H. L.; Dillon, J. G. **A low shear, high temperature rotational viscometer: The viscosity of ultrahigh molecular weight polyethylene,** Chapter 9 in *Polymer Characterization—Spectroscopic, Chromatographic, and Physical Instrumental Methods,* pp. 165-178 (The American Chemical Society, Washington, DC, 1983).

Key words: high temperature rotational viscometer; low-shear; molecular weight; polyethylene; viscosity.

To obtain accurate measurements of the limiting viscosity number of solutions of ultrahigh molecular weight polyethylene (UHMWPE), a low shear floating-rotor viscometer of the Zimm-Crothers type was developed to measure viscosities at elevated temperatures (135°C) and essentially zero shear rate. The zero shear rate measurements for a set of UHMWPE samples were compared with viscosity measurements at moderate and high shear rates (up to 2000 s^{-1}) carried out in a capillary viscometer. The limiting viscosity number of UHMWPE depends, as expected, on shear rate, and the higher shear rate data could not be extrapolated to yield the correct zero-shear rate viscosities.

22045. Schrack, R. A.; Behrens, J. W.; Carlson, A. D.; Bowman, C. D.; Johnson, R. G. **Recent developments in resonance neutron radiography,** *Proc. Fifth Int. Conf. Nondestructive Evaluation Nuclear Industry, San Diego, CA, May 10-13, 1982,* pp. 158-163 (American Society for Metals, Metals Park, OH 44073, 1983).

Key words: microchannel plate; neutron; nondestructive analysis; nondestructive evaluation; radiography; resonance.

An overview of developments in Resonance Neutron Radiography at the National Bureau of Standards is presented. The development of high-resolution, two-dimensional neutron detectors and their application in measurement systems using pulsed neutron sources is covered with special emphasis on the application to nuclear fuel material analysis and evaluation.

22046. Rudder, F. F.; Weber, S. F. **Minimum cost design for noise insulation in building construction,** *Noise Control Eng. J.* **20,** No. 3, 104-121 (May/June 1983).

Key words: architectural acoustics; constrained optimization; construction cost; cost minimization; noise insulation.

A method is described for estimating the construction cost of building components designed to achieve a specified level of noise insulation. The method also determines the noise insulation value of each component of a multi-component wall such that the wall achieves a design level of noise insulation at the minimum construction cost. Curves of minimum construction cost as a function of design noise insulation are easily generated using the method. All calculations can be performed using a pocket calculator. The adjustment of construction cost estimates to account for inflation and geographic variation is discussed. Detailed examples illustrate the application of the method to design problems.

22047. Rhyne, J.; Hardman, K.; Malik, S.; Wallace, W. **Magnetic properties of cubic and hexagonal $HoMn_2$,** Article in *The Rare Earths in Modern Science and Technology* **3,** 391-392 (Plenum Press, New York, 1982).

Key words: Laves compounds; magnetic structure; magnetism; manganese compounds; neutron scattering; rare earths.

$HoMn_2$ forms the C-15 (cubic Laves phase) structure. Upon heat treatment $HoMn_2$ can also be stablized in the C-14 (hexagonal Laves phase) structure. Both $HoMn_2$ samples magnetically order below 25 K. It is generally believed that the RMn_2 compounds with the C-14 structure (e.g., $ErMn_2$ and $TmMn_2$) are ferromagnetic compounds in which the rare earth atoms magnetically order and the Mn atoms do not. However, the RMn_2 compounds with C-15 structure are ferrimagnetic with the magnetic moments of the rare earth atoms coupled antiparallel to the Mn moments. In both $HoMn_2$ (C-14 and C-15) compounds, the magnetically ordered structure is ferrimagnetic. The crystallographic parameters and magnetic moments in both of these compounds have been determined by neutron scattering profile refinement techniques.

22048. Vogel, G. L.; Chow, L. C.; Brown, W. E. **A microanalytical procedure for the determination of calcium, phosphate and fluoride in enamel biopsy samples,** *Caries Res.* **17,** 23-31 (1983).

Key words: analysis; biopsy; calcium; enamel; fluoride; phosphate.

This paper describes analytical methods for the determination of calcium, phosphate and fluoride in successive layers of enamel removed from rat and human teeth by acid etching. These methods include: (i) simple, sensitive spectrophotometric methods for the determination of calcium and phosphate; (ii) an easily constructed miniature fluoride electrode, and (iii) an improved electrode adapter that permits one fluoride electrode to measure numerous microsamples very rapidly. The high sensitivity and simplicity of the analytical techniques described allows many types of microsamples of interest in dental research to be analyzed with an accuracy and speed heretofore attainable only with much larger samples.

22049. Reader, J. **$3p^63d^9$–$3p^53d^{10}$ transitions in cobalt-like ions from Ba^{29+} to Yb^{43+},** *J. Opt. Soc. Am.* **73,** No. 1, 63-65 (Jan. 1983).

Key words: barium; dysprosium; erbium; gadolinium; lanthanum; neodymium; samerium; spectra; vacuum-ultraviolet; ytterbium.

The $3p^63d^9$–$3p^53d^{10}$ transitions in the cobaltlike ions Ba^{29+}, La^{30+}, Nd^{33+}, Sm^{35+}, Gd^{37+}, Dy^{39+}, Er^{41+}, and Yb^{43+} were observed with a laser-produced plasma and a 2.2-m grazing-incidence spectrograph. Predicted wavelengths were obtained for the $3p^63d^9\ {}^2D_{5/2}$–$^2D_{3/2}$ magnetic dipole transitions in Mo^{15+}, Xe^{27+}, and W^{47+}.

22050. Smith, J. M. **Table errata 592—National Bureau of Standards, Handbook of mathematical functions,** *Math. Comput.* **40,** No. 162, 723-724 (Apr. 1983).

Key words: derivative of Lengendre function; Legendre function; maximum end-figure error; NBS Handbook of Mathematical Functions.

Errors detected in Table 8.3, Legendre Functions—Second Kind $Q_n(x)$, of the NBS Handbook of Mathematical Functions are listed with their correct values.

22051. Nee, T. A.; Roberts, J. R. **Comment: Author's reply to comment of Skowronek,** *Phys. Rev. A* **27,** No. 6, 3351-3354 (1983).

Key words: laser pulse duration; laser pulse rise time; laser pulse shaping; plasma diagnostics; Rayleigh scattering; scattering cross section.

Skowronek has commented on a Rayleigh-scattering cross-section measurement for various pulse durations made by us. His comments are discussed, and his questions on our experimental methods are answered.

22052. Roy, R.; Elliott, D. S.; Meschede, D.; Pipkin, F. M.; Smith, S. J. **Collisional dependence of spectral line shapes in CO_2 at low pressures,** *Proc. Sixth Int. Conf. Spectral Line Shapes, Boulder, CO, July 12-16, 1983,* **2,** 651-662 (Walter de Gruyter and Company, Berlin, NY, 1983).

Key words: CO_2; collisions; line shape; Q branch; Raman; rotational constant; stimulated gain; vibration-rotation.

The shape of the ν_1 symmetry stretch line of CO_2 has been studied as a function of gas pressure using stimulated Raman gain spectroscopy with a resolution of approximately 20 MHz. At low pressures (10 Torr) the shape of the line leads to a new value of the ground state rotational constant $B_{000}=0.390168(2)$ cm^{-1}. At high pressures a pronounced collisional narrowing occurs. Velocity changing collisions and Q-branch collapse may both be present in a statistically interdependent way not yet treated in the theoretical literature.

22053. Smak, J. **On the nature of dwarf novae,** *Astrophys. J.* **272,** No. 1, 234-237 (Sept. 1, 1983).

Key words: accretion disks; cataclysmic binaries; dwarf novae.

Observational data on mass transfer rates and radii of disks indicate that the outer parts of disks in novae and nova-like binaries are sufficiently hot for stationary accretion; those in dwarf novae are too cool to avoid an accretion instability; while those in *Z* Cam systems are the borderline cases. The mass ratios of novae and nova-like binaries with main-sequence secondaries appear—at a given orbital period—to be systematically larger than those of dwarf novae, implying that higher mass ratios are responsible for higher mass transfer rates.

22054. Huennekens, J.; Gallagher, A. **Resonance broadening of the sodium D lines,** *Proc. Sixth Int. Conf. Spectral Line Shapes, Boulder, CO, July 12-16, 1983,* **2,** 665-678 (Walter de Gruyter and Company, Berlin, NY, 1983).

Key words: line broadening; sodium.

Sodium vapor, in the density range 10^{13}–5×10^{14} cm^{-3}, was excited by a cw dye laser, tuned 20–140 GHz from either the D_1 or D_2 resonance line. We observed the three peak scattered spectrum, consisting of the Rayleigh component at the laser frequency, and the two fluorescence components (direct and sensitized) at the atomic resonance-line frequencies. Corrections to the Rayleigh signals for anisotropy and polarization effects, and to the fluorescence signals for radiation trapping effects were made in order to obtain the ratio of the intensity of the fluorescence components to that of the Rayleigh component. This ratio of fluorescence to Rayleigh intensity combined with a measurement of the line-wing absorption coefficient yields the sodium density and the D-line self-broadening rate coefficients ($k_{Br2}=4.67\times10^{-7}$ cm^3 s^{-1} ±15% for the D_2 line and $k_{Br1}=3.07\times10^{-7}$ cm^3 s^{-1} ±15% for the D_1 line). Asymmetry in the self-broadened line wings due to fine structure recoupling was observed. Asymmetry in the Rayleigh scattering, as a function of detuning, was also observed, due to interference between the two fine structure levels. In addition, the measured intensity ratio of the D-lines combined with pulsed measurements of the effective radiative decay rate in the presence of radiation trapping yields the fine structure collisional mixing cross section ($\sigma 3P_{3/2}\rightarrow 3P_{1/2}=172$ Å^2±18%). Our results are compared to other experiments and to theory.

22055. Ayres, T. R.; Schiffer III, F. H.; Linsky, J. L. **Outer atmospheres of cool stars. XIII. Capella at critical phases,** *Astrophys. J.* **272,** No. 1, 223-233 (Sept. 1983).

Key words: binary stars; emission-line stars; late-type stars; stellar chromospheres; ultraviolet spectra.

We present a high-dispersion ultraviolet study of the late-type spectroscopic binary capella covering critical phases—three quadratures and one conjunction—in the orbit, as observed with the *International Ultraviolet Explorer.* Our work supports the conclusion previously reached by Ayres and Linsky, based on an early *IUE* study of Capella with limited phase coverage, that the rapidly rotating F9 III secondary star in the system is considerably brighter than the more slowly rotating G6 III primary in ultraviolet emission lines characteristic of the chromospheric ($T\sim6000$ K) and higher temperature ($T\leqslant2\times10^5$ K) plasmas. In particular, the secondary is responsible for about 90% of the C IV (10^5 K) emission from the system, and the secondary/primary surface flux ratio is as large as 25:1. However, the present study reveals that the primary star nevertheless is among the brightest of the yellow giants in C IV surface flux, and perhaps is responsible for a significant fraction of the soft X-ray emission from the system.

The enhanced ultraviolet emission of the Capella giants compared to other yellow giants in recent *IUE* low-dispersion surveys suggests that the primary and secondary both are crossing the Hertzsprung gap for the first time, as proposed previously by Boesgaard in her examination of the lithium absorption in the composite spectrum. If the Capella giants indeed are both first crossers, then the spin-down of stars evolving through the Hertzsprung gap may be quite rapid, as has been suggested on theoretical grounds by Endal and Sofia. In fact, the rotational velocities measured for the Capella giants by Fekel are consistent with the angular momentum histories of yellow giants in the Hertzsprung gap predicted by Gray and Endal in their study of the four more evolved Hyades K giants. We conclude that the extraordinary brightness of the Capella secondary in the far-ultraviolet is a transitory, dynamic magnetic phase in the post-main-sequence evolution of moderately massive ($\sim3\ M_\odot$) stars.

22056. Haan, S. L.; Agarwal, G. S. **Recombination effects in autoionization,** *Proc. Sixth Int. Conf. Spectral Line Shapes, Boulder, CO, July 12-16, 1983,* **2,** 1013-1032 (Walter de Gruyter and Company, Berlin, NY, 1983).

Key words: autoionization; fluorescence; radiative recombination.

Effects of the radiative decay of the unperturbed free-electron continuum on autoionization are investigated using the Møller operator approach. Results for photoelectron and photoemission spectra beyond the usual pole approximation are presented. The modifications of Fano profiles and various sprectra due to the recombination are discussed. We find that the minimum in the Fano profiles is restored if the q values corresponding to the initial and final states are equal.

22057. Kelley, E. F.; Hebner, R. E. **Electro-optic measurement of the electric field distribution in transformer oil,** *IEEE Trans. Power Apparat. Syst.* **PAS-102,** No. 7, 2092-2097 (July 1983).

Key words: electric field; electro-optics; high voltage; Kerr effect; nitrobenzene; space charge; transformer oil.

A system has been developed to measure the electric fields in transformer oil using the electro-optic Kerr effect. The system performance was verified by measuring the electric field and space charge in nitrobenzene. The field distributions were measured in clean oil, in oil which had been used as a wash for a radiator used in a power transformer, and in oil which was removed from a transformer that had failed. Measurements were made from room temperature to 100°C. Under the conditions studied, the electric field strengths were generally within 10% of the strengths that would be predicted assuming that space charge was negligible.

22058. Gallagher, A. **Far wing radiation from atom-molecule collisions,** *Proc. Sixth Int. Conf. Spectral Line Shapes, Boulder, CO, July 12-16, 1983,* **2,** 755-767 (Walter de Gruyter and Company, Berlin, NY, 1983).

Key words: electronic-to-vibrational energy transfer; sodium.

The study of collisional lineshapes has concentrated so far on atom–atom collisions, especially on elastic atom–atom collisions. However, many interesting collision processes occur in atom–molecule collisions and in inelastic collisions. In particular,

energy transfer processes such as electronic-to-vibrational, rotational and translational, and electronic-to-electronic are of great interest. Chemical reactions are perhaps the most important inelastic atom–molecule collisions. The study of chemical reactions, with detailed spectral information regarding the collision complex, is certainly one of the most fascinating possibilities envisioned for the application of collisional lineshapes. Polanyi and his collaborators are already studying such processes. In the present talk I would like to discuss how the theory of line-wing shapes and atom–atom collisions can be expanded to the topic of atom–molecule collisions. I will then go on to discuss the particular example that we are studying in our laboratory, which is the electronic-to-vibrational energy transfer process of an excited sodium atom colliding with nitrogen or hydrogen molecules. The discussion of this example should bring out both the strengths and difficulties encountered in applying the collisional theory of lineshapes to the atom–molecule collision.

22059. Elliott, D. S.; Roy, R.; Smith, S. J. **Role of field fluctuations in nonlinear absorption,** *Proc. Sixth Int. Conf. Spectral Line Shapes, Boulder, CO, July 12-16, 1982,* **2,** 989-998 (Walter de Gruyter and Company, Berlin, NY, 1983).

Key words: acousto-optic; electro-optic; frequency fluctuations; frequency modulation; laser bandwidth; phase diffusion; phase modulation; statistical noise.

A technique for producing statistically characterized fluctuations on initially monochromatic (well-stabilized) laser beam is described. Acousto-optic and electro-optic modulators are used to produce linewidths of up to 35 MHz FWHM and controlled wings to 1 GHz from line center. The lineshapes produced may be fully Lorentzian, or may have essentially Gaussian characteristics beyond designated cutoff points in the wings. The system is being developed for studies of the role of fluctuations in nonlinear atomic absorption processes.

22060. Kusuda, T. **An approximate method for determining monthly heat loss from earth-contact floors,** *Proc. Fourth Int. Symp. Use Computers Environmental Engineering Related to Buildings, Kenchiku Kaikan, Tokyo, Japan, Mar. 30-Apr. 2, 1983,* pp. 110-118 (The Society of Heating, Air-Conditioning & Sanitary Engineers of Japan, 1-8-1 Kitashinjuku, Shinjuku-ku, Tokyo, Japan, 1983).

Key words: Delsante calculation; earth temperature; monthly floor heat loss; slab-on-grade floor.

Based on extensive earth temperature calculations using a Green's function type solution of the heat conduction equation, a simplified procedure was developed to permit the evaluation of monthly heat loss from the slab-on-grade floor. The results obtained by the method developed herein were compared against those determined by Delsante's more rigorous and analytical formula. Good agreements were obtained between the monthly floor heat loss determined by these two methods, provided that the average earth temperature at 0.15 m below the floor surface is used for the heat transfer calculation and that the perimeter width of 0.15 m is used for the Delsante calculations.

22061. Gary, D. E.; Linsky, J. L.; Dulk, G. A. **VLA observations of quiescent and flare microwave emission from late-type stars: A unique probe of coronal magnetic fields,** *Proc. IAU Symp. #102, Solar Stellar Magnetic Fields, Zurich, Switzerland, Aug. 2-6, 1982,* J. O. Stenflo, ed., pp. 387-390 (Reidel, Dordrecht, Aug. 1983).

Key words: coronae; late-type stars; radio observations.

We report the measurement of steady microwave emission from a number of late-type stars, and discuss implications concerning coronal structure and magnetic field strength.

22062. Carino, N. J.; Woodward, K. A.; Leyendecker, E. V.; Fattal, S. G. **A review of the Skyline Plaza collapse,** *Concr. Int.* **5,** No. 7, 35-42 (July 1983).

Key words:: apartment buildings; collapse; compressive strength; concrete construction; concrete slabs; failure; form removal; high-rise buildings; punching shear; reinforced concrete; shear stress.

On March 2, 1973, portions of the Skyline Plaza apartment building, under construction in Fairfax County, Va., collapsed. The failure resulted in the death of 14 workers; 34 others were injured.

This article summarizes the results of the failure investigation carried out by the National Bureau of Standards. Based on structural analyses and estimates of concrete strength at the time of collapse, NBS investigators concluded that the probable cause was a punching shear failure of the 23rd floor slab. The critical condition was attributed to: (1) premature removal of shoring below the 23rd floor slab at the time the 24th floor was being placed, and (2) the low strength of that portion of the 23rd floor which was unshored.

22063. Barlow, M. J.; Hummer, D. G. **The WO Wolf-Rayet Stars,** *Proc. IAU Symp. 99, Wolf-Rayet Stars: Observations, Physics, Evolution, Cancun, Mexico, Sept. 1981,* C. W. H. de Loore and A. J. Willis, eds., pp. 387-393 (Reidel, Dordrecht, Holland, 1982).

Key words: chemical abundances; stellar classification; stellar evolution; Wolf-Rayet stars.

The five stars listed by Sanduleak (1971) as having very strong O VI 3811,34 Å emission are discussed on the basis of absolute visual spectrophotometry (3100–7400 Å), augmented by IUE observations for the first three of the list. Evidence is produced that four of these objects describe an evolutionary sequence that is an extention of the WC sequence. We have introduced the designation WO for these stars. Sand 3 is shown to have a true surface temperature not less than 2×10^5 °K, and is thought to be the remnant central star of e planetary nebula. The surface chemical composition is discussed.

22064. Linsky, J. L. **Coronae of nondegenerate single and binary stars: A survey of our present understanding and problems ripe for solution,** (Proc. Symp. X-ray Astronomy in the 1980s, Goddard Space Flight Center, Greenbelt, MD, Oct. 1981), *NASA Technical Memo 83848,* pp. 13-36 (National Aeronautics and Space Administration, Greenbelt, MD, 1982).

Key words: binary stars; stellar coronae; x-ray sources; x-ray spectra.

Einstein has discovered X-ray emission from stars located in nearly every portion of the HR diagram, and, as a consequence, has completely changed our understanding of stellar coronae. Despite this great accomplishment or perhaps because of it, we now recognize that there are many important unanswered questions that require the capabilities of the next generation of X-ray instrumentation. In this survey I review what *Einstein* has told us about the coronae of stars in different portions of the HR diagram, and how the characteristics of such coronae compare with what we now know about the solar corona. For each type of star, I then list some important unanswered questions and the generic type of X-ray instrument required to answer these questions. This survey clearly points out the critical need for a sensitive X-ray instrument with both *moderate spectral resolution* ($E/\Delta E = 100$–300) and *imaging* ($E/\Delta E \sim 3$) capability that can *monitor* selected targets for long periods of time. There is also a need for high spectral resolution ($E/\Delta E = 10^3$–10^4), provided sensitivities can be improved greatly over *Einstein*, and near simultaneous ultraviolet spectroscopy.

22065. Iverson, W. P.; Olson, G. J. **Anaerobic corrosion by sulfate-reducing bacteria due to highly reactive volatile phosphorus compound,** *Proc. Conf. Microbial Corrosion, National Physical Laboratory, Teddington, England, Mar. 8-10, 1983,* pp. 46-53 (Metals Society, London, England, 1983).

Key words: anaerobic corrosion; desulfovibrio; dimethyldisulfide; hydrogen sulfide; hypophosphite; iron phosphide; iron sulfide; methylmercaptan; microbial corrosion; phosphine; sulfate-reduction; volatile phosphorus compound.

Significant corrosion products, formed in the bacterially induced, anaerobic corrosion of iron, appear to be iron phosphides in addition to iron sulfide. Upon acidification, these products release FH_3 and H_2S respectively, which can be detected by gas chromatography employing a flame photometric detector (GC-FPD). The iron phosphide can be formed by the action of a volatile phosphorus-containing compound produced during the growth of cultures of *Desulfovibrio.* In addition to the production of this phosphorus compound and hydrogen sulfide, the organism also produces two relatively noncorrosive (to iron) compounds: methylmercaptan and

dimethyldisulfide. The bacterial anaerobic corrosion of iron was partly simulated by a phosphorus compound produced during the reaction of H_2S with hypophosphite in aqueous solution. Iron phosphide was formed as a corrosion product. A volatile phosphorus compound was produced by the action of hydrogen sulfide on crystals of hypophosphite, phosphite and phosphate. Although this volatile compound could not be detected with the GC-FPD (phosphorus mode) its presence was indicated by absorbing the compound in acidified permangenate solution and detecting the presence of phosphorus by the phosphomolybdate reaction. Traces of phosphine was also detected, as a possible degradation compound in the headspace above the three phosphorus compounds after a few weeks.

22066. Blair, W. R.; Olson, G. J.; Brinckman, F. E.; Iverson, W. P. **Accumulation and fate of tri-*n*-butyltin cation in estuarine bacteria,** *Microb. Ecol.* **8,** 241-251 (1982).

Key words: bioaccumulation; biocides; biodegradation; cell membranes; chromatography; environment; estuarine bacteria; organotins; speciation; tin-resistance; tin-specific analysis; tributyltin.

The accumulation and possible metabolic transformation of tri-*n*-butyltin cation by tin-resistant estuarine bacteria was studied. The bacterial isolates accumulated tributyltin to 3.7–7.7 mg tin per g dry weight of cells by a nonenergy requiring process, probably by adsorption to the cell envelope. Chemical speciation of cell extracts and culture media by combined liquid chromatography-atomic absorption spectrophotometry and tin-selective purge and trap flame photometric gas chromatography for possible tributyltin degradation products revealed no significant bio-transformations of tributyltin cation by the tributyltin-resistant isolates. Apparently the isolates accumulate, but do not metabolize tributyltin.

22067. Bizau, J. M.; Wuilleumier, F.; Dhez, P.; Ederer, D. L.; Chang, T. N.; Krummacher, S.; Schmidt, V. **Final-state symmetry for the $n=2$ states in photoionized helium determined by theory and experiment,** *Phys. Rev. Lett.* **48,** No. 9, 588-591 (Mar. 1, 1982).

Key words: asymmetry parameter; branching ratio; electron correlation; helium; photoelectron spectroscopy; photoionization; synchrotron radiation.

Experiment and theory have been used to determine the final-state symmetry for the $n=2$ state in photoionized helium. The angular asymmetry parameter β has been measured as a function of photon energy by means of angle-resolved photoelectron spectroscopy. From these measured β values, which are a weighted average of β_{2s} and β_{2p}, together with the theoretical values of β_{2p} and β_{2s}, the ratio, R, of the partial $2p$ photoionization cross section to the partial $2s$ photoionization cross section has been obtained.

22068. Hummer, D. G. **The generalized exponential-integral $V(x,y)\int_1^\infty \exp(-xt)\ \ln(t+y)dt/t$ and computer algorithms for $y=0,1$,** *J. Quant. Spectrosc. Radiat. Transfer* **30,** No. 3, 281-287 (Sept. 1983).

Key words: Chebyshev coefficients; generalized exponential-integral; radiative transfer; rational approximation.

The generalized exponential-integral function $V(x,y)$ defined here includes as special cases the function $E_1^{(2)}(x)=V(x,0)$ introduced by van de Hulst and the functions $M_0(x)=V(x,1)$ and $N_0(x)=V(x,-1)$ introduced by Kourganoff in connection with integrals of the form $\int E_n(t)E_m\ (t\pm x)$, which play an important role in the theory of monochromatic radiative transfer. Series and asymptotic expressions are derived and, for the most important special cases, $y=0$ and $y=1$, Chebyshev expansions and rational approximations are obtained that permit the function to be evaluated to at least 10 sf on $0<x<\infty$ using 16 sf arithmetic.

22069. Robertson, R.; Hils, D.; Chatham, H.; Gallagher, A. **Radical species in argon-silane discharges,** *Appl. Phys. Lett.* **43,** No. 6, 544-546 (Sept. 15, 1983).

Key words: amorphous silicon; discharges; silane.

SiH_n radical densities at the surface of discharges in Ar-SiH_4 mixtures have been measured by low-energy, electron-collisional ionization and mass spectrometer detection of SiH_n^+. The principal radical seen at the substrate surface of a dc proximity discharge is SiH_3.

22070. Gliner, E.; Dymnikova, I. **Covariant concept of gravitational energy,** *Phys. Rev. D* **28,** No. 6, 1278-1284 (Sept. 15, 1983).

Key words: energy conservation law; general relativity.

The covariant approach is proposed for the energy description of matter integrated with gravitation. The approach is based on the generalization of the special relativity stress-energy tensor up to the fourth tensor rank which introduces the anisotropies of mass, impulse, and their fluxes. The components describing anisotropies form an "energy deviator" which is a traceless fourth-rank tensor corresponding to Weyl's part of gravitation.

22071. Smedley, J. E.; Leone, S. R. **Relative quantum yield of $I^*(^2P_{1/2})$ in the tunable laser UV photodissociation of i-C_3F_7I and n-C_3F_7I: Effect of temperature and exciplex emission.** *J. Chem. Phys.* **79,** No. 6, 2687-2695 (Sept. 15, 1983).

Key words: C_3F_7I; $I(^2P_{1/2})$; laser; photodissociation; quantum yield.

Wavelength-specific relative quantum yields of I* from pulsed laser photodissociation of i-C_3F_7I and n-C_3F_7I in the range 265–336 nm are determined by measuring the time-resolved infrared emission ($\lambda=1.315\ \mu m$) from the atomic $I(^2P_{1/2}\rightarrow{}^2P_{3/2})$ transition. The quantum yields of I* from i-C_3F_7I and n-C_3F_7I are constant and appear to be unity from 265–298 nm but decrease to 0.57 and 0.40, respectively, at 336 nm. The lower quantum yields suggest the existence of two distinct bands in this region of the absorption continua. To determine the quantum yields a correction is made for enhanced emission due to formation of exciplexes between I* and the parent (i- or n-C_3F_7I) species. The exciplex emission increases linearly with parent gas pressure, but decreases with increasing temperature. For both molecules the integrated absorption in the long wavelength region (>290 nm) increases substantially with temperature, while at selected wavelengths the quantum yields are found to remain constant with temperature. The results are discussed in terms of the development of solar-pumped iodine lasers.

22072. Bullis, W. M.; Scace, R. I. **The Department of Commerce and the role of government standards,** Paper in *VLSI Electronics Microstructure Science, Chapter 2,* **1,** 281-286 (Academic Press, Inc. 111 Fifth Avenue, New York, NY 10003, 1981).

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.

22073. Barnes, J. D. **Standard reference materials for gas transmission measurements,** *Proc. Symp. Industrial Gas Separations, American Chemical Society, Washington, DC, June 14, 1982,* pp. 75-88 (American Chemical Society, 1155 16th Street, NW., Washington, DC 20036, 1983).

Key words: gas transmission; manometric permeation measurements; permeation; polyester; polyethylene terephthalate; SRM 1470; standard reference material.

Standard Reference Material 1470 is a 23 micrometer thick polyester film whose gas transmission characteristics with respect to helium, carbon dioxide, oxygen, and nitrogen have been carefully measured. A completely computerized manometric permeation measuring facility developed at NBS was used for the measurements. The steps taken to characterize the gas transmission rate of this material over the range of pressures from 67.5 kPa to 135 kPa and over the range of temperatures from 18°C to 31°C are described. The results obtained in these measurements are compared with those in the literature. The role of Standard Reference Material 1470 in improving

the repeatability and reproducibility of gas transmission measurements employing other instrumentation is discussed.

22074. Cutkosky, R. D. **Dedicated multiprocessor system for calculating Josephson-junction noise thermometer frequency variances at high speed,** *Rev. Sci. Instrum.* **54,** No. 7, 886-889 (July 1983).

Key words: computer; Josephson junction; multiprocessor; noise thermometry; thermometry; variance calculations.

A Josephson-junction noise thermometer produces a sequence of frequency readings from whose variations the temperature of the thermometer may be calculated. A preprocessor system has been constructed to collect the frequency readings delivered to an IEEE 488 bus by an ordinary counter operating at up to 1000 readings per second, perform the required calculations, and send summary information to a desk calculator or minicomputer on another 488 bus at a more convenient rate.

22075. Chuang, T. J.; Chuck, L.; Fields, R. J.; Fuller, E. R., Jr. **Effects of crack growth on the load-displacement characteristics of precracked specimens under bending,** *Eng. Fract. Mech.* **18,** No. 6, 1099-1109 (1983).

Key words: ceramic fracture test; crack growth of ceramics; four-point bend test; fracture test; initial value problem; load-displacement characteristics; power-law crack growth.

A critical evaluation of the feasibility of obtaining crack growth parameters from quasi-static bend tests is presented. First derived are the governing differential equations which characterize the time-history of bend test parameters for a given elastic material exhibiting power law crack growth behavior ($\upsilon=\upsilon_{max}(K_I/K_{IC})^N$). A numerical solution scheme is then developed which is capable of solving the initial value problem, thus quantitatively assessing the influence of crack growth on the load-displacement output. The results of this analysis indicate that in order to calculate K_{IC} accurately based on the peak load data, the loading rate has to be set sufficiently fast compared to υ_{max} (but below dynamic rates), otherwise, it will generally overestimate its true value whenever slow crack growth occurs during the test; and that for high N materials the flexural test method gives a broad error band in N prediction and hence is not a reliable technique. However, it can be used by a designer to quickly screen the new materials with high N values which are potential candidates for structural application.

22076. Cooper, L. Y. **On the significance of a wall effect in enclosures with growing fires,** *Proc. 21st Natl. Heat Transfer Conf., Fire Dynamics and Heat Transfer, Seattle, WA, July 24-28, 1983,* J. G. Quintiere, R. L. Alpert, and R. A. Altenkirch, 97-106 (American Society of Mechanical Engineers, Heat Transfer Division, 345 East 47th Street, New York, NY 10017, 1983).

Key words: compartment fires; enclosure fire; fire growth; growing fires; mathematical modeling; smoke movement; two-layer phenomenon; wall flows.

This paper studies the significance of a wall effect that has been observed during the growth stage of enclosure fires. Relative to the two-layer phenomenon which tends to develop during such fires, the effect has to do with the near-wall downward injection of hot upper layer gases into the relatively cool uncontaminated lower layer. It is conjectured that these observed wall flows are buoyancy driven, and that they develop because of the relatively cool temperatures of the upper wall whose surfaces are in contact with the hot upper layer gases. For a growing fire (growth proportional to t^m; t being time and $m\geqslant 0$) in an enclosed compartment, an analysis of the conjectured mechanism for the wall flow leads to a time-dependent solution for the ratio of wall flow mass ejection rate *from* the upper layer, $\dot{m}_w$, to the fire plume mass injection rate *to* the upper layer, $\dot{m}_p$. The solution indicates that in practical fire scenarios $\dot{m}_w/\dot{m}_p$ can be of the order of "several tenths" even prior to the time that the upper layer interface has dropped to an elevation midway between the ceiling and fire. In other words, the results of the analysis indicate the importance of taking the wall effect into account in two-layer zonal analyses of enclosure fire phenomena.

22077. Crissman, J. M. **A new test method for determining environmental stress-crack resistance of ethylene based plastics,** *Am. Soc. Test. Mater., J. Test. Eval.* **11,** No. 4, 273-278 (1983).

Key words: plastics; polyethylene; stress corrosion tests; tests.

A new test method is proposed for the determination of the environmental stress-crack resistance of ethylene based plastics. The method incorporates features of both ASTM Test for Environmental Stress-Cracking of Ethylene Plastics (D 1693) and Test for Environmental Stress Rupture of Type III Polyethylenes Under Constant Tensile Load (D 2552). The specimen is constrained in a fixed geometry by bending it around a cylindrical metallic form, and it is subjected to a constant applied stress. Statistical data are presented which indicate that the coefficients of variation that can be expected from the new test are at least comparable to those reported earlier in round robin tests carried out using ASTM D 2552. The principle advantage of the proposed new test over both ASTM D 1693 and D 2552 is a substantial savings in the time required to collect the data.

22078. Carver, G. P. **Influence of short-channel effects on dopant profiles obtained from the dc MOSFET profile method,** *IEEE Trans. Electron Devices,* **ED-30,** No. 8, 948-954 (Aug. 1983).

Key words: charge conservation models; charge sharing; dopant density; dopant profiles; impurity profiles; MOSFET profiler; profiling; short-channel effects.

Distortions in the dopant density profile obtained from dc MOSFET measurements due to short-channel effects are not properly predicted by present two-dimensional charge sharing, or charge conservation, models. The comparison of dopant profile data with predictions based on charge conservation models is a powerful technique for evaluating the accuracy of these models.

22079. Cezairliyan, A. **Measurement of the heat capacity of molybdenum (standard reference material) in the range 1500–2800 K,** *Int. J. Thermophys.* **4,** No. 2, 159-171 (1983).

Key words: heat capacity; high temperature; molybdenum; rapid heating; reference material.

Measurement of the heat capacity of molybdenum (Standard Reference Material 781 of the National Bureau of Standards) in the temperature range 1500–2800 K by a subsecond-duration, pulse-heating technique is described. The results of the measurements on three specimens are in agreement within 0.6%. The heat capacity of molybdenum in the temperature range 1500–2800 K based on the present results is expressed by the following function (standard deviation=0.5%): $C_p=-3.0429+4.7215\times10^{-2}T-2.3139\times10^{-5}T^2+4.7090\times10^{-9}T^3$ where T is in K and C_p is in $J\cdot mol^{-1}\cdot K^{-1}$. The inaccuracy of the reported results is estimated to be not more than 3%.

22080. Carlson, A. D.; Behrens, J. W. **Measurement of the $^{235}U(n,f)$ cross section from 0.3 to 3.0 MeV using the NBS electron linac,** *Proc. Int. Conf. Nuclear Data Science Technology, Antwerp, Belgium, Sept. 6-10, 1982,* pp. 456-459 (D. Reidel Publ. Co., P.O. Box 17, 3300 AA Dordrecht, Holland, 1983).

Key words: black neutron detector; electron linac; E_n=0.3–3.0 MeV; fission cross section; ionization fission chamber.

Progress is reported on a measurement of the $^{235}U(n,f)$ cross section from 0.3 to 3.0 MeV using the NBS electron linac as a pulsed neutron source. Fission events were detected using a parallel-plate, ionization fission chamber located 69.5 m from the neutron-producing tungsten target and containing 170.9±2.1 mg of ^{235}U. The absolute neutron flux was measured with the NBS black neutron detector, located at 200.4 m and coaxial with the fission chamber. A Monte Carlo program was used to calculate the neutron detection efficiency of the black detector. The present paper gives preliminary results. The fission cross section shape is shown compared to that of the ENDF/B-V $^{235}U(n,f)$ cross section. Absolute values await a complete analysis of the experimental data and the measurement of the black detector efficiency at 2.6 MeV using the associated-particle technique at the NBS Van de Graaff. Accuracies of ±2% are expected in the final analysis of this $^{235}U(n,f)$ cross section measurement.

22081. Coursey, B. M.; Hoppes, D. D.; Unterweger, M. P.; Malonda, A. G.; Margolin, R. A.; Kessler, R. M.; Manning, R. **Standardization of ^{18}F for use in positron-emission tomography,** *Int. J. Appl. Radiat. Isot.* **34,** No. 8, 1181-1189 (1983).

Key words: fluorine-18; Ge(Li) spectrometer; ionization chamber; liquid scintillation; NaI(Tl) well crystals; positron emitters; sodium-22; standardization.

Fluorine-18 has been standardized using three counting systems: (i) the NBS pressurized "4π"γ ionization chamber, (ii) a $4\pi\beta$ liquid-scintillation counter, and (iii) a Ge(Li) gamma-ray spectrometer previously calibrated with sodium-22. The results of the three measurements agreed to within 1 percent. Solution standards of fluorine-18 were used at the NIH to calibrate counting systems used in positron-emission tomography (PET) for nuclear medicine.

22082. Prince, E. **The effect of finite detector slit height on peak positions and shapes in powder diffraction,** *J. Appl. Crystallogr.* **16,** 508-511 (1983).

Key words: convolution; Edgeworth expansion; peak shape; powder diffraction; resolution function; Rietveld method.

The finite height of the detector slit of a powder diffractometer has three observable effects: (1) the peak is shifted by an amount that is proportional to $-\cot 2\theta$; (2) the peak is broadened by an amount proportional to $\cot^2 2\theta$; (3) an asymmetry is introduced into the peak shape that depends on $\cot^3 2\theta$. If the underlying instrumental resolution function has a Gaussian shape, the slit height effects can be approximated, over a rather broad range of shapes for the vertical resolution function, by an Edgeworth series making use of one adjustable parameter. This peak shape function is compared with experimental observations and with other shape functions that have been proposed. A well characterized peak shape is at least as important as resolution when the data are to be used for structure refinement by the Rietveld technique, and diffractometers should be designed so as to keep the slit height within the range that leads to shapes that can be described mathematically. Diffractometers with multiple detectors can usefully have different vertical divergences for detectors that cover different angular ranges.

22083. Lovinger, A. J.; Furukawa, T.; Davis, G. T.; Broadhurst, M. G. **Crystallographic changes characterizing the Curie transition in three ferroelectric copolymers of vinylidene fluoride and trifluoroethylene: 1. As-crystallized samples,** *Polymer* **24,** 1225-1232 (Oct. 1983).

Key words: crystal structure; ferroelectricity; piezoelectric polymers; poly(vinylidene fluoride); pyroelectric polymers; x-ray diffraction.

Copolymers of vinylidene fluoride/trifluoroethylene of molar composition 65/35, 73/27 and 78/22% respectively, are ferroelectric and undergo a Curie transition to the paraelectric state at high temperatures. In contrast to the irregular structure found earlier for the 52/48 mol% copolymer, the structures of these three compositions in the low-temperature state are all well ordered and analogous to that of β-poly(vinylidene fluoride): they consist of molecular chains in a polar *trans* conformation whose order is improved with increasing vinylidene fluoride content, packed pseudo-hexagonally in unit cells whose dimensions decrease with increasing vinylidene fluoride content. In their paraelectric phase, the chains assume a partly disordered conformation consisting of irregular *TG*, *TG* and *TT* sequences and are packed on an expanded pseudo-hexagonal lattice. The Curie transitions were found to occur over a broad temperature range, encompassing ~30°C, and in the case of the 78/22 mol% copolymer to extend into the melting region; they were also found to exhibit hysteresis by occurring at much lower temperatures upon cooling than upon heating.

22084. Hsu, S. M.; Cummings, A. L. **Thermogravimetric analysis of lubricants,** *J. Am. Soc. Automot. Eng., Tech. Paper 831682,* pp. 51-60 (1983).

Key words: lubricants; oxidation; polymerization; thermal degradation; thermogravimetric analysis; volatility.

A novel thermogravimetric analysis test method has been developed for the evaluation of lubricants. It involves superimposing the thermogravimetric trace of the sample in argon over the trace produced in oxygen atmosphere. The difference of the two traces indicates the oxidative influence on volatility as well as on the formation tendencies of high boiling (high molecular weight) oxidation products. The method was illustrated with a base oil with and without a catalyst package and an additive package. The test method is potentially useful for lubricant screening, quality control, and base oil composition effects on thermal oxidative stability.

22085. Holland, D. M. P.; Parr, A. C.; Dehmer, J. L. **Photoelectron asymmetry parameters and branching ratios for sulfur dioxide in the photon energy range 14–25 eV,** *J. Electron Spectrosc. Relat. Phenom.* **32,** 237-243 (1983).

Key words: fluorescence polarization spectroscopy; molecular photoionization; parameters; photoelectron asymmetry; photoelectron kinetic energy; sulfur dioxide; triply differential photoelectron spectroscopy.

Triply differential photoelectron spectroscopy has been performed in the photon energy range 14–25 eV for sulfur dioxide. The results are presented in the form of electronic branching ratios and asymmetry parameters, and are discussed briefly in the context of similar data for CO_2 and of the inner-shell spectra of SO_2.

22086. Hocken, R. J.; Nanzetta, P. **Research in automated manufacturing at NBS,** *Manuf. Eng.* pp. 68-69 (Oct. 1983).

Key words: Automated Manufacturing Research Facility (AMRF); deterministic metrology; hierarchical control; NBS Research Associate Program; software accuracy enhancement.

This article provides a general survey of the technical work and policy decisions which have led to development of an Automated Manufacturing Research Facility at National Bureau of Standards.

22087. Alvarez, R.; Seward, R. W.; Rasberry, S. D. **Clinical standard reference materials from NBS,** *Am. Clin. Prod. Review* **2,** No. 4, 12-25 (July/Aug. 1983).

Key words: calibration materials; chemical analyses; clinical analyses; clinical controls; laboratory standards; spectrophotometers; standard reference materials.

The National Bureau of Standards (NBS), by act of Congress, issues Standard Reference Materials (SRM's) to assist investigators improve the accuracy of their tests. For the clinical laboratory, these well-characterized materials are developed to serve as accuracy-control materials for long-term, measurement quality assurance; to prepare primary calibrator solutions; and to evaluate and monitor the performance of instruments and devices. At present, three accuracy-control materials of lyophilized human serum are available. They are: SRM 909, Human Serum; SRM 900, Antiepilepsy Drug Level Assay; and SRM 1599, Anticonvulsant Drug Level Assay Standard. High-purity clinical SRM's are used to prepare primary calibrator solutions. Examples of these high-purity SRM's are: SRM 911a, Cholesterol; SRM 914, Creatinine; SRM 916, Bilirubin; and SRM 998, Angiotensin I (Human). Instrument-performance SRM's are available for evaluating and monitoring the performance of thermometers, spectrophotometers, spectrofluorimeters, and pH meters.

22088. Bowen, R. L.; Cobb, E. N. **A method for bonding to dentin and enamel,** *J. Am. Dent. Assoc.* **107,** 734-736 (Nov. 1983).

Key words: adhesion; bonding agents; composite; dentin; enamel; resins.

An average tensile bond strength of about one ton (2,000 pounds) per square inch between composites and dentin and enamel was obtained in vitro by applying a 5.3% aqueous solution of ferric oxalate to the tooth surface, followed by water and air cleansing; by applying a 10% acetone solution of NTG-GMA [the adduct of N(*p*-tolyl)glycine and glycidyl methacrylate], followed by cleansing with acetone and air; by applying a 5% acetone solution of PMDM (the addition reaction product of pyromellitic dianhydride and 2-hydroxyethylmethacrylate) followed by air to remove the solvent; and by placing the freshly mixed composite against the treated surface.

Fractures occurred not only in the interfacial region, but also in the composites and in the dentin of the extracted teeth.

22089. Cage, M. E.; Girvin, S. M. **The quantum Hall effect, I,** *Comments Solid State Phys.* **11,** No. 1, 1-16 (1983).

Key words: fine-structure constant; fundamental constants; Landau levels; localized electrons; quantum electrodynamics; quantum Hall effect; resistance standards; semiconductor devices; superconducting magnet; two dimensional electron gas.

The recent surprising observation of a quantization of the Hall resistance in units of h/e^2 in quasi-two-dimensional conductors presents the possibility of obtaining an improved value of the fine structure constant and development of a quantum standard of resistance using a solid state device.

22090. Fassett, J. D.; Moore, L. J.; Travis, J. C.; Lytle, F. E. **The characterization of thermally-produced metastable excited-state atomic species using resonance ionization mass spectrometry,** *Int. J. Mass Spectrom. Ion Processes* **54,** 201-216 (1983).

Key words: Fe; mass spectrometry; metastable excited atoms; Mo; Ni; Re; resonance ionization; thermal vaporization.

Resonance ionization mass spectrometry (RIMS) has been used to study atom plumes produced by thermal vaporization. Experimental results are presented for the elements Fe, Ni, Mo and Re. Ion intensity vs. laser wavelength spectra consistently demonstrate that low-level energy states are significantly populated in the interaction volume of the mass spectrometer. The experimental results are explained by assuming a Boltzmann distribution of states for atoms leaving the heated surface. Since collisional relaxation does not occur in the high-vacuum thermal atom source and the transitions from the excited state to ground state are not radiatively allowed, the Boltzmann distribution of states is maintained in the atom plume. Since many elements possess low-level energy states, both spectroscopic sensitivity and selectivity will be reduced. However, the greater number of intense lines per element allows an increased range of elements to be studied by RIMS in a given wavelength region and opens the possibility of multielement capabilities. The implications for more energetic atomization techniques such as ion sputtering or laser ablation are discussed.

22091. Girvin, S. M.; Cage, M. E. **The quantum Hall effect, II,** *Comments Solid State Phys.* **11,** No. 2, 47-58 (1983).

Key words: fine structure constant; inversion layer; quantum Hall effect; resistance standard; theory.

The recent surprising observation of a quantization of the Hall resistance in units of h/e^2 in quasi-two-dimensional conductors has necessitated a major rethinking of our theoretical picture of transport in these systems. The central problem is understanding why ideal behavior persists even in the presence of strong disorder.

22092. Reader, J.; Ryabtsev, A. **Revised $3p^63d^8\ ^1S_0$ level of Sr XIII, Y XIV, Zr XV, Nb XVI and Mo XVII,** *J. Opt. Soc. Am.* **73,** No. 9, 1207-1208 (Sept. 1983).

Key words: ions; molybdenum; niobium; spectrum; strontium; yttrium; zirconium.

Following an observation by Wyart *et al.* [Phys. Scr. **26,** 141 (1982)], we have revised the position of the $3p^63d^8\ ^1S_0$ level in Sr XIII, Y XIV, Zr XV, Nb XVI, and Mo XVII and have redetermined the $3p^63d^8$ energy parameters in these ions.

22093. Rife, J.; Osantowski, J. **Extreme ultraviolet optical properties of two SiO_2 based low-expansion materials,** *J. Opt. Soc. Am.* **70,** No. 12, 1513-1518 (Dec. 1980).

Key words: ceramics; glasses; low expansion materials; reflectivity; silicon $L_{II,III}$ edge in SiO_2; synchrotron radiation; ultraviolet spectroscopy.

Reflectances of two low-expansion materials, a recrystallized glass ceramic and a high silica glass, have been measured at five angles of incidence from 15° to 85° in the wavelength region from 80 to 310 Å and in some cases up to 1050 Å. Optical constants are derived and silicon core-level transitions analyzed.

22094. Rowe, J. M.; Rush, J. J.; Susman, S. Neutron **powder diffraction study of phase transitions and structures of $(KCN)_x(KBr)_{1-x}$ mixed crystals,** *Phys. Rev. B* **28,** No. 6, 3506-3511 (Sept. 15, 1983).

Key words: $(KCN)_x(KBr)_{1-x}$; mixed alkali cyanide/halide; monoclinic; neutron diffraction; phase transition; structure.

The structures of $(KCN)_x(KBr)_{1-x}$ mixed crystals for $x=0.95$, 0.90, and 0.80 have been determined as a function of temperature. As the temperature is decreased from 295 K, where all of the samples are cubic (as are pure KCN and KBr), all samples measured transform to a monoclinic structure (space group *Cc*). For $x=0.95$ and 0.90, at a lower temperature there is a further transition to an orthorhombic structure similar to that found for pure KCN below 168 K. However, the samples do not transform completely, and the monoclinic and orthorhombic structures coexist down to 6 K. More of the sample transforms for $x=0.95$ than for $x=0.90$. In both cases, that part of the sample which goes into the orthorhombic phase orders completely at the lowest temperatures, in a structure similar to that found for pure KCN at 6 K.

22095. Chang, R. F.; Levelt-Sengers, J. M. H.; Doiron, T.; Jones, J. **Gravity-induced density and concentration profiles in binary mixtures near gas-liquid critical lines,** *J. Chem. Phys.* **79,** No. 6, 3058-3066 (Sept. 15, 1983).

Key words: binary mixtures; concentration gradients; critical azeotropy; density gradients; gas-liquid critical point; gravity effect.

We have calculated gravity-induced density and concentration gradients using scaled equations of state fashioned after that of Leung and Griffiths for binary mixtures near gas-liquid critical lines. The mixtures considered here are those of helium-3 and helium-4 and of carbon dioxide and ethane. Our calculations show that the density profiles for both mixtures in any proportion of the components are similar to those of pure fluids. The concentration gradients in the helium mixture have the same appearance as the density gradients. In the carbon dioxide-ethane system, however, the form of the concentration profile varies greatly, depending on the overall composition. Moreover, the temperature at which a mixture separates into two phases is slightly different from that expected for the mixture in the absence of gravity. We have also examined the case where a mixture is subjected to a large gravitational field such as can be generated in a centrifuge and found that, although the density gradient in all the mixtures is like that in pure fluids, the concentration gradients in the mixtures of carbon dioxide and ethane have complex features related to the presence of critical azeotropy.

22096. Hubbard, C. R. **New standard reference materials for x-ray powder diffraction,** *Adv. X-ray Anal.* **26,** 45-61 (1983).

Key words: fluorophlogopite; internal standard; quantitative analysis; quartz; silicon; standard reference materials; x-ray powder diffraction.

Certification methods and results are presented for several new x-ray powder diffraction standard reference materials. SRM640a silicon powder was certified for lattice parameter and is to be used as a 2θ calibration standard. SRM675 fluorophlogopite was certified as a low 2θ standard to complement SRM640a. A set of five phases are being certified as intensity standards. Preliminary relative intensities and reference intensity ratios are given. A respirable quartz powder is currently being certified for percent amorphous content by a modified spiking analysis method.

22097. Kruger, J.; Rhyne, K. **Current understanding of pitting and crevice corrosion and its application to test methods for determining the corrosion susceptibility of nuclear waste metallic containers,** Paper in *Nuclear and Chemical Waste Management* **3,** 205-277 (Pergamon Press, Inc., Journals Production Dept., Fairview Park, Elmsford, NY 10523, 1982).

Key words: corrosion; crevice corrosion; environmental factors; nuclear waste containers; pitting; susceptibility; testing techniques.

A review of crevice and pitting corrosion mechanism and testing techniques is given to understand the fundamental problems involved in determining corrosion rates of alloys to be used as nuclear waste containers. The mechanisms are broken down into two sections, initiation and propagation of the crevice or pit. Theories of initiation include the absorbed ion displacement model, ion migration or penetration model and the breakdown-repair model. Experimental results concerning the initiation period include a discussion of the kinetics of initiation, the critical potential for breakdowns, and experimental factors affecting the initiation. The theories of pit and crevice corrosion propagation are mentioned as well as factors affecting propagation. Several experimental techniques are discussed that are useful in determining the probability of pitting and/or crevice corrosion of alloys. In assessing the lifetime of the metallic container, accelerated tests are required. With this in mind the testing techniques concentrate on electrochemical techniques and various modifications of these basic techniques. Although susceptibility of alloys to pitting and crevice corrosion can be determined readily, initiation time and propagation rates are not as straightforward particularly over 1000 years. Nevertheless several testing techniques exist that may be used to determine these important values.

22098. Lovinger, A. J.; Furukawa, T.; Davis, G. T.; Broadhurst, M. G. **Crystallographic changes characterizing the Curie transition in three ferroelectric copolymers of vinylidene fluoride and trifluoroethylene: 2. Oriented or poled samples,** *Polymer* **24,** 1233-1239 (Oct. 1983).

Key words: crystal structure; ferroelectricity; piezoelectric polymers; poly(vinylidene fluoride); pyroelectric polymers; x-ray diffraction.

The effects of uniaxial drawing or poling on the structural changes involved in the ferroelectric-to-paraelectric phase transition in copolymers of vinylidene fluoride and trifluoroethylene were examined and compared to the behaviour of as-crystallized films. The compositions studied were 65/35, 73/27 and 78/22 mol% vinylidene fluoride/trifluoroethylene, all of which crystallize from the melt with a molecular conformation and packing analogous to those of the common piezoelectric β-phase of poly(vinylidene fluoride). Contrary to the previously described behaviour of a 52/48 mol% copolymer, orientation did not induce any significant changes in the structure of these copolymers or in its variation with temperature, primarily because these already crystallize directly from the melt in well-ordered, compact unit cells. On the other hand, electrical poling caused the all-*trans* chains of the ferroelectric phase to be packed more compactly and to survive to higher temperatures, thus shifting the Curie transition closer to the melting points of these copolymers. As a result, competition from melting interfered with the later stages of this solid-state transformation in the 73/27 mol% composition, and aborted it at a very early point in the 78/22 mol% samples. The Curie temperature was found to exhibit hysteresis between heating and cooling parts of the thermal cycle, to extend over a broad range of temperatures, and to involve *intra*molecular changes to the same disordered conformation found in melt-crystallized samples. Our results have allowed reasonable implications to be made concerning the existence and nature of a Curie transition in the piezoelectric β-phase of poly(vinylidene fluoride).

22099. Wu, W. L. **Small-angle x-ray study of particulate reinforced composites,** *Polymer* **23,** 1907-1912 (Dec. 1982).

Key words: chord length; composite materials; correlation function; small angle x-ray scattering; three-phase system.

Small-angle X-ray scattering technique can be used to quantify the microvoids structure within a particulate reinforced composite. An expression for the correlation function of three-phase systems has been derived in terms of the correlation function of the individual phases. By using this expression and the scattered intensities from the damaged and the undamaged composites; it has been shown that the volume fraction and the chord length of the microvoids can be obtained, provided no damage occurs to the reinforcement particles. In cases where the microvoids are preferentially oriented within the composites, an approximation scheme based on a linear transformation method has also been developed to measure the aspect ratio of the microvoids provided the volume fraction of these microvoids is much smaller than the other two phases.

22100. Doering, D. L.; Semancik, S. **Low temperature ordering of sodium overlayers on Ru(001),** *Surf. Sci.* **129,** 177-191 (1983).

Key words: adsorption; alkali; LEED; phase-transitions; ruthenium; sodium.

The adsorption of alkali metals on transition metals can produce several technologically important effects, but only limited results have been reported on the geometrical structure of such adlayers, especially for adsorption temperatures below 300 K. We have examined the adsorption of Na on Ru(001) as a function of coverage and temperature using LEED to determine the adlayer structure and thermal desorption spectroscopy to characterize binding kinetics and relative Na coverages. The only Na LEED pattern observed following adsorption at 300 K was that of $(3/2\times3/2)$ structure which occurred near saturation of the first layer. However, Na adsorbed at 80 K produces a progression of distinct, ordered LEED patterns with increasing coverage which does not include the $(3/2\times3/2)$ pattern. These patterns result from increasingly compressed, hexagonal arrangements of adsorbate atoms which are uniformly spaced due to mutually repulsive interactions. The order-disorder transition temperature for each structure was also determined by LEED and used to develop a 2D phase diagram for Na on Ru(001). Ordered structures were observed only when Na thermally induced motion was sufficiently limited and the repulsive Na–Na interaction could force the uniform spacing of Na atoms. Thus, low coverage structures only developed where Na mobility was limited by low temperature. High coverage structures were stable to much higher temperatures since motion was inhibited by the Na density.

22101. Madey, T. E.; Doering, D. L.; Bertel, E.; Stockbauer, R. **Electron- and photon-stimulated desorption: Benefits and pitfalls,** *Ultramicroscopy* **11,** 187-198 (1983).

Key words: chemisorption; electron beam damage; electron stimulated desorption; nickel; photon stimulated desorption; ruthenium; surface chemistry; water.

Electron beam irradiation of solids often results in damage-producing events along with information-producing events. In the present paper we explore mechanisms of beam damage in solids, as well as examples of the benefits of electron- (and photon-) stimulated processes to study molecules at surfaces. Information about the geometrical structure of adsorbed species can be obtained from measurements of the angular distribution of ions released by electron- or photon-stimulated desorption. The directions of ion emission are directly related to the orientations of the surface bonds which are ruptured by the excitation. The method of Electron-Stimulated Desorption Ion Angular Distributions (ESDIAD) has proven particularly useful in characterizing local molecular structure at surfaces in the absence of long-range order; recent measurements of bonding configurations stabilized by impurities or by lateral interactions are discussed. Photon-stimulated desorption (PSD) studies using synchrotron radiation are providing new insights into fundamental electronic excitation processes at surfaces. Mechanisms for the excitation and desorption of ions are examined (valence, shallow core level and deep core level excitations), and examples include ion desorption from adsorbed monolayers, as well as ion formation and desorption processes in condensed molecular films.

22102. Olson, G. J.; Brinckman, F. E.; Jackson, J. A. **Purge and trap flame photometric gas chromatography technique for the speciation of trace organotin and organosulfur compounds in a human urine standard reference material (SRM),** *Int. J. Environ. Anal. Chem.* **15,** 249-261 (1983).

Key words: alkyltins; element specific speciation; flame photometric detection; gas chromatography; organosulfur compounds; organotin compounds; standard reference materials; urine.

Ultratrace levels of organotin species and an organosulfur compound were detected in a National Bureau of Standards (NBS) human urine Standard Reference Material, SRM 2670, and a previously certified urine SRM 2672, using a purge and trap system coupled to a gas chromatograph equipped with a flame photometric detector. Samples of the SRM were treated with sodium borohydride to form volatile tin hydrides. Species detected included dimethyltin (1.04 ng/ml), butyltin (0.03 ng/ml), and dimethyl-disulfide (2.73

ng/ml) in the new stock of freeze dried human urine SRM 2670 being prepared for issue by NBS and methyltin (1.0 ng/ml), butyltin (1.5 ng/ml), and inorganic tin (28.1 ng/ml) in the old stock of SRM 2672. This analytical technique should have useful applications in studies that are needed to develop a toxicological data base and monitoring programs for human organotin exposure.

22103. Olver, F. W. J. **Error bounds for arithmetic operations on computers without guard digits,** *IMA J. Numer. Analysis* **3,** 153-160 (1983).

Key words: absolute precision; error analysis; floating-point arithmetic; inner products; relative precision.

For computers having no form of guard digit in the accumulator register it is not possible to bound the relative error of floating-point subtraction processes in a satisfactory manner. This paper describes some modifications of recent error analyses to cover this situation, including the evaluation of sums and inner products, and indicates the corresponding modifications for the solution of systems of linear algebraic equations.

22104. Phillips, J. C.; Peterlin, A. **Diffusion of ethyl acetate vapor in strained low density polyethylene,** *Polym. Eng. Sci.* **23,** No. 13, 735-742 (Nov. 1983).

Key words: desorption; diffusion; polyethylene; sorption; strained film; transport; vapor.

At a fixed vapor pressure p of the penetrant and constant temperature of the experiment, the sorption $S=c/p$ or concentration c of the ethyl acetate vapor in the uniaxially strained low density polyethylene (LDPE) increases most rapidly at low strains. If, however, on the basis of strain relaxation one separates the total strain ϵ into an elastic ϵ_e, and a plastic ϵ_{pl}, deformation, one obtains an almost linear increase of the concentration c or sorption S of the sorbate with elastic strain ϵ_e. The separation of $\epsilon=\epsilon_e+\epsilon_{pl}$ depends very much on the time t_h the sample is kept elongated and the vapor pressure p of the sorbate. The elastic component decreases and the complementary plastic fraction increases with t_h and p. An almost stationary state is reached after t_h of about $1/2\ h$. The calculation of the diffusion coefficient D_{S1} from the first sorption immediately after the stretching is affected by this slow adjustment in the interval $0 \leqslant t_h \leqslant 1/2h$ and shows a pseudo maximum at a strain of $\epsilon \sim = 10$ percent. The first desorption experiment and all the later sorptions and desorptions yield the same $D_D=D_S<D_{S1}$ that is the correctly calculated diffusion coefficient D. The coefficient D decreases with the strain ϵ or ϵ_e in contrast with the expected increase of D_a of the amorphous component. Such an increase of D_a is expected as a consequence of the fractional free volume (FFV) increase caused by the elongation. According to the FFV concept, a decrease of the measured apparent diffusion coefficient $D=\psi D_a$ requires that with increasing ϵ, the tortuosity factor ψ decreases faster than the increase in D_a.

22105. Powell, C. J.; Erickson, N. E. **Large final-state effects in the core-level electron energy-loss spectra of vanadium at low incident-electron energies,** *Phys. Rev. Lett.* **51,** No. 1, 61-64 (July 4, 1983).

Key words: chromium; core-level binding energies; electron energy-loss spectroscopy; final-state effects; titanium; vanadium.

Large final-state effects have been observed in the $3p$, $3s$, and $2p$ electron energy-loss spectra of vanadium as the incident-electron energy was reduced from 1500 eV to about 50 eV above the core threshold. Changes in the line shapes for the onset of $2p_{3/2}$ excitation and changes in measured threshold energies for $2p_{3/2}$, $3s$, and $3p$ excitation show the significance of the transition from sudden to adiabatic excitation. Strong excitations due to exchange effects are also observed in the $3p$ spectra at low incident energies.

22106. Rhyne, J. J.; Hardman-Rhyne, K.; Smith, H. K.; Wallace, W. E. **Deuterium site occupation and magnetism in $Ho_6Fe_{23}D_x$ compounds,** *J. Less-Common Metals* **94,** 95-105 (1983).

Key words: hydrides; intermetallic compounds; magnetism; neutron diffraction; profile refinement; rare earths.

High resolution neutron diffraction techniques were used to establish the hydrogen (deuterium) site occupation and sublattice magnetization of a series of $Ho_6Fe_{23}D_x$ compounds ($x=1.5$, 8.2, 12.1 and 15.7).

The f.c.c. structure of the parent compound was maintained except for the $D_{12.1}$ sample which exhibited a tetragonal distortion. The f.c.c. lattice was reestablished for the higher $D_{15.7}$ composition. Diffraction and inelastic hydrogen vibration spectra data demonstrate conclusively that the deuterium atoms in the $D_{1.5}$ material fully occupy the octahedral a site with the residual in the tetrahedral f site. At the $D_{8.2}$ and higher concentration level, the a site is empty and the deuterium atoms partially occupy only the tetrahedral sites.

The 4 K holmium magnetic moment was near the free-ion value of 10 μ_B for all compounds and was oriented antiparallel to all four iron site moments (b,d,f_1 and f_2). For the cubic materials, the magnetization on the iron sites varied with deuteration in the range 0.8–2.4 μ_B, with the $D_{15.7}$ compound showing the highest iron moment for all sites. A spin reorientation is observed in the tetragonal material between room temperature and 4 K with the holmium and iron b and n_1 moments rotating out of the basal plane.

22107. Ramaker, D. E. **Comparison of photon-stimulated dissociation of gas-phase, solid and chemisorbed water,** *Chem. Phys.* **80,** 183-202 (1983).

Key words: adsorption; dissociation; ice; photoionization; photon stimulated desorption; water.

Recent electron- and photon-stimulated desorption (ESD/PSD) data for H_2O in the condensed phase and chemisorbed on GaAs(110) and Ti(001) are interpreted utilizing previously published photoemission, electron coincidence and Auger data along with theoretical calculations. Comparison with fragmentation data from the gas phase indicates that only two hole–one electron type states are effective for desorption in condensed or molecularly chemisorbed hydrogen bonded water. The $1b_2^{-1}$ excitation, which effectively dissociates H_2O gas via predissociation, is ineffective in the condensed phase because of the presence of intermolecular decay mechanisms which compete with the predissociation process. Hydrogen bonding reduces the effectiveness of the "$2a_1^{-1}$" excitation for H^+ desorption. The $1b_1^{-2}4a_1$ and $1b_1^{-1}3a_1^{-1}4a_1$ two hole–one electron states are sufficiently long lived; occupation of the strongly antibonding $4a_1$ orbital also makes them repulsive. These properties make the two hole–one electron states the most persistent for H^+ desorption from the H_2O phases studied. The core level PSD spectrum from solid D_2O is also interpreted. All of the results are found to be comparable to previously reported results for CO.

22108. Rupp, N. W. **Status report on amalgamators,** *J. Am. Dent. Assoc.* **107,** 639-640 (Oct. 1983).

Key words: amplitude; capsule; internal length; speed.

Mechanical amalgamators are indispensable adjuncts to placing dental amalgam restorations. Their effectiveness would be improved if the manufacturers of alloy and those for amalgamators would define capsule and pestle characteristics to be used while using certain speed and amplitude amalgamators.

22109. Semancik, S.; Haller, G. L.; Yates, J. T., Jr. **The adsorption and dissociation of methyl isocyanide on Rh(111),** *J. Chem. Phys.* **78,** No. 11, 6970-6981 (June 1, 1983).

Key words: adsorption; dissociation; electron energy loss spectroscopy; methyl isocyanide; rhodium.

The coordination chemistry of methyl isocyanide (CH_3NC), and CO are similar in a number of transition metal complexes, and it is therefore of interest to consider the surface chemistry of these molecules. We have used high resolution electron energy loss spectroscopy (EELS), temperature programmed desorption (TPD), and Auger electron spectroscopy (AES) to characterize the interaction of CH_3NC with Rh(111). At 120 K, EELS measurements indicate that CH_3NC adsorbs nondissociatively as a bridged species. As the coverage is increased, vibrational loss features attributable to singly coordinated bonding occur, and multilayers of CH_3NC eventually develop. In contrast, CO bonds initially to Rh in atop sites, with a bridged form occurring only at higher coverages. Thermally induced changes in the adsorbed CH_3NC have also been monitored; TPD shows that H_2, HCN, and N_2 are liberated from the surface

between 350 and 850 K, and EELS has been used to follow the vibrational mode changes that accompany decomposition. Additional insight was provided by adsorbing CH_3NC onto surfaces predosed with O_2 or CO, both of which produced some site blocking. Other interactional effects include CO and perhaps carbonate formation when CH_3NC reacts with oxygen, and rapid removal of the intensity of the EELS modes associated with CO when CH_3NC is adsorbed onto preadsorbed CO. Comparisons are made with previous results for CH_3NC adsorption on Ni(111), Ag(311), and alumina-supported Rh clusters.

22110. Singleton, D. L.; Irwin, R. S.; Cvetanovic, R. J. **Mechanism of the reaction of oxygen atoms, $O(^3P)$ with dimethyl disulfide,** *Can. J. Chem.* **61,** No. 5, 968-974 (1983).

Key words: chemical kinetics; dimethyl disulfide; ground state oxygen atoms; methyl methanethiosulfonate; oxygen atoms; reaction mechanism; sulfur organics.

The mechanism of the reaction of ground state oxygen atoms, $O(^3P)$, with CH_3SSCH_3 was studied by analysis of the final products. Oxygen atoms were generated by mercury photosensitized decomposition of N_2O such that $[CH_3SSCH_3] \gg [O]$. The only detected product was $CH_3S(O)_2SCH_3$, which accounted for close to 70% of the oxygen atoms reacted. Isomerization of small amounts of *cis*- or *trans*-2-butene added to the reaction mixture indicated the presence of CH_3S radicals. The results are consistent with the primary reaction $O+CH_3SSCH_3 \rightarrow CH_3SO+CH_3S$. The effect of small amounts of CH_3SH and H_2S on the yields of $CH_3S(O)_2SCH_3$ and the products formed provide further information on the nature of the secondary chemistry. A comprehensive reaction mechanism has been proposed.

22111. Zalewski, E. F.; Duda, C. R. **Silicon photodiode device with 100% external quantum efficiency,** *Appl. Opt.* **22,** No. 18, 2867-2873 (Sept. 15, 1983).

Key words: absolute photodetector; absolute radiometer; laser power measurement; photodetector; quantum efficiency; radiometry; silicon photodiodes.

A device utilizing four inversion layer photodiodes in a light-trapping arrangement was constructed and tested. The device was found to have a photon-to-electron conversion efficiency of 0.999 for short wavelength and low power visible radiation. It was found that applying a reverse bias voltage extended the high quantum efficiency response over the entire visible spectrum and up to the highest radiant power level studied (several milliwatts). Several radiometrically important characteristics were studied and the results presented: spectral reflectance; polarization sensitivity; quantum efficiency vs wavelength, photon flux density, and reverse bins voltage; and dark current vs reverse bias.

22112. Veillon, C.; Alvarez, R. **Determination of trace metals in biological materials by stable isotope dilution,** Chapter 5 in *Metal Ions in Biological Systems, No. 16,* pp. 103-122 (Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016, 1983).

Key words: biological materials; mass spectrometry; NBS standard reference materials; stable isotope dilution; trace analysis; tracer studies.

The general principle of stable isotopic dilution (ID) methods for determining trace metals in biological systems is described; and the advantages and disadvantages of specific instrumentation used with ID methods are reviewed. The general method involves equilibration of the trace element with a stable isotope of the element and a determination of the altered isotopic ratio, generally by mass spectrometry.

Compared to other methods, the advantages of ID methods are better accuracy, precision, and sensitivity. In addition, quantitative or known recovery of the elements being determined is not required. The main limitation is the analytical or method blank. A section describes contamination control measures.

Applications of ID procedures are described. At NBS, ID mass spectrometric procedures are used to determine accurately trace elements in biological materials subsequently issued as Standard Reference Materials. A table lists chemical compositions of these SRM's.

22113. Cahn, J. W.; Larché, F. C. **An invariant formulation of multicomponent diffusion in crystals,** *Scr. Metall.* **17,** 927-932 (1983).

Key words: crystal; diffusion; formulation; multicomponent; phenomenological; substitutional.

We give a phenomenological formulation of multicomponent diffusion in crystalline solids that is consistent with our ability to use the lattice as a reference frame and our inability to define chemical potentials of individual chemical potentials, and has some invariances with respect to special relabelling.

22114. Evans, H. T., Jr.; Prince, E. **Location of internal hydrogen atoms in the paradodecatungstate polyanion by neutron diffraction,** *J. Am. Chem. Soc.,* pp. 4838-4839 (July 13, 1983).

Key words: crystal structure; location of hydrogen; molecular complexes; neutron diffraction; polyanion; tungstates.

In previous chemical, x-ray diffraction, and nmr studies, it had been inferred that the paradodecatungstate polyanion, $[H_2W_{12}O_{42}]^{10-}$ contained two internal hydrogen atoms. A neutron diffraction study of the ammonium salt $(NH_4)_5H_2W_{12}O_{42}\cdot 4H_2O$ was undertaken in order to get direct confirmation of this observation and to determine the configuration of the anion complex. The crystals are monoclinic, space group $P2_1n$, with $a=15.079(2)$ Å, $b=14.450(2)$ Å, $c=10.968(1)$ Å, $\beta=109.24(1)°$, $Z=2$. The 25 hydrogen atoms in the asymmetric unit were located by Fourier methods, and the structure was refined by least squares to $R=0.151$, $R_w=0.123$ (based on 1553 observed reflections out of 5256 within the limiting sphere). The positions of the hydrogen atoms within the complex were confirmed. The symmetry of the complex is $\bar{1}$ in the crystal, but it is probably 2/m in solution.

22115. Gates, R. S.; Hsu, S. M. **Development of a four-ball wear test procedure to evaluate automotive lubricating oils,** *J. Am. Soc. Lubr. Eng.* **39,** No. 9, 561-569 (Sept. 1983).

Key words: automotive crankcase oils; boundary lubrication; correlation; oils; step loading; test development; wear test.

Bench wear tests are sometimes used to evaluate antiwear characteristics of lubricating oils in engines, however few correlations are published. In this study, various four-ball wear test methods for evaluating the antiwear characteristics of automotive lubricants were examined. Wear test procedures such as slow and fast sliding speeds, load-capacity tests, and step-loading tests were evaluated using a set of ASTM engine sequence IIID reference oils of known wear performance. Three test procedures were developed that correlated with IIID sequence wear ratings.

22116. Fraker, A. C.; Ruff, A. W.; Sung, P.; Van Orden, A. C.; Speck, K. M. **Surface preparation and corrosion behavior of titanium alloys for surgical implants,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 796,* pp. 206-219 (1983).

Key words: corrosion; implant materials; metal surgical implants; surface films; surface preparation; titanium; titanium alloys.

Surface preparation and corrosion behavior of titanium alloys were studied; both topics deal with the formation of surface oxide films. When metals are prepared for surgical implant use, an effort is made to produce an optimum surface. Effects of the surface treatments on surface morphology, surface film composition, and structure are shown in transmission electron photomicrographs and electron diffraction patterns. Roughened surfaces were produced, and surface films of titanium oxide (TiO) or titanium dioxide (TiO_2) or both occurred on some specimens. Sodium titanate ($NaO\cdot xTiO_2$) occurred on the specimens washed in sodium hydroxide (NaOH) solution.

Open circuit potential versus time curves have been measured to show some electrochemical effects of various surface treatments. The results show that titanium alloys immersed in Hanks' physiological solution reach the same final open-circuit potential after approximately two weeks exposure regardless of prior surface treatment. Measurements of the anodic polarization behavior of titanium alloys and other surgical implant alloys show the effects of alloy composition and the testing solution on the passive region and breakdown potentials of these materials. In general, for titanium alloys, the differences are not great, but the presence of nickel results in a significant lowering of the breakdown potential. The materials

studied were titanium, Ti-6Al-4V, titanium-nickel (memory alloy), Ti-13Cu-4Ni, and Ti-4.5Al-5Mo-1.5Cr. In all cases titanium materials are more corrosion resistant in Hanks' solution than cobalt-chromium-molybdenum Type 316L stainless steel, or cobalt-nickel-chromium alloys. Repassivation measurements show the rapid formation and the high degree of stability of the protective film on titanium and titanium alloys.

22117. Feldman, A. **Graphical representation of prism coupling into thin films,** *Appl. Opt.* **22,** No. 15, 2380-2382 (1983).

Key words: integrated optics; prism coupler; refraction; thin films.

A natural framework for evaluating prism-coupler performance is provided by a recently developed geometrical construction in which refraction through a prism for an arbitrary angle of incidence is represented by an ellipse. The useful operating range of a prism coupler is represented by the portion of the representational ellipse that appears within a window determined by the mode propagation conditions of a thin-film-substrate system.

22118. Kinloch, A. J.; Shaw, S. J.; Tod, D. A.; Hunston, D. L. **Deformation and fracture behaviour of a rubber-toughened epoxy: 1. Microstructure and fracture studies,** *Polymer* **24,** 1341-1354 (Oct. 1983).

Key words: epoxy resins; fracture; liquid rubbers; mechanisms; microstructure; toughening.

The microstructure and fracture behaviour of an unmodified and a rubber-modified epoxy have been studied. Values of the stress intensity factor, K_{Ic}, at the onset of crack growth, the type of crack growth, and the detailed nature of the associated fracture surfaces have been ascertained. Both materials exhibit essentially the same types of crack growth but the values of K_{Ic} for the rubber-modified material were usually significantly higher than those for the unmodified epoxy. The mechanisms for this increased toughness have been considered and a mechanism that accounts for all the observed characteristics has been proposed.

22119. Kinloch, A. J.; Shaw, S. J.; Hunston, D. L. **Deformation and fracture behaviour of a rubber-toughened epoxy: 2. Failure criteria,** *Polymer* **24,** 1355-1363 (Oct. 1983).

Key words: crack modelling; epoxy resins; fracture; liquid rubbers; toughening; yield.

In part 1 the microstructure and fracture characteristics of a rubber-modified epoxy, and for comparison that of the unmodified epoxy, were examined in detail. Based on this analysis a qualitative mechanism involving cavitation, shear yielding and plastic flow was proposed. As an extension of this work, the present paper considers the yield behaviour of the epoxy material and uses the data determined, together with the previously reported fracture results, to calculate values of the crack opening displacement. The rate/temperature dependence of the crack opening displacement and the correlations established between stress intensity factor, K_{Ic}, yield stress and type of crack growth suggest that the extent of crack tip blunting largely governs the relative toughness of the epoxy materials and induces transitions in the types of crack growth observed. A quantitative expression is then presented which successfully describes the fracture toughness values over a wide range of temperatures and rates. The two parameters in this expression are shown to be material constants and therefore provide a unique failure criterion. They can be viewed simply as curve-fitting parameters but they may also have some significance in terms of a critical stress that must act over a critical distance ahead of the crack tip to produce crack growth.

22120. Lang, S. B.; DeReggi, A. S.; Mopsik, F. I.; Broadhurst, M. G. **Preexisting polarization and influence of electrode materials on PVF_2 electrets as determined by thermal pulse and pyroelectric methods,** *J. Appl. Phys.* **54,** No. 10, 5598-5602 (Oct. 1983).

Key words: electrets; electric field poling; electrode materials; electrodes; polarization distribution; polyvinylidene fluoride; pyroelectric coefficient; sample homogeneity; thermal pulse.

A number of polyvinylidene fluoride (PVF_2) electrets were prepared with different permutations of gold and aluminum electrodes and poled with dc fields up to 160 MV m^{-1} at room temperature. Polarization distributions were measured by the thermal pulse method and pyroelectric coefficients were determined. Quantitative measurements were made of a significant level of polarization in nominally unpoled PVF_2 and a contact electrification mechanism was proposed. No consistent effects of electrode materials on polarization distribution were found. PVF_2 poled at room temperature has its highest polarization near the center of the thickness in contrast to the results on samples poled at elevated temperatures and cooled inhomogeneously with the field applied.

22121. Diller, D. E. **Measurements of the viscosity of compressed gaseous and liquid nitrogen+methane mixtures,** *Int. J. Thermophys.* **3,** No. 3, 237-249 (1982).

Key words: composition dependence; compressed gas; compressed liquid; density dependence; methane; mixtures; nitrogen; piezoelectric crystal viscometer; shear viscosity.

The shear viscosity coefficients of three compressed gaseous and liquid nitrogen+methane mixtures have been measured at temperatures between 100 and 300 K and at pressures to about 30 MPa (4350 psia) with a piezoelectric quartz crystal viscometer. The precision of the measurements ranges from about 0.5% at high densities to about 1% at low densities. The estimated experimental error ranges from about 2% at high densities to about 4% at densities near the critical density and at supercritical temperatures near the critical temperature. The measurements have been compared with an extended corresponding states model, previously proposed for calculating the viscosities of fluid mixtures. Differences between the measured and calculated viscosities are discussed.

22122. Sonnefeld, W. J.; Zoller, W. H.; May, W. E. **Dynamic coupled-column liquid chromatographic determination of ambient temperature vapor pressures of polynuclear aromatic hydrocarbons,** *Anal. Chem.* **55,** No. 2, 275-280 (Feb. 1983).

Key words: coupled-column HPLC; gas saturation; high-performance liquid chromatography (HPLC); pH; vapor density; vapor pressure.

A method is described for the direct coupling of a gas saturation system to a high-performance liquid chromatograph for the determination of the vapor pressure of organic compounds in the range of 10^{2}–10^{-6} Pa. The method has been used to determine the vapor pressures of selected polynuclear aromatic hydrocarbons in the ambient temperature range between 10 and 50°C. The vapor pressures (in pascals±standard deviation) at 25°C as determined by this method are as follows: naphthalene, 10.4±0.2; naphthalene-d_8, 10.4±0.1; acenaphthylene, $(8.9\pm0.2)\times10^{-2}$; acenaphthene $(2.9\pm0.9)\times10^{-1}$; fluorene, $(8.0\pm0.2)\times10^{-2}$; phenanthrene, $(1.61\pm0.04)\times10^{-2}$; phenanthrene-$d_{10}$, $(1.92\pm0.05)\times10^{-2}$; anthracene, $(8.0\pm0.2)\times10^{-4}$; fluoranthene $(1.23\pm0.07)\times10^{-3}$; pyrene, $(6.0\pm0.2)\times10^{-4}$; benz[a]anthracene, $(2.8\pm0.1)\times10^{-5}$. These values are generally in good agreement with values extrapolated from determinations made at higher temperatures reported in the literature.

22123. Guyer, D. R.; Hüwel, L.; Leone, S. R. **Single collision ion-molecule reactions at thermal energy: Rotational and vibrational distributions from $N^+ + CO \rightarrow N + CO^+$,** *J. Phys. Chem.* **79,** No. 3, 1259-1271 (Aug. 1, 1983).

Key words: ion-molecule reaction; laser; laser fluorescence; rotation; supersonic jet; vibration.

A new apparatus is developed and used to obtain nascent vibrational and rotational distributions in the ground electronic state of CO^+ formed from the charge transfer reaction $N^+(^3P) + CO(X^1\Sigma^+) \rightarrow N(^4S) + CO^+(X^2\Sigma^+, v, J) + 0.52$ eV, at approximately thermal energies. The device utilizes a flow tube for the production of thermal N^+ ions in a helium buffer and a large diameter sampling orifice which delivers the ions via a mild free jet expansion into a low pressure chamber. The expansion is crossed by a stream of reactant CO molecules and the CO^+ product states are probed by laser-induced fluorescence. Although the energy available is sufficient to populate CO^+ vibrational states up to $v''=2$, the major vibrational channel in the CO^+ product is $v''=0$. The relative vibrational distribution is found to be: $N_{v=0}>0.81$ (observed under single

collision conditions), $N_{v=1}<0.15$ (not observed), and $N_{v=2}\approx 0.04$ (observed only under nonsingle collision conditions). The rotational distribution in the $v''=0$ state is characterized closely by a Boltzmann distribution with a temperature of 410 ± 50 K. This represents a fractional energy disposal into rotation of only 2%. Nearly all of the reaction exothermicity is therefore released into translational recoil. These results are considered in terms of simple dynamical models of the charge transfer process.

22124. Hebner, R. E.; Kelley, E. F.; Fitzpatrick, G. J.; Forster, E. O. **The effect of impurities on positive streamer propagation in n-hexane,** *Proc. 1983 Annu. Report Conf. Electrical Insulation and Dielectric Phenomena, Buck Hill Falls, PA, Oct. 16-20, 1983,* pp. 26-34 (Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, Oct. 1983).

Key words: electrical breakdown; hexane; high speed photography; liquids; prebreakdown phenomena; streamers.

This extended abstract of an oral presentation describes some effects of electrode spacing and chemical purity on the propagation of prebreakdown streamers in n-hexane. One impurity used was dimethyl aniline, a material with low ionization potential, which produced a more hemispherical streamer than was observed in a pure fluid. In addition, the DMA also suppressed the transition to faster propagation modes. The ASA-3, an antistatic additive which reduces the low frequency conductivity, had little effect on the streamer propagation.

22125. Penn, D. R.; Apell, P. **Anomalous electron energy loss in small spheres,** *J. Phys. C: Solid State Phys.* **16,** No. 29, 5729-5743 (1983).

Key words: anomalous; energy loss; nonlocal; small sphere.

In analogy to the case of optical absorption it is shown that inclusion of non-local surface effects results in a very large contribution to the energy loss of fast electrons scattered by a sphere. The scattering is found to be predominantly in the forward direction and is an order of magnitude larger than that calculated classically.

22126. Potzick, J. E.; Robertson, B. **Long-wave acoustic flowmeter,** *Instrum. Soc. Am.* **22,** No. 3, 9-15 (1983).

Key words: density measurements; gas flowmeter; long acoustic waves; mass flowrate; sound speed in fluids; steam flowmeter; volume flowrate.

An acoustic flowmeter has been developed for measuring the flow of an arbitrary single-phase fluid in a pipe. Sound waves are induced in the fluid at two frequencies, one twice the other. The phases and amplitudes of the waves are detected by two microphones located in the wall of the pipe, one downstream from the other a distance of six diameters or more. The frequencies of the sound are automatically adjusted so that the shorter wavelength is equal to the distance between microphones. The instrument then measures in real time the volume flow rate of and the sound speed in the fluid, independent of fluid composition or temperature. If the fluid is a gas and its molecular weight and specific heat ratio are given, the instrument calculates the temperature. Also, given an independent measurement of the pressure in the pipe, the instrument calculates gas density and mass flow rate. The device is nonintrusive, bidirectional, operates in a noisy environment, and responds to rapid changes in flow and temperature. Because the waves are much longer than the pipe diameter, the measurements are independent of the flow, temperature, or density profiles.

22127. Watson, R. E.; Bennett, L. H. **The thermodynamic and physical modelling of alloy phase diagrams,** *J. Mater. Ed.* **5,** No. 4, 635-682 (1983).

Key words: alloys; e.c. phase diagrams; kinetics; metastability; quantum mechanics; semiempirical models; thermodynamics.

This chapter constitutes a status report on current research in the understanding and prediction of alloy phase diagrams. It starts with thermodynamic predictions, emphasizing analytic models for the Gibbs free energies of the various phases. The use of metastable equilibrium phase diagrams which have such an important technological significance is illustrated. Approaches to equilibrium are treated combining equilibrium concepts with kinetics. First principle calculations and semi-empirical models are discussed.

22128. Wilson, W. K.; Parks, E. J. **Historical survey of research at the National Bureau of Standards on materials for archival records,** *Restaurator* **5,** 191-241 (1983).

Key words: accelerated aging; aging; environment; history; history of records materials research; light; microfilm; paper; paper stability; preservation; records; restoration.

The history of research on conservation and stability of records materials at NBS spans more than half a century, and research on stability of materials related to records is still in progress. Most of the effort has been devoted to paper, but work also has been done on stability of microfilm, microfilm blemishes, requirements for a stable laminating film, and environmental requirements for proper storage of records. Research on paper included (1) a study of the effect of light on paper, (2) a comprehensive study of the effect of moisture on accelerated aging, (3) an examination of the effect of aluminum on the aging of paper, (4) two comparisons of accelerated aging and natural aging, and (5) the development of an accelerated aging method that includes some moisture. Several specifications for permanent record papers were developed through a standards organization.

The current research program includes work on the stability of polyester films used as records substrates, and for encapsulation, and the development of statistical techniques for evaluation of the condition of holdings in archival institutions.

22129. Sanchez, I. C. **Bulk and interface thermodynamics of polymer alloys,** *Annu. Rev. Mater. Sci.* **13,** 387-412 (1983).

Key words: Cahn-Hilliard theory; compatibility; corresponding states; critical temperature; equation-of-state; Flory-Huggins theory; interfacial tension; phase stability; spinodal decomposition.

In this review attention is focused on the thermodynamic aspects of polymer alloys (blends) in the liquid state. Three general areas are reviewed: phase behavior, phase separation by spinodal decomposition, and interfacial properties. Only physical blends of homopolymers are considered: alloys involving block or graft copolymers are not reviewed. A major conclusion of this review is that theoretical developments are in general slightly ahead of the experiments. The experimental areas that seem to be lagging behind include measurements of the: phase behavior of oligomeric mixtures, thermodynamic and kinetic parameters that govern spinodal decomposition, interfacial tension and thickness near a critical temperature, and effects of solvent on interfacial properties. Specific suggestions have been made for experimental studies in these deficient areas.

22130. Siegmann, H. C.; Pierce, D. T.; Celotta, R. J. **Spin-dependent absorption of electrons in a ferromagnetic metal,** *Phys. Rev. Lett.* **46,** 452-455 (Feb. 9, 1981).

Key words: absorption; elastic and inelastic scattering; ferromagnetic metal; low-energy electrons; spin-dependent absorption.

It is found that the current collected by a ferromagnet placed in an electron beam depends on the orientation of the incident electron spin. At certain energies, only electrons with spins parallel or antiparallel to the net surface spin density cause a net target current. The spin dependence is caused by the influence of the exchange interaction on the elastic scattering. Inelastic scattering measurements show that the spin dependence of the production of secondary electrons is small.

22131. Stevens, W. J.; Krauss, M. **Finite-field SCF calculations of the dipole polarisabilities of heavy atoms using relativistic effective potentials,** *J. Phys. B: At. Mol. Phys.* **16,** 2921-2930 (1983).

Key words: dipole polarisabilities; relativistic effective potentials; SCF calculations; spin-orbit effects.

The static dipole polarisabilities of Xe, Lu, Hg^+, Hg, Tl and At have been determined from finite-field SCF calculations within a valence-electron relativistic effective potential formalism. The effect of the self-consistent inclusion of spin-orbit coupling on the calculated polarisabilities has been investigated by comparing j-averaged (L,Λ)

results with j-dependent (J,Ω) calculations. The atoms selected provide a range of closed-shell, particle and hole states for comparative study. The results suggest that self-consistent inclusion of spin-orbit coupling is far more important for the particle states than for the hole states.

In the case of Xe, results are presented from calculations using relativistic effective potentials based on both Hamiltonian-consistent and shape-consistent pseudo-orbitals. The shape-consistent approach is found to produce polarisabilities in better agreement with previously determined all-electron Hartree-Fock values. In addition, for Hg the shape-consistent approach yields a polarisability in excellent agreement with all-electron numerical Dirac-Fock calculations.

22132. Sugar, J.; Tech, J. L.; Kaufman, V. **Analysis of the $4d^9$–$4d^85p$ transitions in eleven-times ionized barium (Ba XII),** *J. Opt. Soc. Am.* **73,** No. 8, 1077-1079 (Aug. 1983).

Key words: barium; energy levels; parameters; rhodium sequence; vacuum ultraviolet; wavelengths.

The spectrum of eleven-times ionized barium was generated in a triggered, high-voltage, vacuum spark and photographed with the National Bureau of Standards 10.7-m grazing-incidence spectrograph. The spectral lines of the transition array $4d^9$–$4d^85p$ were identified in the range of 100–125 Å. Thirty-nine lines of this array have been classified as transitions from thirty-two levels of the $4d^85p$ configuration to the $4d^9\ ^2D$ ground term. Radial energy integrals were fitted to the observed levels of $4d^85p$, and the relative intensities in the array were calculated with fitted eigenvectors. These intensities were in good qualitative agreement with the relative intensities that had been visually estimated on the photographic plate. Least-squares-fitted values for the energy parameters and their ratios to the calculated Hartree-Fock (HF) values are given.

22133. Kelley, R. D.; Cavanagh, R. R.; Rush, J. J. **Coadsorption and reaction of H_2 and CO on Raney nickel: Neutron vibrational spectroscopy,** *J. Catal.* **83,** 464-468 (1983).

Key words: carbon monoxide; catalysis; hydrogen; neutron scattering; nickel; vibrational spectra.

Neutron inelastic scattering (NIS) has been used to monitor vibrational modes during the adsorption and reaction of hydrogen and CO on Raney nickel. Evidence for a temperature dependent hydrogen/CO interaction is observed. The results show that CO coadsorbed in equivalent amounts with a saturation layer of H at 80 K has little impact on the H vibrational spectrum and thus on the force constant or configuration of the threefold binding sites occupied by hydrogen. Raising the temperature of the CO+H layer to 295 K shows significant H–CO interactions. Preliminary NIS experiments for H_2/CO gas mixtures under flow conditions indicate that the adsorbed layer present under reaction conditions, i.e., during substantial (~50%) conversion of CO to hydrocarbons (450 K) is dominated by the same adsorbates which are found under non reactive (i.e., no conversion of CO to hydrocarbons) conditions (300 K).

22134. Rakowsky, G. **SURF-II upgrade features magnet and RF system enhancements,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 3444-3446 (Aug. 1983).

Key words: beam; electron storage ring; harmonic cavity; magnet system capability; RF.

The NBS electron storage ring, SURF-II, has been upgraded with a number of major enhancements. The magnet system capability has been increased from 240 to 300 MeV, although actual operation is presently RF limited to 280 MeV. The storage ring magnet has been carefully mapped, resulting in more precise determination of beam energy and better radiometric data. The RF system has been augmented by an auxiliary second harmonic system, terminating in a novel, dual purpose cavity. This structure performs the function of the bump coil during injection, while during acceleration and stored beam operation it functions as a second harmonic cavity. In the latter mode it can either be tuned passively to suppress longitudinal bunch oscillations, or it can be driven actively to modify the longitudinal bunch shape. With proper amplitude and phasing relative to the main RF cavity, bunch lengthening can be achieved, resulting in improved beam lifetime without an increase in vertical size.

22135. Velapoldi, R. A.; White, P. A.; May, W. E.; Eberhardt, K. R. **Spectrofluorimetric determination of polycyclic aromatic hydrocarbons in aqueous effluents from generator columns,** *Anal. Chem.* **55,** No. 12, 1896-1901 (1983).

Key words: aqueous effluents; generator columns; polycyclic aromatic hydrocarbons; spectrofluorimetric technique; standard reference materials.

An on-stream, standards addition spectrofluorimetric technique has been used to determine the concentrations of anthracene, benz[*a*]anthracene, and benzo[*a*]pyrene in the effluents of generator columns (which yield saturated solutions) at temperatures between 10 and 30°C. Concentration values for the standard solutions of PAH's in water over this temperature range were as follows: anthracene, 9.9×10^{-8} to 34.4×10^{-8} mol/L; benz[*a*]anthracene, 1.5×10^{-8} to 5.7×10^{-8} mol/L; and benzo[*a*]pyrene, 2.4×10^{-9} to 8.9×10^{-9} mol/L. Confidence limits (99% Working-Hotelling) for the values at 25°C were approximately 3–8% of the concentration. The method provides data that agree well with data from dynamic coupled column high-performance liquid chromatography and, together with these values, were used to certify the effluent PAH concentrations of the Standard Reference Material generator columns. The method can be used to determine PAH concentrations in aqueous effluents, aqueous solubilities, and octanol-water partition coefficients in a fast, easy procedure.

22136. Baum, H. R.; Rehm, R. G.; Barnett, P. D.; Corley, D. M. **Finite difference calculations of buoyant convection in an enclosure, I. The basic algorithm,** *SIAM J. Sci. Stat. Comput.* **4,** No. 1, 117-135 (Mar. 1983).

Key words: buoyant convection; computations, finite difference; Euler equations; finite difference equations; fire-enclosures; fluid flow.

A novel mathematical model of buoyant convection in an enclosure, developed earlier, is solved by finite difference techniques in the two-dimensional case. This model has been developed as a principal analytical tool for the prediction of the movement of smoke and hot gases in fires. Effects of large density variations caused by substantial heating are retained while acoustic (high-frequency) waves, which are unimportant to buoyant convection, are analytically filtered out. No viscous or thermal conduction effects are included in the model. These two characteristics (filtering and lack of dissipative effects) distinguish the model from all others describing buoyant convection. The mathematical model consists of a mixed hyperbolic and elliptic set of nonlinear partial differential equations: the problem is a mixed initial, boundary value one. An explicit time-marching algorithm, second-order accurate in both space and time, is used to solve the equations. The computational procedure used a software package for solving a nonseparable elliptic equation developed especially for this problem. The finite difference solutions have been carefully compared with analytical solutions obtained in special cases to determine the stability and accuracy of the numerical solutions. The computer model has been used to compute the buoyant convection produced in an enclosure by a spatially distributed heat source simulating a fire. The computed results show qualitative agreement with experimentally observed buoyant convection in enclosure fires.

22137. Proctor, S. J.; Linholm, L. W. **A direct measurement of interfacial contact resistance,** *IEEE Electron Device Lett.* **EDL-3,** No. 10, 294-296 (Oct. 1982).

Key words: contact resistance; integrated circuit test structure; metal-semiconductor contact; semiconductor devices; solid-state electronics; test chip; test pattern; test structure.

A method is described for directly measuring interfacial contact resistance and estimating the degree of uniformity of the interfacial layer in metal-semiconductor contacts. A two-dimensional resistor network model is used to obtain a relationship between the specific contact resistance and the measured interfacial contact resistance for contacts with a homogeneous interfacial layer. Measurement results are given for 98.5% Al/1.5% Si and 100% Al contacts on n-type silicon.

22138. Hardwick, J. L.; Lafferty, W. J. **High values of ΔK_a in the fluorescence of nitrogen dioxide and an improved fit of ground state inertial constants,** *J. Mol. Spectrosc.* **100,** 358-367 (1983).

Key words: fluorescence spectrum; high ΔK_a transitions; improved ground state inertial constants; laser excitation; nitrogen dioxide; spin-forbidden transitions.

Fluorescence of nitrogen dioxide excited by the 4545-Å line of the Ar^+ laser has been dispersed and recorded at high resolution. The most intense transitions arise from the $13_{0,13}$ rotational level of the $^2B_1$ excited electronic state. In addition to the allowed transitions having $\Delta K_a = 1$, weaker transitions with ΔK_a up to 11 have been observed. Moreover, several spin-forbidden (F_1-F_2) transitions have been observed with intensity similar to that of the spin-allowed transitions. The result is unexpected on the basis of the near-prolate symmetric top description of the molecule and the heretofore presumed lack of large perturbations to these levels of the excited electronic state. A simultaneous fit has been performed of virtual spin-free combination differences of the ground vibrational state of NO_2 taken from infrared and microwave spectra. This simultaneous fit yields inertial constants with smaller statistical uncertainty and superior predictive ability than constants derived from any single spectrum and is able to reproduce the fluorescence line positions to within experimental accuracy.

22139. Balluffi, R. W.; Cahn, J. W. **Mechanism for diffusion induced grain boundary migration,** *Acta Metall.* **29,** 493-500 (1981).

Key words: alloys; diffusion; dislocations; grain boundaries; Kirkendall effect; vacancies.

Grain boundaries are found to migrate under certain conditions when solute atoms are diffused along them. This phenomenon, termed diffusion induced grain boundary migration (DIGM), has now been found in six systems. The observed phenomenon and empirical data are used to discard certain concepts for the driving force and the mechanism. We propose a mechanism in which differences in the diffusion coefficients of the diffusing species along the grain boundary cause a self-sustaining climb of grain boundary dislocations and motion of their associated grain boundary steps.

22140. Wilson, M. A.; Cutler, R. I.; Lindstrom, E. R.; Penner, S.; Yoder, N. R.; Ayres, R. L.; Mohr, D. L.; Young, L. M.; Martin, E. R. **NBS-LANL RTM injector installation,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 3021-3023 (Aug. 1983).

Key words: beam transport system; electron gun; NBS-LANL Racetrack Microtron; optics; rf.

A cw 100 keV electron gun and beam transport system has been installed at NBS for the NBS-LANL Racetrack Microtron (RTM). The function of the gun and transport system is to provide a chopped and bunched electron beam for matched insertion into the capture section of a 5 MeV linac injector for the RTM. The chopper system employs multiple r.f. cavities coupled in phase and amplitude to minimize transverse emittance growth. Preliminary gun tests indicate the design emittance of 4π mm-mrad for 4 mA at 100 keV can be achieved. The electron gun, beam transport system, control system, and r.f. chopping and bunching techniques will be described, along with the results of initial 100 keV beam tests.

22141. Wise, S. A.; May, W. E. **Effect of C_{18} surface coverage on selectivity in reversed-phase liquid chromatography of polycyclic aromatic hydrocarbons,** *Anal. Chem.* **55,** No. 9, 1479-1485 (Aug. 1983).

Key words: liquid chromatography; monomeric phase; octadecylsilane; polycyclic aromatic hydrocarbons (PAH); polymeric phase; reversed-phase LC; selectivity; surface coverage.

Recent studies have reported selectivity differences for polycyclic aromatic hydrocarbons (PAH) on different octadecylsilane (C_{18}) reversed-phase liquid chromatographic columns. In this paper the differences in liquid chromatographic selectivity for various C_{18} columns were correlated with differences in C_{18} surface coverage data (as determined from elemental analysis and specific surface area measurements on the C_{18} modified silica). Significant differences in selectivity were observed for selected PAH and polyphenyl arenes on monomeric vs. polymeric C_{18} materials. Selectivity factors for 50 PAH, alkyl-substituted PAH, polyphenyl arenes, and polycyclic aromatic sulfur heterocycles were determined on columns from the same manufacturer from seven different lots of C_{18} material with different C_{18} surface concentrations. In addition to providing information concerning the contribution of C_{18} surface coverage to retention and selectivity in the LC separation of these compounds, these studies provide useful information regarding the selection of the appropriate column to optimize the separation of selected polycyclic aromatic compounds.

22142. Zocchi, M.; Gatti, M.; Santoro, A.; Roth, R. S. **Neutron and x-ray diffraction study on polymorphism in lithium orthotantalate, Li_3TaO_4,** *J. Solid State Chem.* **48,** 420-430 (1983).

Key words: high-temperature form of Li_3TaO_4; low-temperature form of Li_3TaO_4; neutron diffraction; polymorphism; powder method; Rietveld refinement.

The structures of the low- and high-temperature modifications of lithium orthotantalate, Li_3TaO_4, have been determined by neutron and X-ray diffraction methods. The low-temperature, or β, phase has symmetry $C2/c$ and lattice parameters $a_l = 8.500(3)$, $b_l = 8.500(3)$, $c_l = 9.344(3)$ Å, and $\beta = 117.05(2)°$. The high-temperature, or α, phase has symmetry $P2$ and lattice parameters $a_h = 6.018(1)$, $b_h = 5.995(1)$, $c_h = 12.865(2)$ Å, and $\beta_h = 103.53(2)°$. Both structures are ordered. The β-phase has a rock salt-type structure with a 3:1 ordering of the Li^+ and Ta^{5+} ions. Its structure can be generated from the low-temperature modification by means of a complex pattern of shifts of the Ta^{5+} ions.

22143. Tesk, J. A.; Hinman, R. W.; Widera, G. E. O.; Holmes, A. D.; Cassel, J. M. **Effects of porcelain/alloy interfacial diffusion zones on thermo-mechanical strain,** *J. Dent. Res.* **62,** No. 5, 585-589 (May 1983).

Key words: alloys; chemical bonding; dental porcelains; materials; porcelain-fused-to-metal restorations; strain; thermal expansion.

Chemical bonding between dental porcelains and alloys results from interdiffusion of porcelain and metal ions. An interfacial diffusion zone is created which, most likely, has properties different from those of bulk materials. The changed interface might affect experimental measurements of thermo-mechanical strain. To determine the magnitude and conditions under which this would occur, the interface was modeled as the intermediate layer of a three-layered porcelain-veneered split-metal ring. Layer thicknesses and coefficients of thermal expansion were varied, and the effects on gap change after cooling through 500°C were calculated. Results are presented in a series of 14 Figs., ten curves each, which depict not only interfacial effects, but are extended for use in interpretation of the effects of properties of opaques and glazes as well. Under most conditions, the interface will not affect experimental measurements; some special exceptions are noted.

22144. Hansen, R. J.; Hunston, D. L. **Fluid-property effects on flow-generated waves on a compliant surface,** *J. Fluid Mech.* **133,** 161-177 (Dec. 1983).

Key words: compliant coating; drag reduction; hydrodynamic drag; hydrodynamic instability; laminar flow; polymer solutions; turbulent flow; viscoelasticity; viscosity.

An experimental study of the influence of liquid viscosity and viscoelasticity on flow-generated waves on a compliant surface has been conducted in a rotating-disk geometry. Over the entire range of liquid properties studied, each test gave a well-defined critical onset flow velocity above which waves were present and below which no waves were observed. This onset velocity increased with increasing fluid viscosity, and for sufficiently high viscosities the onset occurred when the flow on the disk was laminar rather than turbulent. The effects of liquid viscoelasticity were examined in the turbulent flow using dilute solutions of high-molecular-weight polymers. This type of viscoelasticity has little influence on the onset flow velocity in these circumstances, but did make the wave structure on the surface more regular in appearance than when the liquid was Newtonian. In all cases the wave structure produced a dramatic increase in drag similar to that expected for a rough surface. For the viscoelastic fluid, however, the increase in drag was much less than for a viscous fluid of the same viscosity.

22145. Olsen, R. B.; Hicks, J. C.; Broadhurst, M. G.; Davis, G. T. **Temperature-dependent ferroelectric hysteresis study in polyvinylidene fluoride,** *Appl. Phys. Lett.* **43,** No. 1, 127-129 (July 1983).

Key words: coercive field; cooperative models; Curie point; ferroelectric hysteresis; piezoelectric; polarization; polyvinylidene fluoride; six-site model; two-site model.

An experimental study of temperature-dependent ferroelectric hysteresis phenomena of polyvinylidene fluoride is presented. The temperature dependence of this remanent polarization and coercive field was measured from saturated ferroelectric hysteresis curves with a temperature range 60–130°C. These data were then compared to a two-site and six-site ferroelectric switching model.

22146. Prince, E.; Nicholson, W. L. **A test of a robust/resistant refinement procedure on synthetic data sets,** *Acta Crystallogr.* **A39,** 407-410 (1983).

Key words: error distributions; least squares; refinement techniques; robust/resistant methods; structure refinement; synthetic data.

The conventional crystallographic least-squares procedure has been compared with a robust/resistant modification in which the weight of each reflection is multiplied by a function of the ratio of its residual to a resistant measure of the width of the residual distribution on the previous cycle. Three synthetic data sets were created by adding random errors, according to various probability distributions, to the calculated structure factors for a known crystal structure. A set with a Gaussian error distribution was refined with two sets of weights: one assigned correctly in proportion to the reciprocals of the variances of the data points, the other using unit weights throughout. The second error distribution was Gaussian contaminated by 10% drawn from another Gaussian distribution with its variance nine times greater. The third distribution was a long-tailed distribution derived by dividing a random variable with a Gaussian distribution by an independent random variable with a uniform distribution. Each of the first three cases was refined to convergence using both conventional and robust/resistant procedures, with the modified procedure leading to a result at least as close to the known structure as the conventional procedure. In the fourth case, the conventional procedure gave a poor fit, but the robust/resistant procedure converged to a reasonable approximation to the correct structure.

22147. Penner, S. **The NBS proposal for a one GeV CW racetrack microtron facility,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 3279-3285 (Aug. 1983).

Key words: accelerator; beam transport system; racetrack microtron facility; rf modes.

As part of a joint accelerator research project with the Los Alamos National Laboratory, NBS is now building a 200 MeV, high current, CW racetrack microtron (RTM). Upon its completion, scheduled for 1984, we propose to use this machine to provide CW electron beams to nuclear physics experimenters, and also as the injector for a second stage RTM to boost the final energy to one GeV. A building addition of 35,000 square feet will house the second stage RTM and new experimental facilities. Subharmonic RF beam splitting is planned to allow up to three simultaneous beams for experiments, with currents up to 100 μA each. In addition, low and high energy beams at low currents for tagged-bremsstrahlung experiments can be delivered at the same time. This proposed multi-user facility is intended to be a national center for electromagnetic nuclear physics research.

22148. Eliason, L. K.; Calvano, N. J.; Wakamiya, S.; Frank, D. E. **38/357 caliber revolvers,** *NIJ Standard 0109.00,* 10 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, July 1983).

Key words: handguns; handgun safety; handgun standard; handgun testing; protective equipment; revolvers; 38 caliber revolvers.

This standard establishes performance requirements and test methods for revolvers to be used by law enforcement officers. It addresses only 38 caliber double action revolvers, including those known as 357 magnum. It also provides guidelines for assessing the acceptability of new or reissue revolvers. While revolver sights are not standardized, the factors to be considered in reference to the sighting system are discussed in an appendix.

22149. Eliason, L. K.; Brenner, D.; Treado, M. **Continuous-recording voice-logging tape recorders,** *NIJ Standard 0220.00,* 13 pages (U.S. Department of Justice, National Institute of Justice, Washington, DC, July 1983).

Key words: continuous-recording; law enforcement; multichannel recorder; performance standard; tape recorder; tape recorder test methods; voice-logging recorder; voluntary standard.

The purpose of this standard is to establish performance requirements and test methods for 24 hour continuous-recording, multichannel, reel-to-reel, voice-logging tape recorders used by law enforcement agencies. In addition to performance requirements and test methods, the standard includes the necessary definitions, the information to be supplied to the user or testing facility by the manufacturer or distributor and a listing of the principal items of test equipment needed. This standard is intended for voluntary use by agencies in the selection and procurement process.

22150. Bunding, K. A.; Durst, R. A.; Bell, M. I. **Surface-enhanced Raman spectroscopy of *N*-methylpyridinium cation and pyridine. Identification of surface species,** *J. Electroanal. Chem.* **150,** 437-446 (1983).

Key words: Lewis-acid sites; *N*-methylpyridinium halides; pyridine; surface-enhanced Raman scattering; surface-enhanced Raman spectroscopy.

In this paper are described the results of a series of experiments undertaken to clarify the role of the anion in surface-enhanced Raman scattering (SERS) measurements involving the *N*-methylpyridinium cation (NMP^+) and to identify the actual surface species observed in such experiments. We have studied the effects of varying the anion, pH and electrochemical potential, have performed competition experiments in which both pyridine and NMP^+ were present in the electrolyte and have compared the ordinary Raman spectrum of the solid silver-pyridine complex, $Ag(py)_2NO_3$, with the various SER spectra obtained. By these experiments, we have demonstrated that different pyridine/NMP^+ species are responsible for the observed spectra. In addition, it appears that surface-induced and/or photochemical reactions may produce species not orginally present in the sample solution. Consequently, care must be exercised in the assignment of SER bands to sample components without consideration of possible decomposition to other species capable of producing SERS.

22151. Lovas, F. J.; Suenram, R. D.; Stevens, W. J. **Reaction products from a discharge of N_2 and H_2S: The microwave spectrum of NH_2SH,** *J. Mol. Spectrosc.* **100,** 316-331 (1983).

Key words: dipole moment; hyperfine structure; microwave spectrum; molecular structure; rotational spectrum; thiohydroxylamine.

Thiohydroxylamine has been identified as one of the reaction products from the discharge reaction of N_2+H_2S. Both *cis* and *trans* conformers have been observed. The rotational spectra have been studied from 56 to 170 GHz for the normal species and several deuterated isotopic species of each conformer. The electric dipole moments of both conformers have been determined. A number of the transitions of the *cis* conformer exhibit splittings due to the nuclear quadrupole moment of the ^{14}N nucleus. A least squares fit of the frequency splittings have led to an analysis of the *eQq* values. Ab initio calculations using a 4–31G basis set both with and without polarization functions have been carried out to aid in the analysis and to provide a final structural comparison with the microwave results.

22152. Jacox, M. E. **Reaction of F atoms with nitromethane. Vibrational spectra of the addition complex and of the nitromethyl free radical,** *J. Phys. Chem.* **87,** No. 16, 3126-3135 (Aug. 4, 1983).

Key words: F-atom addition complex; F-atom reactions; H-atom abstraction; hydrogen bonding; infrared spectrum; isotopic substitution; matrix isolation; nitromethane; nitromethyl; photodecomposition; tunneling; vibrational assignment.

When the products of the reaction between F atoms formed in a microwave discharge and CH_3NO_2 are frozen in a large excess of argon at 14 K, new infrared absorptions appear which, with the help of detailed isotopic substitution studies, have been assigned to the nitromethyl free radical. A large fraction of the nitromethyl is hydrogen bonded to HF trapped in an adjacent site. Analysis of the infrared spectrum for the HF complex indicates that the hydrogen bonding is relatively strong. The threshold for photodecomposition of nitromethyl lies between 300 and 280 nm. The resulting H_2CO and NO may be formed either directly or by the cage recombination of CH_2 and NO_2. In the $F+CH_2DNO_2$ and CHD_2NO_2 reaction studies, H-atom abstraction occurs selectively, and in the $F+CD_3NO_2$ reaction study, prominent absorptions of an F-atom addition complex are present in the spectrum of the initial deposit. The threshold for the photodecomposition of this complex into CD_2NO_2+DF lies between 490 and 420 nm. These observations suggest that the initial attack of the F atom on nitromethane results in the formation of an addition complex which, when H atoms are present, eliminates HF by a tunneling mechanism.

22153. Eriksson, K.; Linsky, J. L.; Simon, T. **Outer atmospheres of cool stars. XIV. A model for the chromosphere and transition region of Beta Ceti (G9.5 III),** *Astrophys. J.* **272,** No. 2, 665-677 (Sept. 15, 1983).

Key words: stars, chromospheres; stars, coronae; stars, individual; stars, late-type; ultraviolet, spectra; x-rays, sources.

We compute a model for the chromosphere and transition region of β Ceti (G9.5 III) consistent with *IUE* spectra of the resonance lines of Mg II, C II, and C IV. We treat the Mg II *h* and *k* lines in partial redistribution and the C II and C IV lines in complete redistribution. A good match to the observed line profile fluxes and to the Mg II *k* line profile is achieved for a hydrostatic equilibrium one-component model with temperature plateaus at 5500 K and 22,500 K, but this model is not unique. We present computed line fluxes for a range of models to show the range of permitted temperature structures. Beta Ceti lies immediately to the left of the boundary in the H-R diagram generally separating stars with and without high temperature plasmas. Comparing the β Ceti model to models previously computed in a similar way for other stars, we find a trend of decreasing chromospheric pressure and increasing geometric scales as single stars evolve across the tansition region boundary. Also this analysis suggests that the transition region pressures decrease drastically and geometric scales increase rapidly as single giant stars evolve to the right toward the boundary. Beta Ceti is a very luminous X-ray emitter for its spectral type and rotational velocity. Its X-ray brightness could be explained either by a corona containing many high-pressure loops or a high-pressure homogeneous corona overlying an inhomogeneous transition region. The question of pressure balance between the corona and transition region including magnetic forces requires further study.

22154. Drake, S. A.; Linsky, J. L. **The formation of emission lines in the expanding chromospheres of luminous cool stars. I. The importance of atomospheric extension and partial redistribution effects,** *Astrophys. J.* **273,** No. 1, 299-308 (Oct. 1, 1983).

Key words: line profiles; radiative transfer; stars, chromospheres; stars, late-type.

Most late-type luminous stars are losing mass in cool stellar winds, although the mass-loss rates and mechanisms of these outflows remain uncertain. In many red giants the only evidence for mass loss is the presence of a characteristic asymmetry in the strongest ultraviolet resonance lines, such as the Mg II *k* line. In this paper, we discuss the available methods for treating radiative transfer in such chromospheric lines in an expanding, extended medium and select the comoving frame method (including partial redistribution) as the most suitable. We briefly outline this technique in the context of a two-level atom. Prior to applying this technique to deriving atmospheric properties from observed line profiles, we present some schematic examples to illustrate the sensitivity of the calculated line profiles to the outflow velocity, chromospheric temperature gradient, physical extent of the atmosphere, line-to-continuum strength, and the incoherence fraction. In this paper, we illustrate the difference in the computed line profiles between assuming partial and complete redistribution for a wide range of atmospheric and wind parameters.

22155. Kahan, D. J.; Harris, J. F.; Bennett, L. H. **Compilations of alloy phase diagram and related data,** *Bull. Alloy Phase Diagrams* **3,** No. 4, 417-435 (1983).

Key words: alloy; alloy crystallography; compilation; phase diagram; phase stability; thermodynamics.

This revised compilation of alloy phase diagram compilations and evaluations supersedes earlier versions. It lists most of the English language, and several Russian and other language, publications containing significant amounts of alloy phase diagram data. It is intended that coverage of the important evaluated data compilations from all over the world on this subject be comprehensive.

22156. Lawn, B. R.; Dabbs, T. P.; Fairbanks, C. J. **Kinetics of shear-activated indentation crack initiation in soda-lime glass,** *J. Mater. Sci.* **18,** 2785-2797 (1983).

Key words: crack initiation; decohesion; glass; incubation time; indentation flaws; shear faults.

The initiation of radial cracks in Vickers indentation of soda-lime glass is found to be strongly rate dependent. For long contact durations the radial cracks pop in during the indentation event, at a reproducible stage of the unloading half-cycle; for short contacts the pop-in occurs after the event, with considerable scatter in delay time. The phenomenon is interpreted in terms of an incubation time to develop a critical nucleus for the ensuing fracture. Increasing either the water content of the environment or the peak contact load diminishes the incubation time. Scanning electron microscopy of the indentation patterns indicates that the sources of the crack nuclei are constrained shear faults within the deformation zone. A qualitative model is developed in terms of a two-step process, precursor faulting followed by crack growth to pop-in instability. Moisture may influence both these steps, in the first by interfacial decohesion and in the second by slow crack growth. No definitive conclusion is reached as to which of the steps is rate-controlling, although it appears that it is the shear across the fault and not the tension across the crack which is vital in driving the initiation. The implications of these results in connection with the basic mechanical properties of brittle solids, particularly strength, are considered.

22157. Lindstrom, E. R.; Debenham, P. H.; Mohr, D. L.; Yoder, N. R. **The NBS-LANL RTM end-magnet field mapper,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 3605-3607 (Aug. 1983).

Key words: circuitry; coils; data acquisition and control; magnetic field mapper; measurement; NBS-LANL racetrack microtron.

A computer-controlled magnetic field mapper is under construction at the National Bureau of Standards to map the end magnets of the NBS-LANL racetrack microtron (RTM). The mapper consists of a large, two-dimensional translation stage which simultaneously positions a nuclear magnetic resonance (NMR) magnetometer probe in the 55 cm×135 cm uniform field region and a temperature-compensated Hall effect probe in the fringe field region. A computer-based control system automatically positions the probes at points on a selected grid and records the measured field values and positions in computer memory. In this paper we describe the field mapping requirements, the mapper, its operation, and the field measurements and analysis that are to be performed.

22158. Lodge, T. P.; Han, C. C.; Akcasu, A. Z. **Temperature dependence of dynamic light scattering in the intermediate momentum transfer region,** *Macromolecules* **16,** No. 7, 1180-1183 (1983).

Key words: Akcasu-Gurol Formalism; characteristic frequency; first cumulant; intermediate region; modified blob model; quasielastic scattering; temperature dependence.

Dynamic light scattering measurements have been made on dilute solutions of very high molecular weight polystyrenes in cyclohexane at 35.4, 45.0, and 55.2°C. The data have been analyzed in terms of the first cumulant $\Omega(q)$ of the dynamic structure factor $S(q,t)$, with particular emphasis on the intermediate momentum transfer region ($R_g^{-1} \ll q \ll l^{-1}$), for which theoretical predictions yield $\Omega(q) \sim q^3$. The temperature dependence of the magnitude of $\Omega(q)$ is examined in terms of a "modified blob" model for the equilibrium distribution

function and the preaveraged Oseen tensor description of hydrodynamic interaction. The temperature dependence of the experimental results is found to be in very good agreement with the theoretical calculations, although the magnitude of $\Omega(q)$ at each temperature falls consistently slightly below ($\sim 15\%$) the theoretical predictions, as reported previously for both good solvent and Θ conditions.

22159. Lynn, J. W.; Shelton, R. N.; Horng, H. E.; Glinka, C. J. **Investigation of the magnetic and superconducting properties of $(Er_{1-x}Ho_x)Rh_4B_4$,** *Physica* **120B,** 224-226 (1983).

Key words: coexistence; ferromagnetism; neutron scattering; small-angle scattering; superconductivity; susceptibility.

Neutron scattering, susceptibility and resistivity measurements have been carried out for the system $(Er_{1-x}Ho_x)Rh_4B_4$ near the multicritical point where the magnetic and superconducting phase boundaries converge ($x \simeq 0.9$). On the Ho rich side ($x > x_c$) no superconducting state is observed, whereas for $x < x_c$ there is a temperature interval $T_{c2} < T < T_{c1}$ were superconductivity exists. For all concentrations studied a transition to a long-range ordered ferromagnet is observed, with the Ho moments ordering along the tetragonal axis. The behavior of the order parameter is mean-field like, indicating that the range of the magnetic interactions is large. For $x \sim x_c$ the ferromagnetic transition appears to be continuous, and occurs within the superconducting phase, suggesting the coexistence of ferromagnetic order and superconductivity. Below T_m strongly temperature dependent small angle scattering is observed, characterized by a cross section of the Porod form $S(Q) = A(T)/Q^4$. The strength of the scattering $A(T)$ increases monotonically with decreasing temperature.

22160. Lyon, G. **Machines, programs, and languages: A simplistic introduction to computer science,** *ACM SIGSOFT Software Eng. Notes* **8,** No. 3, 61-63 (July 1983).

Key words: algorithms; computer science; data structures; digital computers; programming languages; programs.

The general aim of computer science is to discover and exploit principles of computation that are suitable on digital computers. In pursuit of this goal, there emerge three broad conceptual categories: digital computers that store discrete information and work in discrete steps, programs which describe operation sequences and operand formats within computers, and programming languages that express programs.

22161. Mangum, B. W. **The succinonitrile triple-point standard: A fixed point to improve the accuracy of temperature measurements in the clinical laboratory,** *Clin. Chem.* **29,** No. 7, 1380-1384 (1983).

Key words: analytical error; clinical laboratory; instrument calibration; quality control; succinonitrile; temperature fixed point; temperature reference point; thermistor; thermometry.

In an investigation of the melting and freezing behavior of succinonitrile, the triple-point temperature was determined to be 58.0805°C, with an estimated uncertainty of ±0.0015°C relative to the International Practical Temperature Scale of 1968 (IPTS-68). The triple-point temperature of this material is evaluated as a temperature-fixed point, and some clinical laboratory applications of this fixed point are proposed. In conjunction with the gallium and ice points, the availability of succinonitrile permits thermistor thermometers to be calibrated accurately and easily on the IPTS-68.

22162. Mann, W. B. **Needs for radioactivity standards and measurements,** *Int. J. Appl. Radiat. Isot.* **34,** No. 8, 1041-1046 (1983).

Key words: alpha rays; beta rays; gamma rays; lasers; radioactivity; spectrometry; standards; traceability.

At the summer school held in Herceg Novi in 1972, a paper was given on the then contemporary needs in the field of radionuclide metrology. In the intervening years many of the measurements needs have been met and, moreover, the interest in nuclear power in some countries and in its by-products, has waned. Some of the chief interests now lie in the development of the more sensitive methods of measurement such as atom counting to the same level of accuracy as activity measurements, and also in the acquisition of needed and consistent decay data.

22163. Meijer, P. H. E.; Clausse, D. **Rate of ice formation in supercooled water,** *Physica* **119B,** 243-248 (1983).

Key words: crystallisation; onset time; quenching; supercooling.

In this paper we argue that the form of the crystallisation curves obtained for supercooled water and benzene can be explained by assuming a two-step process. This hypothesis can also give a phenomenological explanation of the behaviour of a system subject to precooling, as well as the rate dependence on the crystallisation. We predict how the onset time will depend on the duration of the precooling. We give a number of arguments to support the idea of an intermediate phase. The description does not rely on small fluctuations in order to trigger the crystallisation process.

22164. Mountain, R. D.; MacDonald, R. A. **Thermal conductivity of crystals: A molecular-dynamics study of heat flow in a two-dimensional crystal,** *Phys. Rev. B* **28,** No. 6, 3022-3025 (Sept. 15, 1983).

Key words: heat flow; Lennard-Jones crystal; Lennard-Jones liquid; molecular dynamics; thermal conductivity; two dimensions.

We have studied steady-state heat flow in a two-dimensional crystal by the method of molecular dynamics. The model system contains 1000 particles on a triangular lattice interacting via the Lennard-Jones potential. The system is 50 unit cells long and 10 unit cells wide. We find that the thermal conductivity κ of this system is consistent with $1/T$ behavior as expected when phonon-phonon scattering is the dominant mechanism for thermal resistance. We have also carried out similar calculations for three-dimensional Lennard-Jones systems in both fluid and crystalline configurations. The results for the fluid were in good agreement with earlier calculations but for the fcc solid system, 16 unit cells in length, κ was independent of temperature. We determined that boundary scattering was the dominant resistive mechanism in this case. To escape the boundary-limited regime, the length of the three-dimensional crystal needs to be increased by at least a factor of 3. It is feasible to simulate a system of this size with the use of modern computers.

22165. Munro, R. G.; Mountain, R. D. **Phase relations and properties of lithium via molecular dynamics,** *Phys. Rev. B* **28,** No. 4, 2261-2263 (Aug. 15, 1983).

Key words: molecular dynamics; phase diagram.

The phase diagram of lithium in the region $295 \leqslant T \leqslant 600$ K and $0 \leqslant p \leqslant 12$ GPa has been studied theoretically with the use of the recently developed molecular dynamics formalism of Parrinello and Rahman. Excellent agreement between theory and experiment has been obtained for (1) the room-temperature bcc-fcc structural phase transition; (2) the temperature dependence of the bcc-fcc phase boundary; (3) the room-temperature compression curves for the bcc and fcc phases; and (4) the bcc-liquid melting curve. Additionally, a theoretical prediction has been made for the isobaric thermal expansion from 400 to 600 K at 5 GPa pressure.

22166. McLaughlin, W. L.; Uribe, R. M.; Miller, A. **Megagray dosimetry (or monitoring of very large radiation doses),** *Radiat. Phys. Chem.* **22,** Nos. 3-5, 333-362 (Sept. 1983).

Key words: beam mapping; dosimetry; electron beams; gamma radiation; high radiation doses; LiF; megagrays; megarads; plastic films; radiation imaging; radiation processing; radiochromic dyes.

A number of suitably calibrated plastic and dyed films and solid-state systems can provide mapping of very intense radiation fields with high spatial resolution and reasonable limits of uncertainty of absorbed dose assessment. Although most systems of this type suffer from rate dependence and temperature dependence of response when irradiated with charged particle beams at high dose rates, a few are suitable, easily calibrated, and capable of faithful imaging of detailed dose profiles, even at doses up to 10^6 Gy and dose rates up to 10^8 Gy·s^{-1}. Candidates include certain undyed plastic films (e.g., polyethylene terephthalate and polyhalostyrenes), some dyed cellulosics, radiochromic dye films (e.g., Nylon-base "Trogamide" films) and pure LiF crystals.

22167. Ellingwood, B. **Towards unified probability-based design,** *Build. Res. Pract.* **9,** No. 2, 162-171 (Mar./Apr. 1983).

Key words: buildings (codes); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; standards; statistical analysis; steel; structural engineering.

Throughout the world there are moves to achieve a common basis for structural design applicable to concrete, steel, timber and masonry, but the problems are considerable. They are exemplified in the USA, but recent advances there in applying probabilistic methods have made the objective more feasible. The Center for Building Technology of the U.S. National Bureau of Standards has an important role in this unifying process, and an engineer at the Center here discusses the progress achieved in that country and the problems ahead.

22168. Timothy, J. G.; Madden, R. P. **Photon detectors for the ultraviolet and x-ray region,** Chapter 5 in *Handbook on Synchrotron Radiation,* pp. 315-366 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1983).

Key words: electronographic cameras; gas ionization; ionization chambers; microchannel array plates; operating characteristics; photodiodes; photon detectors; ultraviolet; x-ray region.

Synchrotrons and storage rings provide intense sources of continuum radiation that are of particular importance at ultraviolet and X-ray wavelengths. A 4 GeV synchrotron-radiation source will provide significant power down to hard X-ray wavelengths as short as 0.25 Å (50 keV), and a 4 GeV machine boosted by a wiggler will emit at wavelengths as short as 0.15 Å (80 keV).

In this chapter, we review the available photon detectors that are suitable for use with synchrotron radiation at ultraviolet and X-ray wavelengths between 3000 Å (4 eV) and 0.1 Å (124 keV). Since this wavelength range covers more than four decades in photon energy, it is necessary to subdivide it into a number of distinct regions on the basis of a series of technical considerations.

22169. Mickley, M.; Hanley, H. J. M. **The influence of physical property data on the design of shell and tube heat exchangers,** (Proc. American Society of Mechanical Engineers 1982 Winter Meeting, Phoenix, AZ, Nov. 14, 1982), *Paper No. 82-WA/HT-60,* pp. 1-3 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, Nov. 1982).

Key words: cost analysis; error effects; heat exchanger; heat transfer; thermophysical properties.

This paper addresses the physical property data needed to design heat transfer equipment and the effect of imprecision in such data on capital investment and operating costs. An analysis is presented for the design of a shell and tube heat exchanger. For two specific examples chosen, it is shown that a ten percent error in data for the working fluids may result in as much as a 24 percent uncertainty in the optimum size of the heat exchanger, which translates into a 13 percent increase in the installed exchanger cost and a 10 percent increase in the annual fixed costs of the exchanger.

22170. Faller, J. E.; Guo, Y. G.; Niebauer, T. M.; Rinker, R. L. **Promise and plans for the JILA gravimeter,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 477-488 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, June 1983).

Key words: acceleration of gravity; precision measurement.

During the past several decades, scientific interest in gravity has continued to be strong. At the Joint Institute for Laboratory Astrophysics (JILA) we have recently designed and built a new highly-portable absolute gravity apparatus based on laser interferometry. This instruments performance and our plans for its use are discussed.

22171. Faller, J. E. **Little "g": An introduction to dropping things,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 465-476 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, June 1983).

Key words: acceleration of gravity; design of experiments; gravity; mechanical design.

An introduction to the measurement of g, the acceleration of gravity is given. In particular the experimental details and problems are discussed in a pedagogical way.

22172. Hanley, H. J. M.; Baltatu, M. E. **Data and thermal design: The role of fluid property data and their significance in design calculations,** *Mech. Eng.* **105,** No. 6, 68-72 (June 1983).

Key words: data; design calculations; heat exchanger; mixtures; partially characterized fluids; uncertainties in data base.

The role of fluid property data, and the significance of data in design calculations, is discussed. Some difficulties are pointed out with partially characterized fluids, with mixtures of diverse species, and with fluids under difficult operating conditions, such as near a critical point or subject to a high shear rate and transient temperature. A practical example is presented to illustrate how problems with a partially characterized fluid could affect the design of a heat exchanger.

22173. Faller, J. E. **Introductory remarks. Opening ceremony, January 31, 1983. Symposium on precision measurement and gravity experiment,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 5-6 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, June 1983).

Key words: precision measurement; scientific method; system at errors.

The character and philosophy of precision measurement is discussed. Problems relating to systematic errors are mentioned.

22174. Faller, J. E. **Telescopes and the forces that mold them: An introduction to optics and mechanical design,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 21-34 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, June 1983).

Key words: design of experiments; mechanical design; optical design; telescopes.

This is designed to serve as an introduction to optics and mechanical design. It does this by discussing the how and the whys of telescope design. In particular it emphasizes the fact that as telescopes evolve from small to big, structural considerations have proved to be of great importance and have often been of primary considerations in dictating the final design.

22175. Faller, J. E.; Keiser, G. M.; Keyser, P. T. **The fluid-fiber based torsion pendulum: An alternative to simply getting a bigger hammer,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 557-569 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, June 1983).

Key words: design of experiment; Eötvös experiment; torsion fibers.

In the preceding lectures I've given in this school, I've tried to suggest that sometimes one needs to look for a new or different approach to a problem rather than simply proceeding to do everything slightly better or to make the same type of apparatus somewhat bigger. Today I'm going to talk about an alternative to the traditional torsion fiber which we have developed in connection with an experiment to check the equivalence of gravitational and inertial mass. This experiment, which asks the question—"Do all materials fall at the same rate in a gravitational field?"—is also known as the Eötvös experiment.

22176. Haynes, W. M. **Measurements of densities and dielectric constants of liquid propane from 90 to 300 K at pressures to 35 MPa,** *J. Chem. Thermodyn.* **15,** 419-424 (1983).

Key words: Clausius-Mossotti function; compressed liquid; density; dielectric constant; propane.

Results of density and dielectric-constant measurements on compressed liquid propane are reported. The results cover a temperature range from 90 to 300 K at pressures to 35 MPa. The experimental densities and dielectric constants have been used to compute values for the Clausius-Mossotti function.

22177. Giarratano, P. J.; Steward, W. G. **Transient forced convection heat transfer to helium during a step in heat flux,** *J. Heat Trans.* **105,** 350-357 (May 1983).

Key words: forced convection; heat transfer; helium; natural convection; subcritical; supercritical; transient.

Transient forced convection heat transfer coefficients for both subcritical and supercritical helium in a rectangular flow channel heated on one side were measured during the application of a step in heat flux. Zero flow data were also obtained. The heater surface which served simultaneously as a thermometer was a fast response carbon film. Operating conditions covered the following range: Pressure, 1.0×10^5 Pa (1 bar) to 1.0×10^6 Pa (10 bar); Temperature, 4 K–10 K; Heat Flux, 0.1 W/cm^2–10 W/cm^2; Reynolds number, $0–8\times10^5$. The experimental data and a predictive correlation are presented.

22178. Young, M. **Quantum noise limits the pinspeck camera to simple objects,** *J. Opt. Soc. Am.* **72,** No. 3, 402-403 (Mar. 1982).

Key words: camera; film-grain noise; Fresnel zone plate; image; photography; photon noise; pinhole camera; pinspeck camera; quantum noise; veiling glare; zone plate.

The pinspeck camera projects a low-contrast image with a great deal of veiling glare. Quantum noise determines that the camera can image only simple objects that contain no more than a few hundred picture elements.

22179. Young, M. **Optical fiber index profiles by the refracted-ray method (refracted near-field scanning),** *Appl. Opt.* **20,** 3415-3422 (Oct. 1, 1981).

Key words: fiber index profile; index profile; near-field scanning; optical communications; optical fiber; optical waveguide; refracted near-field scanning; refracted-ray scanning; resolution limit.

This paper has two primary purposes. First, it provides an elementary description and tutorial overview of the refracted-ray method of measuring fiber index profiles. Second, it presents new results concerning the theoretical foundation, the linearity and precision, and other aspects of the method. In particular, we find that index differences may be measured to 5% or better and conclude by showing ~3% agreement with another laboratory and good agreement with numerical aperture measurements performed by participants in an interlaboratory comparison.

22180. Young, M. **Book review: Principles of Optical Fiber Measurements by Dietrich Marcuse,** *Laser Focus,* pp. 118-119 (Jan. 1982).

Key words: book review; fiber; measurements; optical communications; optical fiber; optical waveguide.

A review of the book, Principles of Optical Fiber Measurements, by Dietrich Marcuse.

22181. Yokel, F. Y.; Salomone, L. A.; Gray, R. E. **Housing construction in areas of mine subsidence,** *Am. Soc. Civ. Eng. J. Geotech. Eng. Div.* **108,** No. GT9, 1133-1149 (Sept. 1982).

Key words: foundation design; housing construction; mine subsidence; mining settlement; structural design.

Many areas in the United States are underlain by abandoned mines and many more areas will be undermined in the future. As mine cavities collapse they cause settlement and ground distortions on the surface which may damage or destroy buildings and utilities. Many of these subsidence-prone areas are presently used or will be used in the future for residential housing development. Three problems associated with the development of mine subsidence areas are addressed: site exploration and evaluation; site development; and housing construction in mine subsidence areas. This paper is derived from a study sponsored by the Department of Housing and Urban Development.

22182. Wineland, D. J.; Bollinger, J. J.; Itano, W. M. **Laser-fluorescence mass spectroscopy,** *Phys. Rev. Lett.* **50,** No. 9, 628-631 (Feb. 28, 1983).

Key words: atomic g factor; atomic spectroscopy; ion storage; laser fluorescence; mass spectroscopy; proton to electron mass spectroscopy.

Measurements of ion cyclotron-resonance frequencies in a Penning trap, by a laser fluorescence technique, are described. This technique has been applied to indirect measurements of the proton-to-electron mass ratio and the $^9Be^+$ electron g_j factor. It is found that $m_p/m_e=$ 1836.152 38(62) (0.34 ppm) and $g_j(^9Be^+)=2.002\ 262\ 06(42)$ (0.21 ppm). Ultimately, ion cyclotron-resonance accuracies near 1 part in 10^{13} should be possible.

22183. White, G. S.; Marchiando, J. F. **Scattering from a V-shaped groove in the resonance domain,** *Appl. Opt.* **22,** No. 15, 2308-2312 (Aug. 1, 1983).

Key words: diffusion; electromagnetic; IR; NDE; profile; roughness; scattering; shallow groove; surface.

Radiation scattered from a *V*-shaped groove in the resonance domain was measured and compared to predictions from a rigorous theory. The calculated scattering accurately predicted the number of peaks and general shape of the observed scattering. Small variations in groove shape were found to alter peak heights noticeably and peak positions slightly. Finite beam size caused unavoidable discrepancies between calculated and measured scattering.

22184. Warshaw, S. L. **New directions for the Office of Product Standards Policy,** *NSCL Newslett.* **22,** No. 3, 7 (Sept. 1982).

Key words: accreditation; laboratory; legal; metrology; policy; standards; weights and measures.

The Department of Commerce, Office of Product Standards Policy was reorganized and transferred within the Department to the National Bureau of Standards in May 1982. The office is now responsible for the formulation and implementation of policy on national and international standards, laboratory accreditation, and legal metrology. A top priority of the office is to promote the international competitiveness of American industry by assisting in efforts to reduce the number of technical barriers to trade in the form of standards or testing and certification programs.

22185. Wait, D. F. **Precision measurement of antenna system noise using radio stars,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 110-116 (Mar. 1983).

Key words: antenna gain; antenna half-power beamwidth; atmospheric loss; Cassiopeia A; Earth Terminal Measurement System; figure of merit; moon; noise equivalent flux; noise measurement; radio stars; satellite communication.

This paper reviews the National Bureau of Standards (NBS) precision noise measurements program for antenna systems which have been made using Cassiopeia A and the moon. The Earth Terminal Measurement System (ETMS) was developed by NBS to make measurements of figure of merit (G/T), and the noise equivalent flux (NEF). The accuracy of the noise measurements are, typically, between 5 and 15 percent for systems with antenna gains between 51 and 65 dB and frequencies between 1 and 10 GHz.

22186. Wada, H.; Inoue, K.; Tachikawa, K.; Ekin, J. W. **Effect of strain on the critical parameters of V_2(Hf,Zr) Laves phase composite superconductors,** *Appl. Phys. Lett.* **40,** No. 9, 844-846 (May 1982).

Key words: C15 superconductor; critical current; critical temperature; Laves phase superconductor; strain effect; upper critical field.

Strain effects on the critical parameters of composite-processed V_2(Hf,Zr) Laves phase superconductors have been examined. The critical temperature is found to be insensitive to the strain induced by the thermal differential contraction between the composite components. Critical current versus uniaxial strain curves obtained are completely flat at magnetic fields up to 19 T. It also turns out that the bulk upper critical field shows essentially no sensitivity to uniaxial strain. These results, which are quite different from those reported for A15 compound superconductors, are discussed in terms of the structural insensitivity of the Laves phase superconductor. Fractography suggests that the mechanical properties of V_2(Hf,Zr) composite conductors may be improved by the grain refinement of component alloys.

22187. Geltman, S. **Threshold behaviour for ionisation by electrons and positrons,** *J. Phys. B: At. Mol. Phys.* **16,** No. 17, L525-L528 (1983).

Key words: Coulomb-projected Born approximation; electron and positron impact; ionisation; threshold laws.

The threshold laws for atomic ionisation by electron and positron impact are derived in the Coulomb-projected Born approximation, and compared with other theories. There is a very large difference between the resulting threshold forms for electron and positron impact.

22188. Haynes, W. M. **Measurements of densities and dielectric constants of liquid normal butane from 140 to 300 K at pressures to 35 MPa,** *J. Chem. Thermodyn.* **15,** 801-805 (1983).

Key words: Clausius-Mossotti function; compressed liquid; density; dielectric constant; normal butane.

Results of density and dielectric-constant measurements on compressed liquid normal butane at temperatures from 140 to 300 K and pressures to 36 MPa are reported. Simultaneous measurements of these properties were carried out using a magnetic-suspension densimeter and a concentric-cylinder capacitor. Also presented are computed values of the Clausius-Mossotti function.

22189. Hemmati, H.; Bergquist, J. C. **Generation of continuous-wave 243-nm radiation by sum-frequency mixing,** *Opt. Commun.* **47,** No. 2, 157-160 (Aug. 15, 1983).

Key words: ADP crystal; hydrogen; nonlinear optics; sum-frequency mixing; thermal lensing; 243-nm radiation.

We have generated tunable cw radiation near 243 nm with a linewidth of less than 4 MHz by sum-frequency mixing the 351 nm radiation from an argon-ion laser with the 789 nm radiation from a ring dye laser in a crystal of ammonium dihydrogen phosphate held at moderate temperature. An external ring cavity, resonant with the dye laser, gives a power enhancement of about 12 in the sum-frequency generated radiation. Thermal lensing due to laser heating of the nonlinear crystal, distorted the 351 nm mode structure. This effect could limit the efficiency of the sum frequency mixing process.

22190. Haynes, W. M.; McCarty, R. D. **Low-density isochoric (p,V,T) measurements on (nitrogen+methane),** *J. Chem. Thermodyn.* **15,** 815-819 (1983).

Key words: compressed gas; density; isochore; methane; mixtures; nitrogen; pVT.

Isochoric (p,V,T) measurements have been made on three mixtures of nitrogen and methane ($0.29N_2+0.71CH_4$), ($0.50N_2+0.50CH_4$), and ($0.68N_2+0.32CH_4$) at densities of 1 to 6 mol·dm^{-3}. The three isochores for each mixture cover a temperature range from approximately 150 to 320 K up to a maximum pressure of 16 MPa. Comparisons with other experimental results and with values calculated from an extended corresponding-states model are discussed.

22191. Jeffries, J. B.; Barlow, S. E.; Dunn, G. H. **Theory of space-charge shift of ion cyclotron resonance frequencies,** *Int. J. Mass Spectrom.* **54,** 169-187 (1983).

Key words: frequency shift; ICR cells; ion-cyclotron frequencies; ion traps; mass spectroscopy; Penning traps; space charge.

A theory of ion space-charge influence on the observed ion cyclotron resonance frequency in static field ion traps is presented. The dependence of this influence on ion density, ion cloud shape, and trapping geometry is investigated. Four trapping geometries are specifically analyzed: the Penning trap, the cubical ICR cell, the common rectangular ICR cell, and an elongated ICR cell. This treatment is readily extended to other geometries. The theory applies to common situations where the exciting or detecting antennae fields are not homogeneous, and individual particle motions are excited/detected as opposed to center-of-mass motions.

22192. Provan, J. S.; Ball, M. O. **The complexity of counting cuts and of computing the probability that a graph is connected,** *SIAM J. Comput.* **12,** No. 4, 777-788 (Nov. 1983).

Key words: complexity; graphs; network reliability; reliability; #P-complete.

Several enumeration and reliability problems are shown to be #P-complete, and hence, at least as hard as NP-complete problems. Included are important problems in network reliability analysis, namely, computing the probability that a graph is connected and counting the number of minimum cardinality (s,t)-cuts or directed network cuts. Also shown to be #P-complete are counting vertex covers in a bipartite graph, counting antichains in a partial order, and approxmating the probability that a graph is connected and the probability that a pair of vertices is connected.

22193. Gallawa, R. L. **On the definition of fiber numerical aperture,** *Electro-Opt. Syst. Des.,* pp. 48-54 (Apr. 1982).

Key words: fiber communications; fiber optics; numerical aperture.

This paper addresses the definition of a fundamental fiber optics term: fiber numerical aperture. The popular definition of the term is not adequate as a measure of light-gathering ability, because of leaky rays. Nevertheless, it is recommended that the term be accepted because of its utility for most fibers in use today.

22194. Gallawa, R. L.; Franzen, D. L. **Progress in fiber test standards,** *Photonics Spectra,* pp. 55-68 (Apr. 1983).

Key words: fiber characterization; fiber metrology; fibers; measurement standards; optical fiber measurements; optical waveguides.

This paper reviews optical waveguide test procedures and techniques that are approved by, or in review for, the Electronics Industries Association (EIA). We concentrate on those procedures and documents to which we have been a party, either directly or indirectly. In particular, we discuss a glossary of terms, fiber attenuation, fiber bandwidth, and refractive index profile, the last of which leads to a determination of core diameter.

22195. Gans, W. L. **The measurement and deconvolution of time jitter in equivalent-time waveform samplers,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 126-133 (Mar. 1983).

Key words: deconvolution; impulse response; jitter; noise; pulse; sampler; time jitter; waveform.

The presence of time jitter between the trigger signal and the sampling strobe in an equivalent-time sampling oscilloscope can cause appreciable distortion of the recorded waveform. Under additive signal averaging conditions, a method has been developed to reduce this distortion. The method consists essentially of deconvolving a jitter-related effective impulse response from the recorded waveform data.

22196. Gavaler, J. R.; Greggi, J.; Wilmer, R.; Ekin, J. W. **Properties of NbN films crystallized from the amorphous state,** *IEEE Trans. Magn.* **MAG-19,** No. 3, 418-421 (May 1983).

Key words: amorphous; B1 crystal structure; film; mechanical properties; NbN; superconductors.

Cubic B1 structure NbN was prepared by annealing amorphous Nb-N films made by sputtering niobium in an argon-nitrogen atmosphere onto low temperature ($\lesssim$350°C) substrates. Crystallized films on sapphire substrates have equiaxed grains while films on niobium are

columnar. Grain sizes vary from 12.5 nm to >100 nm. The highest superconducting critical properties measured in these films are: T_c= 16K, J_c(4.2K, zero field)=8×10^5 A/cm^2, and B_{c2}(1.3K)=28T. Data on the effect of uniaxial tensile strain on J_c show that there is no measurable elastic (reversible) strain effect. Irreversible J_c degradation begins at an intrinsic tensile strain of 1.3% in the best case.

22197. Crawford, M. L. **Evaluation of shielded enclosure for EMI/EMC measurements without and with rf anechoic material,** *Proc. 5th Symp. Technical Exhibition Electromagnetic Compatibility, Zurich, Switzerland, Mar. 8-10, 1983,* pp. 397-402 (ETH, Symposium Record, Zurich, Switzerland, 1983).

Key words: anechoic quieting; shielded enclosure; tempest measurements.

This paper gives the results of measurements performed by the National Bureau of Standards to evaluate the potential influence of rf absorbing material installed inside a shielded enclosure on the accuracy of EMI/EMC measurements made using the shielded enclosure. The facility evaluated was a 3.76 m wide by 6.2 m long by 2.44 m high shielded enclosure. The paper briefly discusses the measurement technique used, describes the test facility and test configurations, and the spherical dipole radiators used for generating the reference standard fields. Tests were performed to evaluate the influence of 1) placement location of both the source and receiving antenna inside the enclosure, 2) separation distance between source and receiving antenna, and 3) height of source above the floor of the enclosure on the measurement results. Measurements made before and after installation of the rf absorbing material indicated a significant improvement in accuracy (error typically less than ±10 dB as compared to ⩾30 dB) at frequencies above 30 MHz where the absorber is effective.

22198. Young, M. **The Greenhouse effect,** *Phys. Teach.,* pp. 194-195 (Mar. 1983).

Key words: convection loss; flat plate collector; Greenhouse; Greenhouse effect; heat loss; infrared radiation; radiation loss; solar collector; solar energy.

Answer to the question whether the Greenhouse effect is a "hoax," submitted at the request of the associate editor of the journal. The Greenhouse effect (radiation trapping) is not a hoax, although reduced convection plays a major role.

22199. Young, M. **Calibration technique for refracted near-field scanning of optical fibers,** *Appl. Opt.* **19,** No. 15, 2479-2480 (Aug. 1, 1980).

Key words: index profile; near-field scanning; optical communications; optical fiber; optical waveguide; refracted near-field scanning; refractive index profile.

This paper describes a method for calibrating and determining the linearity of the refracted near-field scanning technique for measuring the index profile of optical waveguides. The method relies on a quartz fiber and several fluids whose indices are known at the measurement wavelength of 633 nm. The results show that near-field scanning is linear and that index profile may be measured to a precison of ±0.0005 or better.

22200. Davis, D. D.; Weiss, M.; Clements, A. C.; Allan, D. W. **Remote syntonization within a few nanoseconds by simultaneous viewing of the 1.575 GHz GPS satellite signals,** *Proc. CPEM 82 Digest, Conf. Precision Electromagnetic Measurements, Boulder, CO, June 28-July 1, 1982,* Wallace J. Alspach, ed., pp. N-15–N-17, (Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, 1982).

Key words: differential time transfer; frequency calibration; global positioning system; international frequency coordination; primary frequency standards; satellite time transfer; satellite timing receiver; synchronization; time comparison.

The NBS/GPS receiver has been designed around the concept of obtaining high accuracy, low cost time and frequency comparisons between remote frequency standards and clocks with the intent to aid international time and frequency coordination. Simultaneous viewing with the USNO commercial GPS receiver at Washington, DC and the NBS constructed receiver at Boulder, CO (≈3000 km baseline) yielded synchronization accuracies of less than 10 ns as compared with several portable clock trips.

The hardware and software of the NBS/GPS receiver will be outlined in the text. The receiver is fully automatic under microprocessor control with a built-in 0.1 ns resolution time interval counter. The microprocessor also does data processing. Satellite signal stabilities are routinely at the 5 ns level for 15 s averages, and the internal receiver stabilities are at the 1 ns level. The second generation receiver has a built-in CRT and parallel keyboard for operator interface. Serial RS232 is provided for local hardcopy (printer) and telephone modem use.

22201. Datta, S. K.; Ledbetter, H. M.; Kriz, R. D. **Predicted elastic constants of transversely isotropic composites containing anisotropic fibers,** *Proc. Prog. Sci. Eng. Composites, Tokyo, Japan, October 1982,* T. Hayashi, K. Kawata, and S. Umekawa, eds., pp. 349-355 (Japan Society for Composite Materials (ICCM-IV), Tokyo, Japan, 1982).

Key words: bulk modulus; composites; dispersion relationship; elastic constants; fiber reinforcement; graphite-epoxy; shear modulus; wave propagation; Young's modulus.

By a wave-scattering method, we derive dispersion relationships for waves propagating perpendicular to continuous fibers that are oriented unidirectionally. In the long-wavelength limit one obtains relationships that predict the composite's effective static elastic constants. We compare these relationships with others derived by energy methods to obtain upper and lower bounds of the effective static moduli. We demonstrate this comparison graphically by plotting for graphite-epoxy the predicted composite constants over the full range of fiber volume fractions. We consider the fibers to be anisotropic, but transversely isotropic. Under special conditions, the energy-method upper and lower bounds compare identically with the results of this study. The static properties are, of course, special cases of the more general dispersion relationships. Graphs are given for nine elastic constants: axial and transverse Young's and shear moduli, bulk and plane-strain-bulk moduli, and three Poisson's ratios.

22202. Drullinger, R. E.; Evenson, K. M.; Jennings, D. A.; Petersen, F. R.; Bergquist, J. C.; Burkins, L.; Daniel, H. U. **2.5 THz frequency difference measurements in the visible using metal-insulator-metal diodes,** *Appl. Phys. Lett.* **42,** No. 2, 137-138 (Jan. 15, 1983).

Key words: frequency difference measurements; metal-insulator-metal (MIM) diodes; optical heterodyne detection; visible.

Using point-contact metal-insulator-metal diodes, we have demonstrated heterodyne detection of visible laser radiation at frequency differences up to 2.5 THz (generated by a 119-μm laser). The signal to noise on the observed rf beat falls off at 2.3 dB/octave of laser frequency difference and would seem to indicate that 30-THz difference beats will be observable with improved laser stability or signal averaging. While the diode detector "bandwidth" per se has not been evaluated, these measurements demonstrate an increase in the frequency difference which can be measured in the visible by more than an order of magnitude over that previously reported.

22203. Fortunko, C. M.; Schramm, R. E. **Evaluation of pipeline girth welds using low-frequency horizontally polarized waves,** *J. Nondestruct. Eval.* **3,** No. 3, 155-173 (Jan. 17, 1983).

Key words: elastic waves; electromagnetic transducers; nondestructive evaluation; ultrasonic scattering; ultrasonic transducers; ultrasonic waves; wave phenomena.

The practical implementation of alternative acceptance criteria for pipeline girth welds requires the use of inspection tools capable of determining the principal dimensions and positions of planar flaws. A new ultrasonic inspection method is described that permits complete volumetric inspection of the girth welds. The new system uses noncontacting electromagnetic-acoustic transducers (EMATs) that operate at low ultrasonic frequencies (454 kHz). Theoretical models of the measurements are developed and verified experimentally. In addition practical performance limits of the new system are established in terms of minimum flaw sizes that can be detected. The results are related to accept-reject curves based on a model of the failure processes. An inspection protocol for field applications is also described.

22204. Gellermann, W.; Luty, F.; Pollock, C. R. **Optical properties and stable, broadly tunable cw laser operation of new F_A-type centers in Tl^+-doped alkali halides,** *Opt. Commun.* **39,** No. 6, 391-395 (Nov. 15, 1981).

Key words: color centers; F centers; Tl^+-doped alkali halides; tunable cw lasers.

A new group of complex color centers with F_A-type properties, involving simple center production and high thermal and optical stabilities, has been found in six Tl^+-doped alkali halides: NaCl, KCl, RbCl, KBr, RbBr and RbI. In its first tested examples, KCl and KBr, broadly tunble cw laser operation over the 1.4 to 1.7 μm range has been obtained, with output powers in the 100 mW range. In contrast to already existing F_2^+ and F_2^+-like centers, operating in the same wavelength range, the new $F_A(Tl^+)$ lasers are optically stable and do not show any bleaching effects under laser operation

22205. Ekin, J. W. **Four-dimensional *J-B-T-*ϵ critical surface for superconductors,** *J. Appl. Phys.* **54,** No. 1, 303-306 (Jan. 1983).

Key words: critical strain; critical surface; Nb_3Sn; strain; superconductors; V_3Ga.

The concept of a superconducting critical surface in a four-dimensional *J-B-T-*ϵ space is introduced and from this a critical strain parameter ϵ_c is defined in analogy to the usual three superconducting critical parameters: J_c, B_{c2}, and T_c. Examples of a subset of this surface in a three-dimensional *J-B-*ϵ space are presented as a function of temperature for the A15 superconductors, Nb_3Sn and V_3Ga, utilizing the recently discovered strain scaling law. The usefulness of the *J-B-T-*ϵ critical surface in characterizing the interaction of strain with the other three critical parameters and in setting strain limits for the mechanical design of superconducting devices is illustrated.

22206. Suzuki, T.; Ledbetter, H. M. **Barrier energy for the b.c.c.-f.c.c. martensitic transition in sodium,** *Philos. Mag. A* **48,** No. 1, 83-94 (1983).

Key words: alkali metal; Bain distortion; barrier energy; binding energy; martensite; nucleation; phase transition; pseudopotential; sodium.

Using an Ashcroft empty-core model pseudopotential, we have calculated the binding energy of the intermediate structures between b.c.c. and f.c.c. sodium at zero temperature for two homogeneous-deformation reaction-path models, namely those of Bain (1924) and Zener (1948). Bain's model gives a lower barrier energy than that of Zener: 9·2 K per atom, much lower than a previous estimate based on the second-order elastic constants.

22207. Mann, W. B. **Special review: The human environment—Past, present, and future,** *Int. J. Appl. Radiat. Isot.* **34,** No. 11, 1563 (1983).

Key words: ecology; energy; environment; pollution; resources; wildlife.

The Seventh Lauriston S. Taylor lecture was delivered by Merril Eisenbud as part of the annual meeting of the National Council on Radiation Protection and Measurements held at the National Academy of Sciences in Washington, DC, on April 6 and 7, 1983.

22208. Fultz, M. L.; Durst, R. A. **Investigation of two multichannel image detectors for use in spectroelectrochemistry,** *Talanta* **30,** No. 12, 933-939 (1983).

Key words: optically transparent electrode; *o*-tolidine; silicon photodiode array detector; spectroelectrochemistry; UV-visible absorption spectroscopy; vidicon detector.

Two multichannel image detectors, a vidicon and a silicon photodiode array, were investigated for their performance as detectors in ultraviolet-visible absorption spectroelectrochemical experiments. Their spectral band-pass, dispersion, dynamic range, and precision of absorbance measurements were compared. *o*-Tolidine was used as a model compound to study their performance in a spectropotentiostatic experiment using an optically transparent thin-layer electrode. Both detectors performed well, but the silicon photodiode array had twice the spectral resolution and dynamic absorbance range of the vidicon detector.

22209. Margolis, S. A.; Konash, P. L. **The high-performance liquid chromatographic analysis of diastereomers and structural analogs of angiotensins I and II,** *Anal. Chem.* **134,** 163-169 (1983).

Key words: amino acid composition; angiotensin; diastereomers; HPLC; impurities; peptides.

Diastereomers, α- and β-aspartic acid forms, and partial sequences of angiotensin I and II were resolved by reversed-phase high-performance liquid chromatography (HPLC). Nearly all of the peptides which were examined contained significant amounts of peptides whose amino acid composition differed from the designated peptide. This chromatographic procedure combined with amino acid analysis clearly offers the investigator a rapid method for analyzing and quantifying the purity of angiotensins which are intended for use as reference substances for radioimmunoassay and biological assay.

22210. Kautz, R. L. **The ac Josephson effect in hysteretic junctions: Range and stability of phase lock,** *J. Appl. Phys.* **52,** No. 5, 3528-3541 (May 1981).

Key words: current; phase lock; zero-bias voltage.

The rf-induced constant voltage steps generated by the ac Josephson effect are studied within the context of the Stewart-McCumber model. Simulations are used to determine the range of current bias over which phase lock occurs for model parameters appropriate to hysteretic tunnel junctions. The effect of noise on phase lock is also considered. The results are applied to a zero-bias voltage standard proposed by Levinsen *et al.*

22211. Ledbetter, H. M. **Low-temperature elastic-constant anomalies in Fe-Cr-Ni-Mn alloys,** *Physica* **119B+C,** Nos. 1&2, 115-118 (Apr. 1, 1983).

Key words: bulk modulus; elastic constants; low temperatures; magnetic phase transition; Poisson ratio; shear modulus; stainless steels; Young's modulus.

By measuring velocities of longitudinal and shear waves we determined accurately the temperature variation of elastic constants—Young modulus, shear modulus, bulk modulus, Poisson ratio—of a polycrystalline austenitic steel: Fe-5Cr-26Mn. Versus temperature, near 335 K, this alloy exhibits an anomalous elastic-constant transition. In similar alloys, a magnetic-susceptibility cusp occurs at the transition temperature, T_c. The bulk modulus shows a maximum at a higher temperature. Below T_c, the Poisson ratio behaves anomalously, increasing with decreasing temperature.

22212. Hamilton, C. A.; Lloyd, F. L. **A superconducting 6-bit analog-to-digital converter with operation to 2×10^9 samples/second,** *IEEE Electron Device Lett.* **EDL-1,** No. 5, 92-94 (May 1980).

Key words: A/D converter; comparators; interferometers.

The design and performance of a 6-bit superconducting A/D converter are described. The converter is based on double junction interferometers used as current comparators. The unique periodic response of these comparators makes possible a fully parallel N-bit converter requiring only N comparators. Conversion rates up to 2×10^9 samples per second have been demonstrated.

22213. Ho, J. C.; Oberly, C. E.; Garrett, H. J.; Walker, M. S.; Zeitlin, B. A.; Ekin, J. W. **Processing limits for ultrafine-multifilament Nb_3Sn,** *Adv. Cryog. Eng.* **26,** 358-366 (1980).

Key words: multifilamentary Nb_3Sn; Nb_3Sn; processing limits; ultra-fine Nb_3Sn.

The high yield and fracture strengths of the ultrafine-filament bronze-process wire, combined with the demonstration of no fundamental processing limits in an extensive manufacturing methods evaluation effort, promise a bronze manufacturing process for high-strength ultrafine-filament Nb_3Sn conductors. These bronze-process conductors can be well controlled geometrically so that the losses experienced by randomly close-spaced filaments of in situ-process Nb_3Sn conductors can be tightly controlled.

Proper billet design and manufacturing methods may enable even smaller filaments to be produced. The economic value of an ultrafine-filament conductor produced by the bronze process must, however, be seriously considered because of the large number of draw-and-

anneal cycles that are required.

22214. Kasen, M. B.; Schramm, R. E. **Variability in mechanical performance of G-10CR cryogenic-grade insulating laminates,** *Cryogenics,* pp. 279-280 (May 1983).

Key words: cryogenics; elastic properties; insulators; laminates; magnets; mechanical properties.

An assessment is made of the variability in cryogenic mechanical performance of insulating laminates produced by five manufacturers to a common component and procedure specification. Results at 295 K and 76 K indicate that the specification is adequate to ensure the desired degree of product uniformity.

22215. Kasen, M. B. **Solute segregation and boundary structural change during grain growth,** *Acta Metall.* **31,** No. 4, 489-497 (1983).

Key words: aluminum; copper; electrical resistivity; grain boundary transformation; grain growth; segregation.

It is shown that the residual resistivity of dilute aluminum and copper alloys at liquid helium temperature systematically falls below that of the single crystal value during grain growth annealing. The resistivity undergoes a sudden upward perturbation at intermediate anneal times or temperatures, and again declines before finally returning to the single crystal value at very large grain sizes. Comparing the observed resistivity change with that attributable to the changing density of grain boundaries permits this electronic purification to be interpreted in terms of a redistribution of solute to and from migrating boundaries. Calculation of boundary solute content levels during the grain growth process suggests that the initial resistivity decline corresponds to an adsorption stage of segregation that terminates upon attainment of a common boundary solute density approximating that of full saturation. It is proposed that the observed resistivity perturbation occurs concomitantly with attainment of full saturation and reflects the onset of a grain boundary structural transformation. Support for this interpretation is provided by experimental evidence that grain boundaries in the same aluminum material can exist in different states having different electronic scattering probabilities and different calculated levels of solute at full adsorption. The results of this study suggest that existing models describing solute-influenced grain boundary phenomena may require revision to incorporate the contribution of boundary motion to segregate levels.

22216. Rainwater, J. C.; Biolsi, L.; Biolsi, K. J.; Holland, P. M. **Transport properties of ground state nitrogen atoms,** *J. Chem. Phys.* **79,** No. 3, 1462-1468 (Aug. 1, 1983).

Key words: atomic nitrogen; collision integrals; dilute gas; thermal conductivity; transport properties; viscosity.

Transport properties of dilute monatomic gases depend on the two body atom-atom interaction potential. When two ground state (^4S) nitrogen atoms interact, they can follow any of four potential energy curves corresponding to the N_2 molecule; the $X\ ^1\Sigma_g^+$, $A\ ^3\Sigma_u^+$, $^5\Sigma_g^+$, and $^7\Sigma_g^+$ curves. Transport collision integrals for the $^5\Sigma_g^+$ and $^3\Sigma_u^+$ states have been calculated by representing the potentials for these states with the Hulburt-Hirschfelder potential. The $^5\Sigma_g^+$ state has a large local maximum which requires changes in the computational procedure used previously; a modified Hulburt-Hirschfelder potential has been used to represent the potential for this state. Collision integrals for the $^7\Sigma_u^+$ state have been obtained by direct use of a recent theoretical potential for this state. The collision integrals are compared with results obtained in previous studies.

22217. Franzen, D. L.; Kim, E. M. **Long optical fiber Fabry-Perot interferometers,** *Appl. Opt.* **20,** No. 23, 3991-3992 (Dec. 1, 1981).

Key words: interferometer; optical fibers.

A Fabry-Perot interferometer using single mode optical fibers is described. A finesse of 14 was obtained for fiber lengths of a few meters.

22218. Hale, M. O.; Leone, S. R. **Laser excited, state detected calcium-rare gas collisional energy transfer: Ca(4*s*5*p* $^1P_1$) spin changing and Ca(4*s*5*p* $^3P_1$) fine structure changing cross sections,** *J. Chem. Phys.* **79,** No. 7, 3352-3362 (Oct. 1, 1983).

Key words: calcium; energy transfer; fine structure state; laser; lifetime; spin change.

Pulsed dye laser excitation along with time and wavelength-resolved fluorescence detection techniques are used to measure cross sections for state changing collisions of Ca(4*s*5*p* $^1P_1$) and Ca(4*s*5*p* $^3P_1$) with the rare gases He, Ne, Ar, Kr, and Xe. The Ca(4*s*5*p* $^1P_1$)+M deactivation involves a near-resonant spin changing process which populates predominantely the Ca(4*s*5*p* $^3P_{2,1,0}$) states. The total deactivation cross sections for $^1P_1$ are 22, 25, 5, 3, 13, and 31 Å^2 (±20%) for ^{3}He, ^{4}He, Ne, Ar, Kr, and Xe, respectively. The cross sections for Ca(4*s*5*p* $^3P_1$)+M fine-structure changes are 38, 25, 46, 56, and 135 Å^2 (±35%) for He, Ne, Ar, Kr, and Xe, respectively. Branching ratios for the electronic energy transfer Ca(4*s*5*p* $^1P_1$)+He⇌Ca(4*s*5*p* ^3P_J, 3*d*4*p* ^3F_J, and 3*d*4*p* $^1D_2$)+He are determined to be 90±3:6±4:3±2, respectively, compared to statistical values of 26:60:14. The predominant product states 4*s*5*p* $^3P_{2,1,0}$ are produced by a near-resonant spin changing process; the fine structure components of the ^3P state are populated essentially statistically (55:33:11). Fine-structure branching Ca(4*s*5*p* $^3P_1$)+M⇌Ca(4*s*5*p* $^3P_{2,0}$)+M is also measured and gives a statistical distribution of Ca(4*s*5*p* $^3P_{2,0}$) states. The radiative lifetimes of the 4*s*5*p* $^1P_1$ and 4*s*5*p* $^3P_1$ levels are measured to be 65±2 and 71±8 ns, respectively. The results are discussed in terms of the competing effects of velocity and interaction strengths on the curve crossing probabilities.

22219. Zoller, P.; Cooper, J. **Nonlinear noise fields and strongly driven atomic transitions,** *Phys. Rev. A* **28,** No. 4, 2310-2317 (Oct. 1983).

Key words: ac Stark splitting; Fokker-Planck equation; light statistics; multiphoton processes.

A theory of the interaction of an atom with an intense nonlinear (non-Gaussian) noise field is developed, with emphasis on the connection with the underlying physics of laser coherence. We point out the possibility of obtaining exact solutions for the stochastically averaged atomic density matrix in terms of (matrix) continued fractions for a large class of nonlinear noise fields by generalizing the techniques developed by Risken and co-workers to solve nonlinear Fokker-Planck equations. As an example we discuss the absorption spectrum of an atom strongly driven by noisy phase-locked radiation.

22220. Krauss, M.; Stevens, W. J. **Electronic structure of UH, UF, and their ions,** *J. Comput. Chem.* **4,** No. 2, 127-135 (1983).

Key words: electronic structure; ions; SCF calculation; spectroscopic constants; UF; UH.

A relativistic effective core potential (REP) has been generated for the uranium atom and used in self-consistent-field calculations of the Λ states of UH, UF, and their ions. Energy curves were calculated at the base configuration level which ensures the dissociating atoms are described by Hartree-Fock wavefunctions. The electronic bonding of these molecules is found to be similar to that of comparable alkaline-earth hydrides and fluorides. The uranium 6*p*, 6*d*, and 5*f* orbitals retain their atomic character but the orbitals extend into the bonding region and are distorted by overlap repulsion and electrostatic effects. Nonetheless, the atomic energetic coupling determines that low energy states will have the maximum spin multiplicity and maximum orbital angular momentum projection consonant with the charge-transfer bonding.

22221. Stein, S.; Glaze, D.; Levine, J.; Gray, J.; Hilliard, D.; Howe, D.; Erb, L. A. **Automated high-accuracy phase measurement system,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 227-231 (Mar. 1983).

Key words: dual mixer; frequency measurements; phase; time; time comparison.

The measurement of the accumulated phase or the time difference between pairs of clocks is required for timekeeping and is the most powerful method of making very accurate frequency measurements since time interval, frequency, and frequency difference may all be calculated from these measurements. In the past, frequency was usually not derived from time measurements for short sample times because the time measurements could not be performed with adequate precision. However, we have developed a new measurement system which overcomes this limitation. It combines the most advantageous properties of the three most common techniques: the heterodyne measurement system; the frequency divider; and the dual-mixer

measurement system. As a result, it can satisfy nearly any requirement for frequency or time measurement.

The new system has the low-noise and high-resolution properties of a single heterodyne system: the rms time deviation for a single measurement is typically 2 ps and the theoretical resolution is 0.2 ps for the particular design parameters we have chosen. But a single heterodyne system is seriously limited since it can only make a measurement at the time of a zero crossing between the oscillators under test, not at the time of the operators choice. As the result of the addition of a transfer oscillator, the new system, like the dual mixer system, makes measurements within 0.1 s of any selected time and like a divider, the new measurement system stores the time of each clock in hardware and requires readout by a computer very infrequently. For example, no ambiguity occurs before 19 days have elasped. The hardware utilizes the ANSI/IEEE-583 (CAMAC) interface standard to communicate with either a computer or desktop calculator in order to store and analyze data.

This paper discusses the theory of the measurement method, presents typical performance data, and outlines the important features of the computer operating system. Both the hardware and software could be adapted to a wide variety of measurement needs.

22222. Stubenrauch, C. F.; Galliano, P. G.; Babij, T. M. **International intercomparison of electric-field strength at 100 MHz,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 235-237 (Mar. 1983).

Key words: electric strength; intercomparison.

This paper discusses an international intercomparison of electric field strength at 100 MHz. Laboratories in four countries participated in the intercomparison. Measurements from each of the laboratories fell within a range of +0.75 to -0.5 dB with respect to the overall average. The transfer standard used in the measurement is described and the details of the results are presented.

22223. Folkner, C. A.; Noble, R. D. **Transient response of facilitated transport membranes,** *J. Membr. Sci.* **12,** 289-301 (1983).

Key words: cylinders; facilitated transport; flat plate; one-dimensional; spheres; transient response; unsteady-state.

The transient flux of permeate is determined for one-dimensional facilitated transport in flat plate, cylindrical, and spherical geometries. The results are presented graphically. The flux is a function of four parameters. The graphical results allow one to determine the permeate flux as a function of time for given set of operating conditions, determine the steady-state value of the permeate flux and the time to reach steady-state.

22224. Hanley, H. J. M.; Evans, D. J.; Hess, S. **Structure of a binary mixture under shear: Non-Newtonian effects from computer simulation,** *J. Chem. Phys.* **78,** No. 3, 1440-1446 (Feb. 1, 1983).

Key words: conformal solution theory; Couette flow; fluid mixture; nonequilibrium molecular dynamics; nonNewtonian effects; normal pressure differences; radial distribution function; soft spheres.

A binary equimolar dense fluid mixture is subjected to a shear. The orientational distribution of particles of type i around particles of type $j(i,j=1,2)$ and the distortion of the radial distribution function is discussed for planar Couette flow. Results are presented in terms of a mixture of soft spheres, for which one species differs substantially in size and mass from the other, simulated on the computer using the technique of shear nonequilibrium molecular dynamics. Transport coefficients, including those associated with normal pressure differences, are given for the mixture and for the species in the mixture. Non-Newtonian phenomena are observed.

22225. Agarwal, G. S.; Friberg, A. T.; Wolf, E. **Elimination of distortions by phase conjugation without losses or gains,** *Opt. Commun.* **43,** No. 6, 446-450 (Nov. 15, 1982).

Key words: integral equations; phase conjugacy; scattering.

It is shown on the basis of scalar wave theory that complete cancellation of distortion effects by the technique of phase conjugation will be achieved under the following circumstances: The scatterer is non-absorbing, the conjugate wave is generated without losses or gains at an infinite phase-conjugate mirror and the effects of the evanescent waves outside the scatterer are negligible. The analysis is carried out to all orders of perturbation theory and is based on a new integral-equation formulation that involves a Green's function which takes into account the presence of the phase-conjugate mirror.

22226. Noble, R. D. **Shape factors in facilitated transport through membranes,** *Ind. Eng. Chem. Fundamentals,* 138-144 (Feb. 1983).

Key words: cylindrical geometry; facilitated transport; flat-plate geometry; permeate flux; shape factor; spherical geometry; steady-state.

The steady-state flux of permeate is calculated for spherical and cyclindrical membranes by use of a nonvolatile carrier to facilitate transport under two limiting conditions, reaction equilibrium and reaction-limited conditions. This result is used in conjunction with similar results for flat-plate membranes to obtain a shape factor for each geometry. The shape factor demonstrates the limits of transport in spherical and cylindrical membranes compared to flat plate membranes of equivalent thickness under identical conditions. For reaction equilibrium, the shape factor is found to depend only on geometry. For the reaction-limited or "frozen" condition, the shape factor is a function of transport and kinetic properties as well as geometry. The results can be used to predict the change in facilitated flux of the volatile species with a change in geometry. Since experimental flux measurements are often performed in flat membranes, the results of this work can be combined with experimental results to predict the total flux obtained in a tubular or a spherical configuration.

22227. Haynes, W. M.; McCarty, R. D. **Prediction of liquefied natural gas (LNG) densities from new experimental dielectric constant data,** *Cryogenics,* pp. 421-426 (Aug. 1983).

Key words: Clausius-Mossotti function; density; dielectric constant; liquefied natural gas (LNG); multicomponent mixtures.

A concentric cylinder capacitor has been used to measure the orthobaric liquid dielectric constants of multicomponent mixtures of the major components of liquefied natural gas (LNG) to an accuracy of approximately ±0.05% at temperatures from 110 to 130 K. These mixtures ranged from a ternary mixture containing nitrogen, methane, and normal butane to four to eight component methane rich (74 to 90 mol %) mixtures containing up to 5 mol % of nitrogen, 16 mol % of ethane, 7 mol % of propane, 5 mol % of the butanes, and 0.44 mol % of the pentanes. Some of these mixtures were prepared to simulate commercial LNG compositions. Experimental densities previously reported for these mixtures have been combined with the mixture dielectric constant data to calculate values of the Clausius-Mossotti (CM) function and the excess CM function. Pure component experimental CM functions for LNG components except for propane and isobutane have been combined with the mixture data in the development of a simple calculational technique for the prediction of LNG densities to an uncertainty of approximately ±0.15% based on a knowledge of the composition and dielectric constant of the liquid mixtures. In fitting the data, pseudo values of the CM function are derived for the slightly polar components, propane and isobutane, while constraining the mixture excess CM function to be zero.

22228. Buschman, R.; Noble, R. D. **Laplace transformation methods for some heat transfer problems.** *Indian J. Pure Appl. Math.* **14,** No. 5, 575-580 (May 1983).

Key words: heat transfer; Laplace transformation.

We approach the problems in the spirit of Carslaw and Jaeger in our attempts to obtain "exact" or "analytic" solutions to some boundary value problems which have arisen. Our method of approach is to apply multidimensional Laplace transformations and to extend some of the ideas which Voelker and Doetsch have used on simpler problems. In this paper we develop the mathematics which is used in order to obtain the results which are stated elsewhere and we show how related problems can be solved in which some of the boundary conditions are generalized. In Section 2 we discuss the "river" problem of predicting temperatures downstream and at later times and in Section 3 we discuss the "lake" problem of predicting vertical temperature profiles in stagnant large water bodies. In the Appendix we collect together some useful formulas which were derived in the course of our work and which do not appear directly in the tables. The definitions for the heat kernels, χ and ψ, are also included.

22229. Rainwater, J. C.; Hess, S. **A solvable weak-potential model of a non-Newtonian fluid,** *Physica* **118A,** 371-382 (1983).

Key words: Gaussian potential; Kirkwood-Smoluchowski equation; nonNewtonian fluid; normal pressure differences; pressure tensor; shear dilatancy; shear thinning; viscosity; weak potential.

A theoretical model is developed for a non-Newtonian fluid of spherical molecules interacting with a weak potential. The Kirkwood-Smoluchowski equation for planar Couette flow reduces in leading order in potential strength to a shear-diffusion equation with an inhomogeneous source term. The pressure tensor elements are calculated and, for a Gaussian potential,reduce to one-dimensional integrals which are evaluated numerically. The model reproduces several qualitative features of non-Newtonian liquids and the computer simulations of Evans and Hanley. These features include shear thinning, shear dilatancy, normal pressure differences, and dependence on shear rate to a half-integer power.

22230. Olver, F. W. J.; Smith, J. M. **Associated Legendre functions on the cut,** *J. Comput. Phys.* **51,** No. 3, 502-518 (Sept. 1983).

Key words: angular momentum; difference equations; extended-range arithmetic; Ferrers functions; Lengendre functions; normalized Lengendre polynomials.

Algorithms and a code are described for the computation of the associated Lengendre functions $P_\nu^\mu(\cos\theta)$, $P_\nu^{-\mu}(\cos\theta)$, $Q_\nu^\mu(\cos\theta)$ and the normalized Lengendre polynomial $\bar{\mathcal{P}}_\nu^\mu(\cos\theta)$ in the ranges $0<\theta\leqslant\frac{1}{2}\pi$, $\mu=0,1,2,\ldots$, $-\frac{1}{2}\leqslant\nu<\infty$. The algorithms are based on power-series expansions and recurrence relations. They are executed in extended-range arithmetic, thereby admitting very extensive ranges of μ and ν without causing overflow or underflow.

22231. Kamke, B.; Kamke, W.; Niemax, K.; Gallagher, A. **Rb and Cs broadening of the Na resonance lines,** *Phys. Rev. A* **28,** No. 4, 2254-2263 (Oct. 1983).

Key words: line broadening; sodium.

The broadening of the Na resonance lines, due to collisions with Rb and with Cs, has been measured with the use of the normalized fluorescence-intensity method of Chatham, Lewis, and Gallagher. Several Na resonance-radiation diffusion and absorption corrections were necessary in the Rb case, due to an unavoidable excess of Na density in the Rb vapor. The line-broadening rate coefficients k_1 and k_2 for the D_1 and D_2 resonance lines are $k_1(\mathrm{Rb})=(6.2\pm0.4)\times10^{-9}$ $\mathrm{cm^3s^{-1}}$, $k_2(\mathrm{Rb})=(5.5\pm0.6)\times10^{-9}$ $\mathrm{cm^3s^{-1}}$, $k_1(\mathrm{Cs})=(6.9\pm1.0)\times10^{-9}$ $\mathrm{cm^3s^{-1}}$, and $k_2(\mathrm{Cs})=(5.5\pm0.9)\times10^{-9}$ $\mathrm{cm^3s^{-1}}$ at $T\simeq300$°C. The leading (C_6R^{-6}) dipole-dipole long-range dispersion forces for the Na-Rb and Na-Cs interactions are calculated, and are used in the impact-theory formula to obtain theoretical line-broadening rate coefficients. These are in poor agreement with the measurements, indicating that as suggested by Vadla, the higher-order (C_8R^{-8}) dispersion terms are also important at the very long range responsible for this line broadening.

22232. Zumberge, M. A.; Faller, J. E.; Gschwind, J. **Results from an absolute gravity survey in the United States,** *J. Geophys. Res.* **88,** No. B9, 7495-7502 (Sept. 10, 1983).

Key words: absolute gravimeter; geophysics; gravity.

Using the recently completed JILA absolute gravity meter, we made an absolute gravity survey which covered 12 sites in the United States. Over a period of 8 weeks, the instrument was driven a total distance of nearly 20,000 km to sites in California, New Mexico, Colorado, Wyoming, Maryland, and Massachusetts. The time spent in carrying out a measurement at a single location was typically 1 day. A measurement accuracy of around 1×10^{-7} $\mathrm{m/s^2}$ (10 μGal) is believed to have been obtained at each of the sites.

22233. Willems, F.; de Jong, T. **Infrared observations of OH/IR stars,** *Astron. Astrophys.* **115,** No. 1, 213-215 (Nov. 1982).

Key words: infrared photometry; OH/IR stars.

As part of a program to study in the infrared all presently known type II OH sources in a 140 square degrees area of sky along the galactic equator between longitudes 10° and 27°5 we have identified several OH sources with previously unknown infrared counterparts. These identifications could only be made because accurate radio positions were available, partly determined by ourselves using the Westerbork Radio Synthesis Telescope as a two-element interferometer at 18 cm. In this paper we present 1–20 μm observations obtained with the ESO 1 m telescope of the three brightest sources in our sample so far. One source, OH 12.8–1.9, has not been observed before in the infrared, while OH 26.4–1.9 has been observed previously only out to 5 μm. The third source, OH 26.5+0.5, was about six times more luminous in 1981.3 than at its minimum in 1975.3.

22234. Ekin, J. W.; Flükiger, R.; Specking, W. **Effect of stainless steel reinforcement on the critical-current versus strain characteristic of multifilamentary Nb_3Sn superconductors,** *J. Appl. Phys.* **54,** No. 5, 2869-2871 (May 1983).

Key words: critical current; Nb_3Sn; stainless steel reinforcement; strain effect.

A series of multifilamentary Nb_3Sn superconductors were fabricated containing from 0% to 52 vol % stainless steel reinforcement strands as an integral part of the conductor. Critical current versus strain measurements are reported which show that the stainless steel introduces a relatively large compressive prestrain, ϵ_m, into the superconductor, ranging from $\epsilon_m\simeq0.3\%$ for no stainless steel reinforcement to $\epsilon_m=0.84\%$ for 52 vol % stainless steel. Accompanying this high compressive prestrain in the reinforced conductors is a large degradation of the conductor's critical current, I_c. The I_c degradation relative to the strain-free value has been measured, for example, to be more than 50% at 13 T for $\epsilon_m=0.64\%$. Several methods are discussed for reducing the large I_c degradation in A15 superconductors containing internal reinforcement.

22235. Henry, L.; Valentin, A.; Lafferty, W. J.; Hougen, J. T.; Malathy Devi, V.; Das, P. P.; Narahari Rao, K. **Analysis of high resolution Fourier transorm and diode laser spectra of the ν_9 band of ethane,** *J. Mol. Spectrosc.* **100,** 260-289 (1983).

Key words: double group Coriolis resonance; ethane; Fourier transform; intensity; internal rotation; rotational analysis; torsional splittings.

Fourier transform measurements with an apodized apparatus function up to 0.002 $\mathrm{cm^{-1}}$ are reported for the ν_9 band (ϵ_u) of ethane in the 12-μm region, together with an integrated band strength obtained from intensity measurements on selected Q-branch lines recorded using a diode laser spectrometer. Since the ν_9 band falls in an atmospheric window, these data may be useful in studies of the ethane concentration in the atmosphere of Jupiter and other outer planets. Torsional splittings in the ν_9 level caused by a higher-order Coriolis interaction with the close lying $3\nu_4$ state(a_{1u}) have been analyzed in a global least squares fit of 2206 Fourier transform lines and 58 diode splittings to a molecular Hamiltonian containing 20 parameters, with a standard deviation of 0.35×10^{-3} $\mathrm{cm^{-1}}$. Rotational levels of one component of the torsionally split $3\nu_4$ state cross interacting rotational levels of the ν_9 state for $K=17$, and the spectrum is followed to $K=19$ on the ^pP subband side to permit inclusion of ν_9 levels beyond this crossing. No transitions to $3\nu_4$ levels were observed. The theoretical treatment presented here makes use of standard symmetric top formalism and of the G_{36}^+ double-group formalism for ethane.

22236. Holland, D. M. P.; Parr, A. C.; Ederer, D. L.; West, J. B.; Dehmer, J. L. **Triply differential photoelectron studies of the four outermost valence orbitals of cyanogen,** *Int. J. Mass Spectrom. Ion Phys.* **52,** 195-208 (1983).

Key words: cyanogen; photoelectron spectroscopy; photoionization synchrotron radiation.

Photoelectron measurements, differential in incident wavelength, photoelectron energy and photoelectron ejection angle, have been performed on cyanogen, C_2N_2, from threshold to a photon energy of 24 eV, using synchrotron radiation. The results are presented in the form of photoionization branching ratios and photoelectron angular distributions, including vibrationally resolved results for the outermost orbital, $1\pi_g$. Some evidence for resonant processes is observed and discussed within the framework of recent work on related molecules. However, reliable assignments require further theoretical guidance with regard to the location and identities of possible shape resonances and autoionizing intravalence transitions in

the C_2N_2 spectrum.

22237. Filliben, J. J.; Kafadar, K.; Shier, D. R. **Testing for homogeneity of two-dimensional surfaces,** *Math. Modelling* **4,** 167-189 (1983).

Key words: cluster analysis; homogeneity; minimum spanning tree; statistics; surface analysis; tests of significance; two-dimensional randomness.

This paper presents and develops three approaches for evaluating the degree of "homogeneity" or "randomness" present in a two-dimensional material. Such problems of detecting homogeneity arise in several technological, biological and geological applications. The first approach defines the concept of a "cluster" and develops some test statistics based on the number of clusters and their size distribution. The second approach divides the material into blocks and then applies a nonparametric analysis of variance to these blocks. The third approach employs a graph-theoretic model, in which the length of a certain minimum spanning tree is used as a measure of homogeneity. These approaches are compared using simulation experiments, and are then applied to a problem from materials science.

22238. Lamaze, G. P.; McGarry, E. D.; Schima, F. J. **Integral reaction rate measurements in ^{252}Cf and ^{235}U fission spectra,** *Proc. Nucl. Data Sci. Technol., Antwerp, Belgium, Sept. 6-10, 1982,* pp. 425-428 (D. Reidel Publ. Co., P.O. Box 17, 3300 AA Dordrecht, Holland, 1983).

Key words: neutron dosimetry; reaction rate measurements; spectrum averaged cross sections; U-235 and Cf-252 fission neutrons.

In support of the light water reactor-pressure vessel (LWR-PV) surveillance dosimetry program established by the U.S. Nuclear Regulatory Commission, the National Bureau of Standards is undertaking a series of measurements to provide a physical basis for neutron dosimetry standards. Reaction rate measurements have been made with both ^{252}Cf and ^{235}U fission neutron fields. The following reactions have been measured through an activation technique: ^{115}In(n,n'), ^{58}Ni(n,p) and ^{54}Fe(n,p).

The neutron emission rate of the ^{252}Cf source has been measured with the $MnSO_4$ bath technique, thus permitting a direct measure of the spectrum averaged integral cross section for Cf ($\bar{\sigma}_{cf}$). The source strength of the ^{235}U fission neutron field has been measured relative to the ^{252}Cf neutron field using the ^{115}In(n,n') reaction. All measurements of cross sections in the ^{235}U fission field are therefore relative measurements.

22239. Koepke, G. H.; Ma, M. T. **A new method for determining the emission characteristics of an unknown interference source,** *Proc. 5th Symp. Technical Exhibition Electromagnetic Compatibility, Zurich, Switzerland, Mar. 8-10, 1983,* pp. 35-40 (T. Dvořák, Editor, ETH Zentrum-KT, 8092 Zurich, Switzerland, 1983).

Key words: dipole moments; electrically small; interference source; phase measurements; power measurements; radiation pattern; TEM cell; total radiation power.

Quantitative determination of the radiation characteristics of an unknown interference source is of importance to the users, manufacturers, and regulatory authorities. The theoretical background and measurement procedures for a new method to achieve this objective are presented with experimental results.

22240. Albers, J. **The relation between the correction factor and the local slope in spreading resistance,** *J. Electro. Chem. Soc.* **130,** No. 10, 2076-2080 (Oct. 1980).

Key words: correction factor; Laplace equation; local slope; multilayer analysis; resistivity; spreading resistance.

Dickey had proposed a technique, known as the local slope method, for the calculation of the correction factor which is used to obtain resistivity profiles from spreading resistance data. The technique is founded upon two asymptotic models for the conduction process involved in the spreading resistance measurement for the cases of (*i*) a conducting layer over an insulating substrate, and (*ii*) a high resistivity layer over a low resistivity or conducting substrate. The results of these two extreme cases are bridged by means of an assumed functional relation between the correction factor and the local slope of the spreading resistance data. This paper examines the two asymptotic models as well as the assumed functional relation between the correction factor and the local slope. It is shown that the asymptotic models adequately describe the behavior of the correction factor for a thin uniform layer over insulating or conducting boundaries. In addition, the single-valued relation between the correction factor and the local slope, which is assumed by the local slope method, is shown not to be an adequate representation of the multiple-valued relation between these two quantities found from multilayer data. For the cases considered, this distinction leads to an error in the resistivities as interpreted by the local slope method by as much as 60%. Nonetheless, the local slope results qualitatively follow the multilayer results thus making the technique a usable one for the calculation of approximate correction factors. A comparison of the two correction factor *vs.* local slope relations provides a basis for the behavior of the interpreted resistivities when they are compared with the input resistivities.

22241. Waterstrat, R. M. **The Hf–Os constitution diagram,** *J. Less-Common Met.* **95,** 335-344 (1983).

Key words: constitution diagram; hafnium alloys; intermetallic compounds; metastable phases; osmium alloys; phase diagram.

The Hf–Os constitution diagram was determined by metallography, X-ray diffraction and electron microprobe studies. Three new compounds were discovered. One of these (η phase) has a cubic Ti_2Ni-type structure, but the other two (ζ and θ phases) have not yet been identified. The η and ζ phases form by sluggish peritectic reactions which are easily suppressed in cast alloys by formation of stable CsCl-type (δ phase) dendrites and the metastable θ phase. The metastable θ phase formed in this manner is remarkably stable during solid state annealing at relatively high temperatures (about 1800°C), and this can strongly inhibit the formation of the equilibrium η and ζ phases. A glassy phase was produced by ultrarapid quenching of the liquid alloy containing about 25 at.%Os.

22242. Rennex, B. G.; Jones, R. R.; Ober, D. G. **Development of calibrated transfer specimens of thick, low-density insulation,** *Proc. Seventeenth Int. Thermal Conductivity Conf., National Bureau of Standards, Gaithersburg, MD, June 15-18, 1981,* pp. 419-426 (Plenum Press, 233 Spring Street, New York, NY 10013, Jan. 1983).

Key words: finite element models; guarded hot plate; low-density thick insulation; standard reference material; thickness effect.

The Thermal Insulation Group at the National Bureau of Standards has been developing the techniques necessary to provide thick, low-density calibrated specimens to the thermal testing community. Previous research has indicated the need to measure the apparent thermal conductivity or resistance at thicknesses up to 6 inches in order to account for apparatus systematic errors, and in order to understand better the "thickness effect" due to radiation heat transfer. In order to provide consistency among the heat-flow-meter and guarded-hot-plate apparatuses in the United States, NBS has agreed to provide the above-mentioned samples, in addition to the high-density specimens already provided.

The following conditions must be met to provide the calibrated specimens. First, the guarded-hot-plate apparatus must be large enough to approximate one-dimensional heat flow in the meter area. Then careful design and construction make possible the accurate determination of the experimental variables of plate-to-plate thickness, plate temperature, and heat flow. An error analysis must be performed. Finally, the highly variable low-density insulation samples must be well characterized. The NBS efforts to meet these conditions are the subject of this paper.

22243. Kim, E. M.; Franzen, D. L. **Calibration reticle for optical fiber near-field core diameter measurements,** (Proc. CPEM 82 Digest, Conf. Precision Electromagnetic Measurements, Boulder, CO, June 28-July 1, 1982), *IEEE Cat. No. 82CH1737-6,* pp. L-17–L-19, (Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, 1982).

Key words: calibration reticle; core diameter; index profile; near-field; optical fiber; resolution; systemic offset.

A device is described for calibrating near-field core diameter measurement systems. It consists of a reticle fabricated by photolitographic techniques and illuminated by diffuse light from an optical fiber. Absolute calibration, performance in the NBS system, and interlaboratory measurements will be discussed.

22244. Lynn, J. W. **Neutron scattering studies of magnetic phase transitions in superconductors,** *J. Less-Common Met.* **94,** 75-83 (1983).

Key words: coexistence; ferromagnetic; neutron scattering; oscillatory; phase transitions; superconducting.

The rare earth (R) ternary superconductors belonging to the RMo_6X_8 (X≡S,Se) and RRh_4B_4 classes of materials have provided the first unambiguous examples of the coexistence of superconductivity and long-range magnetic order. For systems in which the interactions between rare earth moments are antiferromagnetic in nature, the magnetic order only weakly perturbs the superconductivity since there is no macroscopic magnetization associated with the magnetic state. There are now a rather large number of ternary materials which exhibit long-range antiferromagnetic order coexisting with superconductivity over a wide range of temperature.

22245. Hong, M.; Hull, G. W., Jr.; Holthuis, J. T.; Hassenzahl, W. V.; Ekin, J. W. **Multifilamentary Nb-Nb_3Sn composite by liquid infiltration method: Superconducting, metallurgical, and mechanical properties,** *IEEE Trans. Magn.* **MAG-19,** No. 3, 912-916 (May 1983).

Key words: critical current density; liquid infiltration; mechanical properties; metallurgy Nb_3Sn; powder; uniaxial strain.

A rapid solid-liquid reaction mechanism has been used to form A15 Nb_3Sn in the liquid-infiltration processed Nb-Sn wire. Small, equiaxed A15 grains across the fine reacted filaments of 0.2–1.0 μm thickness were revealed with the transmission electron microscopy studies. A uniform Sn concentration near the stoichiometry was found in the A15 region. High inductive T_c's of 17.9 K with sharp transition widths (<0.3 K) and excellent overall J_c's of 10^4 A/cm^2 at 19 T and 4.2 K were achieved. Mechanical properties of the reacted wire are no worse than those of typical commercial bronze-process Nb_3Sn conductors, and ϵ_{irrev} is slightly higher.

22246. Goodrich, L. F. **The effect of field orientation on current transfer in multifilamentary superconductors,** *IEEE Trans. Magn.* **MAG-19,** No. 3, 244-247 (May 1983).

Key words: critical current; current density; current transfer; electric field; experiment; magnetic field; multifilamentary superconductor; superconductor.

Experimental data and discussion are presented on the current distribution along the length of a superconducting wire when subjected to multiple parallel and perpendicular magnetic fields. The experimental data were taken on a rectangular pancake coil with the applied magnetic field in the plane of the coil. These data indicate that significant current transfer occurs in the first and last perpendicular magnetic field sections and little transfer occurs between these two sections. The implication for superconducting magnet design will also be discussed.

22247. Liu, B. H.; Chang, D. C.; Ma, M. T. **Design consideration of reverberating chambers for electromagnetic interference measurements,** (Proc. IEEE 1983 Int. Symp. Electromagnetic Compatibility, Washington, DC, Aug. 23-25, 1983), *IEEE Cat. No. 83CH1838-2,* pp. 508-512 (Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, 1983).

Key words: eigen frequency; mode density; quality factor; reverberating chambers.

Two aspects pertaining to the design of rectangular, mode-stirred, or mode-tuned reverberating chambers are considered in this paper, namely the spectral distribution of resonant modes and the composite quality factor of the chamber. After obtaining the total number of eigenmodes with eigenfrequencies less than or equal to any given value and an exact expression for the mode density, the solution of the total number of modes is seen to consist of smooth and fluctuating parts. Then simple criteria are identified for designing the shape of the chamber. To take into account the conductor loss of the walls, a simple, closed-form composite quality factor is also proposed. These results are useful as design guidelines of reverberating chambers.

22248. FitzGerrell, R. G. **E-fields over ground,** (Proc. IEEE 1983 Int. Symp. Electromagnetic Compatibility, Arlington, VA, Aug. 23-25, 1983), *IEEE Cat. No. 83CH1838-2,* pp. 6-9 (Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, 1983).

Key words: antenna factor; EMI; half-wave dipole.

Equations from a classic paper by K. A. Norton are used to generate plots of electric field strengths versus distance, at fixed heights above ground, from horizontal and vertical dipole antennas. These data are used to estimate the strength and pattern of electric fields over plane perfect and imperfect ground test sites. A preliminary measurement effort, designed with the aid of these calculated data, indicates that the half-wave dipole antenna factor is essentially independent of distance from short, horizontal dipole, E-field sources over a plane metal ground screen at 1 m to 10 m separation distances in the 30 MHz to 1000 MHz frequency range. Measured data also show the influence of the transmission line on the vertically polarized dipole antenna factor and source antenna E-field combined (combined because measurements cannot separate transmission line effects on dipole input impedance and antenna pattern).

22249. Fickett, F. R.; Goldfarb, R. B. **Magnetic properties,** Chapter 6 in *Materials at Low Temperatures,* pp. 203-236 (American Society for Metals, Metals Park, OH 44073, July 1983).

Key words: alloys; hysteresis; magnetic property; magnetization; metals; review; susceptibility.

The magnetic properties of materials at low temperatures and techniques for their measurement are described. The low temperature literature is reviewed. The emphasis of the review is on metals and alloys of technological importance. Similarly, the treatment of theory and of measurement techniques is aimed toward the user interested in the more practical aspects of the subject. In every instance, however, references are given which allow the reader to pursue the subject at any level he may desire.

22250. Fickett, F. R. **Oxygen-free copper at 4 K: Resistance and magnetoresistance,** *IEEE Trans. Magn.* **MAG-19,** No. 3, 228-231 (May 1983).

Key words: copper; cryogenics; magnetoresistance; oxygen-free copper; resistance; resistivity; stabilizer; superconductor.

Oxygen-free copper is the most common material used for stabilizing practical superconductors. This type of copper may show residual resistance ratios (RRR) that vary from 50 to 700 in the full soft condition. Knowledge of the exact RRR value is often essential for optimum system design. We have investigated the effect of stress, temper, and reanneal on the RRR and magnetoresistance of several hundred samples of oxygen-free copper from many sources. In this paper we describe the program and present a sampling of the results obtained to date.

22251. Eisenhower, E. H. **A national quality assurance program for personnel dosimetry,** (Proc. 14th Annu. Natl. Conf. Radiation Control, Portland, ME, May 24-27, 1982), *Conf. Publ. 83-1,* pp. 225-239 (Conference of Radiation Control Program Directors Inc., 65 Fountain Place, Frankfort, KY 40601, Apr. 1983).

Key words: ionizing radiation; measurement; occupational radiation; performance testing; personnel dosimetry; quality assurance; radiation; radiation monitoring; radiation protection.

In 1973, a workshop of the Conference of Radiation Control Program Directors identified a need for improved reliability of personnel dosimetry services, and recommended that a Federal agency such as the National Bureau of Standards direct a continuing performance testing program of those services. This paper describes actions taken since then to implement the recommendation by means of a national program under development. The essential elements of the program are (1) the criteria for testing performance of dosimetry processors, (2) pilot tests of the practicality of those criteria, (3) the

laboratory that will conduct routine performance tests, (4) quality control within the testing laboratory and monitoring by NBS, (5) accreditation of dosimetry processors under the procedures of the National Voluntary Laboratory Accreditation Program, (6) the criteria for accreditation of dosimetry processors, (7) and uniform implementation of the national program. The total concept of the planned national program is described, and it is estimated that routine operation will begin in 1983. This program could serve as a model for similar testing programs in areas such as performance of radiation survey instruments, bioassay laboratories, and environmental radiation monitoring laboratories. A chronology of key actions taken since 1973 is included.

22252. Ely, J. F.; Hanley, H. J. M. **Prediction of transport properties. 2. Thermal conductivity of pure fluids and mixtures,** *Ind. Eng. Chem. Fund.* **22,** No. 1, 90-97 (Feb. 1983).

Key words: corresponding states; fluid mixtures; pure fluids; thermal conductivity.

A technique for the prediction of the thermal conductivity of nonpolar pure fluids and mixtures over the entire range of *PVT* states is presented. The model is analogous to the extended corresponding states viscosity model reported previously by Ely and Hanley in 1981. Calculations for the thermal conductivity require only critical constants, molecular weight, Pitzer's acentric factor, and the ideal gas heat capacity as a function of temperature for each mixture component as input. Extensive comparisons with experimental data for pure fluids and nonpolar binary fluid mixtures including paraffins, alkenes, aromatics, and naphthenes with molecular weights to that of C_{24} are presented. The average absolute deviation between experiment and prediction is less than 7% for both pure species and mixtures.

22253. Faller, J. E. **The physics of basketball: An introduction to scientific thinking,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 9-20 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, 1983).

Key words: basketball; design of experiments; physics of basketball; scientific thinking.

Basketball, and in particular the physics of basketball is used as an introduction to scientific thinking. The how's and why's of basketball are discussed and their counterparts in the scientific approach one points out.

22254. Penner, S.; Debenham, P. H.; Green, D. C.; Lindstrom, E. R.; Mohr, D. L.; Wilson, M. A. D.; Young, L. M.; Boyd, T. J.; Knapp, E. A.; Potter, J. M.; Swenson, D. A.; Tallerico, P. J. **NBS-LASL racetrack microtron,** *Proc. 11th Int. Conf. High-Energy Accelerators, Geneva, Switzerland, July 7-11, 1980,* pp. 110-114 (Birkhauser Verlag, Basel, Boston, Stuttgart, 1980).

Key words: electromagnetic interaction; electron accelerators; racetrack microtron; transport system.

The NBS-LASL racetrack microtron (RTM) is a joint project of the National Bureau of Standards (NBS) and the Los Alamos Scientific Laboratory (LASL). This is a new accelerator research project whose goal is to determine the feasibility of building a high-energy, high-current, cw electron accelerator using beam recirculation and room-temperature rf acceleration structures. The NBS-LASL RTM is being designed and built to develop the required technology for a large national 1 to 2 GeV cw accelerator for nuclear physics research and to prove experimentally that high currents can be accelerated successfully in an RTM. Some of the parameters of the NBS-LASL RTM are 185 MeV final energy, 550 μA maximum current, 15 passes, 12 MeV one-pass energy gain, and 2380 MHz frequency. One 450 kW cw klystron will supply rf power to both the 5 MeV injector and the 12 MeV linac in the RTM.

22255. McLaughlin, W. L.; Miller, A.; Uribe, R. M. **Radiation dosimetry for quality control of food preservation an disinfestation,** *Radiat. Phys. Chem.* **22,** Nos. 1-2, 21-29 (1983).

Key words: chemical dosimetry; dosimetry; electron beams; food irradiation; food preservation; gamma radiation; insect control; quality control; radiation processing; x rays.

In the use of x and gamma rays and scanned electron beams to extend the shelf life of food by delay of sprouting and ripening, killing of microbes, and control of insect population, quality assurance is provided by standardized radiation dosimetry. By strategic placement of calibrated dosimeters that are sufficiently stable and reproducible, it is possible to monitor minimum and maximum radiation absorbed dose levels and dose uniformity for a given processed foodstuff. The dosimetry procedure is especially important in the commissioning of a process and in making adjustments of process parameters (e.g., conveyor speed) to meet changes that occur in product and source parameters (e.g., bulk density and radiation spectrum). Routine dosimetry methods and certain corrections of dosimetry data may be selected for the radiations used in typical food processes.

22256. Ely, J. F.; Olien, N. A. **Measurements and data for carbon dioxide in the near critical and supercritical region,** *Proc. Fifty-Eighth Int. School Hydrocarbon Measurement, Norman, OK, Apr. 12-14, 1983,* pp. 146-149 (University of Oklahoma, Norman, OK, Apr. 1983).

Key words: carbon dioxide; critical properties; custody transfer; enhanced oil recovery; equation of state; phase equilibria; supercritical extraction.

Large scale use of carbon dioxide in enhanced oil recovery and supercritical extraction processes has given rise to a need for accurate thermophysical properties of this fluid and its mixtures. This is also true for metering associated with CO_2 pipelines. Due to the proximity of the critical point of CO_2 to ambient temperatures (304 K or 88°F), most engineering models are not of sufficient accuracy to be used in this custody transfer calculation. The capability of modeling the behavior and properties of CO_2 and its mixtures in the extended critical region is essential to the development of efficient and scalable supercritical processes. An accurate model or equation of state does not presently exist. To overcome some of these problems a consortium of industrial companies has been formed to sponsor research at the National Bureau of Standards on near critical CO_2 mixtures. This paper outlines the general problem being addressed at NBS and the anticipated results of the program.

22257. Roder, H. M. **Thermal conductivity of normal hydrogen,** *Proc. Thermal Conductivity 17, Gaithersburg, MD, June 15-18, 1981,* J. G. Hust, ed., pp. 257-264 (Plenum Publ. Corp., 233 Spring Street, New York, NY 10013, 1983).

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

The paper presents new experimental measurements of the thermal conductivity of normal hydrogen for eight isotherms at temperatures from 78 to 300 K with pressures to 70 MPa and densities from 0 to 40 mol/L. The data are represented with an equation that is based in part on an existing correlation of the dilute gas. The data are compared with the experimental measurements of others through the new correlation. It is estimated that the overall uncertainty of both experimental and correlated thermal conductivity is 1.5 percent.

22258. Crawford, M. L. **Comparison of open-field, anechoic chamber and TEM cell facilities/techniques for performing electromagnetic radiated emissions measurements,** (Proc. 1983 Int. Symp. Electromagnetic Susceptibility, Arlington, VA, Aug. 23-25, 1983), *IEEE Cat. No. 83CH1838-2,* pp. 413-418 (Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, 1983).

Key words: anechoic chamber; electromagnetic compatibility measurements; open-field; transverse electromagnetic cell.

This paper compares the results of measurements performed at discrete frequencies between 30 MHz to 300 MHz using a spherical dipole reference standard radiator to evaluate: 1) a 6.0 m×9.0 m ground screen open-field site, 2) a 3.0 m×4.88 m×6.1 m anechoically quieted shielded enclosure, and 3) a 2.8 m×2.8 m×5.6 m anechoically quieted TEM cell for use in measuring radiated rf emissions from electronic equipment. The paper briefly describes each facility, the test techniques, and the test configuration used. The results given provide a comparison of the radiated measurement uncertainty anticipated from a point source radiator for each facility, when all known correction factors (assuming far-field conditions) are applied.

22259. Itano, W. M. **Chemical shift correction to the Knight shift in beryllium,** *Phys. Rev. B* **27,** No. 3, 1906-1907 (Feb. 1, 1983).

Key words: atomic diamagnetic shielding; beryllium; chemical shift; Knight shift; nuclear magnetic moment; nuclear magnetic resonance.

The Knight shift in beryllium has previously been measured to be small and negative, when referred to an aqueous solution of $BeCl_2$. Theoretical calculations assume a reference consisting of a bare nucleus shielded by the core electrons. With the use of a recent measurement of the shielded nuclear magnetic moment in free Be^+ ions and published Hartree-Fock wave functions of Be and Be^+, it is shown that 20(4) ppm should be added to the experimental shifts in order to compare them with theory. This correction is of about the same magnitude as the measured Knight shift.

22260. Poliakoff, E. D.; Dehmer, J. L.; Dill, D.; Parr, A. C.; Jackson, K. H.; Zare, R. N. **Polarization of fluorescence following molecular photoionization,** *Phys. Rev. Lett.* **46,** No. 14, 907-910 (Apr. 6, 1981).

Key words: fluorescence; photoionization; polarization.

With use of the $B^2\ \Sigma_u^+$ state of N_2^+ as an example, this Letter presents the first measurements demonstrating that fluorescence from molecular ions formed by photoionization is partially polarized. Furthermore, it is shown that the degree of polarization reflects the alignment of the molecular ion and the ratio of the dipole strengths for the degenerate channels producing the ionic state. The wavelength-dependent measurements are compared with both quantum mechanical and classical calculations. Temperature-dependent effects are predicted.

22261. Peterson, R. L.; McDonald, D. G. **Voltage and current expressions for a two-junction superconducting interferometer,** *J. Appl. Phys.* **54,** No. 2, 992-996 (Feb. 1983).

Key words: Josephson junctions; SQUIDs; superconducting electronics.

The average voltage and circulating current of a superconducting interferometer containing two Josephson junctions (a dc SQUID) are calculated analytically, in various approximations, as functions of bias current and applied magnetic field or control current. The results are useful in calculations of the noise characteristics of the dc SQUID, as well as in other applications.

22262. Nahman, N. S. **Picosecond-domain waveform measurement: Status and future directions,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 117-124 (Mar. 1983).

Key words: electrical; optical; picosecond; pulse; time domain measurements; waveform.

A review of the state of the art of picosecond time-domain waveform measurements is presented which includes measurements in both the electrical and optical regions of the electromagnetic spectrum. This review is the latest edition of a series of reviews on high-speed pulse measurements compiled by the author commencing in 1967; specifically this review updates the 1978 review. The significance of the IEEE Pulse Standards 181 and 194 (or the identical IEC Standards 469-1 and 469-2) are discussed briefly. The classification of time-domain measurements from the 1978 review is summarized and augmented with basic instrumentation block diagrams. The advances in the present-day capabilities from those in 1978 are presented via temporal resolution state-of-the-art charts using the 1978 format; however, the only entries in the charts are those that have changed since 1978. Also, presented are some opinions as to the future directions of electrical and optical picosecond domain measurements. Fifty-six references are cited.

22263. McCaffrey, B. J. **Momentum implications for buoyant diffusion flames,** *Combust. Flame* **52,** No. 2, 149-167 (Sept. 1983).

Key words: buoyancy; diffusion flames; fluid mechanics; momentum; pool fires; turbulence.

Using assumed Gaussian forms for the transverse variation of mean quantities and well-established centerline variations, the integrated form of the momentum equation is solved for the vertical variation of the radial extent of buoyant diffusion flames. Closure is obtained by assuming that the convective heat flux at the flame tip is equal to the total heat release rate minus the radiative fraction. Solutions are obtained in terms of λ, which is the ratio of the $1/e$ transverse widths of the thermal energy profile to that of the velocity profile, and a local, centerline Froude numberlike parameter, $C_B = U/\sqrt{2gz\ \Delta T/T_0}$. The parameters differentiate between initial buoyancy-dominated (necking-in) behavior associated with solid or liquid pool flames versus momentum-dominated gas jet flame behavior. Recent data from porous refractory gas burners at flame conditions near the transition are compared to the simple analysis. Calculated transverse components of velocity compare favorably to Thomas's thistledown tracer experiments and provide the basis for an evaluation of the use of the boundary layer equations in pool fire modeling. Estimates of the effects of turbulence in the upper portion of the flame are presented.

22264. Madden, R. P.; Ebner, S. C. **Storage rings as sources for soft x-ray emission,** *AIP Conf. Proc.* **75,** 1-5 (1982).

Key words: diagnostic instrumentation; radiometric calibration; soft x-ray emission; storage rings; synchrotron radiation.

The properties of synchrotron radiation will be discussed and the outputs and characteristics of the storage rings available in the U.S. will be intercompared. The use of these sources for the radiometric calibration of plasma diagnostic instrumentation will be discussed in some detail. The importance of the proper treatment of polarization, overlapping orders, and solid angle effects will be covered. The experience gained at NBS in the calibration of plasma diagnostics instruments will be examined.

22265. Madden, R. P. **Availability of NBS radiometric standards for solar irradiance studies,** *Proc. Workshop Solar UV Irradiance Monitors, Boulder, CO, July 31-Aug. 1, 1980,* pp. 79-86 (Dr. R. F. Donnelly, Space Environment Laboratory, NOAA ERL, Boulder, CO 80303).

Key words: irradiance standards; radiance standards; radiometric standards; silicon diodes; synchrotron ultraviolet radiation facility; VUV diodes.

The development of primary and secondary radiometric standards at the National Bureau of Standards (NBS) is a responsibility of the Center for Radiation Research, in the National Measurement Laboratory. Three different Divisions in this Center contribute to the effort. Within the Radiometric Physics Division, H. Kostkowski is responsible for the development of radiance and irradiance source standards from the infrared through the visible and extending down to 250 nm (irradiance) and 225 nm (radiance), and J. Geist's group is developing irradiance standard detectors (silicon diodes) for use from 1000 nm down to a similar cut-off. In the Atomic and Plasma Radiation Division, W. Ott has been responsible for the development of the argon mini-arc transfer source standard and, in collaboration with H. Kostkowski's group, the calibration of D_2 lamps. These sources cover more or less the region 115–350 nm, although the shorter wavelength regions are still under development. Finally, in the Radiation Physics Division, R. Madden is responsible for the development of SURF II (a storage ring source of synchrotron radiation) as an irradiance standard useful from the infrared to 5 nm, and the calibration of photodiode detector standards covering the range 320–5 nm. Details of the standards available from NBS are given in Table 1.

22266. Mabie, C. P.; Menis, D. L.; Whitendon, E. P.; Trout, R. L.; Metherate, R. S.; Ferry, C. H. **Gel route preparation of low fusing dental porcelain frit,** *J. Biomed. Mater. Res.* **17,** 691-713 (1983).

Key words: ceramic; dental; gel; inorganic; metal; porcelain.

Dental porcelain frits have been prepared by the gel route, a procedure involving solubilization of alkalies, boron, rare earth, and other compounds in an alumina-silica sol. Using this procedure, porcelain frits suitable for metal-ceramic application have been prepared that fire to maturity at temperatures lower than current commercial porcelains. Solubilities, translucencies, thermal expansion coefficients, dilatometric softening temperatures, and flexure strengths are within the ranges of current commercial porcelains. The high degree of dispersion of pigments and phosphors made possible by gel route technology and the technology's ability to disperse crystalline phases to strengthen porcelain offers many processing advantages.

Gel route technology also offers a great degree of freedom in modifying porcelain properties.

22267. Janev, R. K.; Belić, D. S.; Bransden, B. H. **Total and partial cross sections for electron capture in collisions of hydrogen atoms with fully stripped ions,** *Phys. Rev. A* **28,** No. 3, 1293-1302 (Sept. 1983).

Key words: charge exchange; electron capture; electron capture into excited stated; final state distributions of capture electrons; fully stripped ions; highly charged ions.

Systematic investigations of charge-transfer reactions $H(1s)+A^{Z+}\rightarrow H^{+}+A^{(Z-1)+}(n,l)$ (A^{Z+} being a fully stripped ion) within the multichannel Landau-Zener theory with rotational coupling included (MLZCR) are presented. Total cross-section (σ) calculations in the energy region 0.03–80 keV/amu for selected projectiles with charges $5\leqslant Z\leqslant 74$ are performed. Oscillations in the Z dependence of σ are observed at low collision energies in the low-Z region. Above this region the Z dependence of σ is linear. The n,l distributions of captured electrons are investigated and results for the partial cross sections σ_n for a number of reactions are presented. The maxima of n distributions appear at $n_m\approx Z^{3/4}$ (in accordance with other theoretical predictions) and have a weak velocity dependence. Validity and limitations of the MLZRC model and the obtained results are discussed.

22268. Krummacher, S.; Schmidt, V.; Bizau, J. M.; Ederer, D. L.; Dhez, P.; Wuilleumier, F. **Inner-shell photoemission studies of lithium and sodium vapour,** *J. Phys. B: At. Mol. Phys.* **15,** 4363-4374 (1982).

Key words: lithium; photoelectron spectroscopy; sodium; synchrotron radiation; vacuum ultraviolet branching ratios.

The complete electron spectra caused by photoionisation of Li and Na vapour in the 1s and 2p shells respectively, have been investigated in the region from 5 eV above threshold up to about twice the binding energy of the ionised electron. Even though the contribution of molecules to the vapour pressure was only of the order of a few per cent, molecular features are found in the experimental spectra with intensities comparable with the atomic structures. The interpretation of all features observed in the spectrum is given. In specific energy regions, where the molecular contributions do not disturb the atomic ones, a detailed study of the fine-structure branching ratio and of the satellite structure accompanying these ionisation processes has been made. The results of this investigation are compared with other experimental and theoretical data.

22269. Kim, E. M.; Franzen, D. L. **Measurement of the core diameter of graded-index optical fibers: An interlaboratory comparison,** *Appl. Opt.* **21,** No. 19, 3443-3450 (Oct. 1, 1982).

Key words: core diameter; optical fibers.

An interlaboratory measurement comparison of optical fiber-core diameter was conducted by the National Bureau of Standards (NBS) in cooperation with the Electronic Industries Association. Participants include NBS and three fiber manufacturers. Six graded-index fibers were measured by all participants using the transmitted near-field method. As a group, the transmitted near-field measurements were consistent and exhibited an average standard deviation of 0.5 μm for 50-μm core fibers. These results were also compared to diameters determined by refracted near-field and transverse interference measurements contributed by other laboratories. For smooth-index profiles, all three methods agree within ~1 μm; substantial differences between the transmitted near-field and the other two methods can exist for fibers having step structure near the core-cladding boundary.

22270. Huennekens, J.; Gallagher, A. **Associative ionization in collisions between two Na(3*P*) atoms,** *Phys. Rev. A* **28,** No. 3, 1276-1287 (Sept. 1983).

Key words: associative ionization; sodium.

We have measured the rate coefficient [$k=5.6\times10^{-12}$ cm^3/s (±37%)] for associative ionization occurring in collisions between two Na(3*P*) atoms, by measuring the current resulting from excitation of Na vapor by cw-laser radiation. The major source of uncertainty in measurements of this type is in the determination of the number density and spatial distribution of excited atoms. Here we have measured the excited-atom density by three methods, and we have studied the spatial distribution of excited atoms in detail. Our rate coefficient at $T\sim650$ K is compared to other experimental results.

22271. Huie, R. E.; Peterson, N. C. **The photolysis of concentrated perchloric acid solutions,** *J. Photochem.* **21,** 31-34 (1983).

Key words: chlorine dioxide; manganese (II); manganese (III); perchloric acid; photolysis.

The production of ClO_2 after the photolysis of 6 M perchloric acid ($HClO_4$) has been identified on the basis of its absorption spectrum. Using 3 M $HClO_4$, no absorption corresponding to ClO_2 was observed, but rather a weaker absorption at around 300 nm attributed to ClO^- was identified.

22272. Haber, S. **Parameters for integrating periodic functions of several variables,** *Math. Computation* **41,** No. 163, 115-129 (July 1983).

Key words: approximation; diophantine; Fourier series; integrals; irregularity of distribution; multiple integrals; numerical integration; numerical quadrature; periodic functions; quadrature; theory of numbers; uniform distribution.

A number-theoretical method for numerical integration of periodic functions of several variables was developed some years ago. This paper presents lists of numerical parameters to be used in implementing that method. The parameters define quadrature formulas for functions of 2, 3, ..., 8 variables; error bounds for those formulas are also tabulated. The derivation of the parameters and error bounds is described.

22273. Cheng, Y. W.; McHenry, H. I.; Read, D. T. **Crack-opening displacement of surface cracks in pipeline steel plates,** *Am. Soc. Test. Mater. Spec. Tech. Publ.* **791,** 11-214–11-231 (1983).

Key words: fracture mechanics; pipeline steel; surface crack; surface deformation.

A series of 30.4 by 10 by 1.6-cm tensile panels of an API 5LX-70 pipeline steel with different surface crack lengths and depths were tested. Measured crack-mouth-opening displacements (CMOD) were compared with the predictions from linear elastic fracture mechanics (LEFM) plus the modified critical crack-opening displacement (COD) model. Within the range of crack sizes and shapes studied, good agreement between the experimental data and the predictions from the LEFM plus the modified critical COD model was observed. Surface deformations observed in the neighborhood of the crack also are discussed. The surface deformation patterns were obtained through instrumentation of the specimen with electrical resistance strain gages and brittle lacquer. On the front surface of the specimen, the deformation patterns revealed by the brittle lacquer correlated well with the observed CMOD-stress relations. The highest strain regions on the back surface were about ±45 deg from the plane of the crack emanating from the leading edge of the crack. The ligament yielding stress estimated from the modified critical COD model agreed well with the readings of the electrical resistance strain gages on the back surface.

22274. Itano, W. M.; Wineland, D. J.; Hemmati, H.; Bergquist, J. C.; Bollinger, J. J. **Time and frequency standards based on charged particle trapping,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 2, 1521-1523 (Apr. 1983).

Key words: atomic frequency standards; Be^+; Hg^+; ion traps; laser cooling; Mg^+.

Microwave or optical frequency standards based on internal resonance transitions of ions confined in electromagnetic traps have the fundamental advantages of long observation times and small perturbations. These advantages are somewhat offset by low signal to noise ratios. Work at NBS has concentrated on microwave hyperfine transitions of atomic ions stored in Penning-type ion traps. The use of narrowband, tunable light sources for state selection and detection and for reducing the average kinetic energy of the ions (laser cooling) is an important feature of this work. Results to date include the fluorescence detection and cooling to about 50 mK of a single Mg^+

ion and the observation of a 0.012 Hz linewidth on a 300 MHz $^{25}Mg^{+}$ hyperfine transition. A frequency standard based on $^{201}Hg^{+}$ ions is under development. Related work, mostly based on RF-type ion traps, is underway at several other labs.

22275. Burr, W. E. **An overview of the proposed American National Standard for Local Distributed Data Interfaces,** *Commun. ACM* **26,** No. 8, 554-561 (Aug. 1983).

Key words: back-end network; broadcast network; bus network; carrier sense multiple access; CSMA; input/output interface; magnetic disk interface; open systems interconnection.

The Local Distributed Data Interface (LDDI) Project of X3 Technical Committee X3T9 has resulted in three draft proposed American National Standards for a high performance local area network. The proposed standards are organized in accordance with the ISO Reference Model for Open Systems Interconnection and encompass the lowest two protocol layers (data link and physical) of the model, plus a serial broadband coaxial bus interface. The intended application of the LDDI is as a backend network for the interconnection of high performance CPUs and block transfer peripherals such as magnetic disk and tapes. A carrier-sense multiple access with collision prevention (CSMA-CP) distributed bus arbitration protocol is employed. The cable interface supports the attachment of up to 28 ports over a cable distance of 0.5 km (8 ports may be attached to a 1 km cable) at a transfer rate of 50 Mbit/s.

22276. Persily, A. **Repeatability and accuracy of pressurization testing,** *Proc. Thermal Performance Exterior Envelopes Buildings II, Las Vegas, NV, Dec. 6-9, 1982,* pp. 380-390 (American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, 1983).

Key words: air leakage; airtightness; blower; building diagnostics; doors; leakage testing; pressurization.

Pressurization testing is used to evaluate the airtightness of building envelopes. To experimentally determine the repeatability of pressurization test results, a home was pressure tested about eighty times in one year. The effect of weather conditions on the test results was studied, along with changes in the results over time. For local wind speeds less than 5.5 mph (2.5 m/s), the 0.2 in H_2O (50 Pa) leakage rate has a standard deviation of about 2% of the mean over short time periods. For stronger winds, errors as large as 15% compared to the calm weather test results occurred. A seasonal variation in the leakiness of the house, on the order of 25%, was also found. This variation is due to changes in the moisture content of the building materials caused by yearly variation in the moisture content of the outside air.

22277. Olson, G. J.; Iverson, W. P.; Brinckman, F. E. **Biodeterioration potential of standard reference materials (SRMs),** Paper in *Biodeterioration 5,* 434-444 (John Wiley & Sons, New York, NY, 1983).

Key words: bacteria; biodeterioration; biotransformations; deterioration of materials; element volatilization; fungi; metals; microorganisms; speciation; standard reference materials; water activity.

Several National Bureau of Standards Standard Reference Materials have been examined for susceptibility to biodeterioration. Several of these materials were attacked by bacteria and fungi when stored at elevated humidity after exposure to outdoor air. Dry, powdered biological SRMs rapidly take up water from humid atmospheres but should not undergo biodeterioration if laboratory relative humidity is below 60%.

22278. Miller, J. H.; Mallard, W. G.; Smyth, K. C. **Optical studies of polycyclic aromatic hydrocarbons in pyrolysis and diffusion flame environments,** *Proc. Polynuclear Aromatic Hydrocarbons: Seventh Int. Symp. Formation, Metabolism, Measurement, Columbus, OH, Oct. 26-28, 1982,* M. W. Cooke and A. J. Dennis, eds., pp. 905-919 (Battelle Press, Columbus, OH, 1982).

Key words: combustion; flow tube; laser-induced fluorescence; PAH formation; pyrolysis; soot formation.

In the present work results are presented for two types of optical measurements of PAH in fuel rich systems: ultraviolet absorption spectroscopy (in a flowing pyrolysis tube and in a slot burner supporting a diffusion flame) and visible laser-induced fluorescence. Preliminary results show that the absorption spectrum obtained in a flowing, 50 torr mixture of 1,3-butadiene and nitrogen at 600–700 K is similar in spectral shape to an absorption spectrum taken under identical optical conditions in a diffusion flame. From this spectral shape it is determined that PAH from 1 to 4 rings in size are present in the sampled area (2 mm diameter), which is on the fuel side of the flame front. A spatial profile of the broad, unstructured fluorescence observed when probing with a visible laser beam peaks in approximately the same position in the flame.

22279. McCabe, M. E.; Lecourte, J.; Robinson, S. **Calorimetric test facility for field measuring thermal performance of passive/hybrid solar components,** *Proc. Thermal Performance Exterior Envelopes of Building II, Las Vegas, NV, Dec. 6-9, 1982,* pp. 673-686 (American Society of Heating, Refrigerating & Air-Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, 1983).

Key words: calorimeter; energy storage; heat transfer; passive solar component; solar energy; test procedure.

Studies of the thermal performance of passive solar buildings have indicated a need for precise field measurement of solar heat gain and thermal heat loss or gain for modular passive/hybrid solar components. A description of the conceptual design and the major assemblies and subsystems for a new calorimetric test facility is presented in this paper. The facility is designed for field testing of passive solar components at the National Bureau of Standards in Gaithersburg, MD. It is anticipated that the test facility will provide a substantial improvement in the field measuring techniques for passive and hybrid solar components over the test cells currently in use and thereby provide a firm technical basis from which laboratory test procedures can be evaluated.

Computer studies of the thermal performance of the metering chamber assembly made with a 65-node finite-difference thermal model are described. The model was used to compute the heat balance for the solar absorber panel and the air-conditioning units, located in the metering chamber. Design days in both summer and winter were studied for a worst-case test article, which consisted of a single sheet of window glass. A description of the passive/hybrid solar components proposed for testing in the calorimeter during the winter season of 1982–1983 is also provided.

22280. Miller, J. H.; Mallard, W. G.; Smyth, K. C. **The condensation of PAH during the soot formation process,** *Proc. Polynuclear Aromatic Hydrocarbons: Seventh Int. Symp. Formation, Metabolism and Measurement, Oct. 26-28, 1982,* M. W. Cooke and A. J. Dennis, eds., pp. 921-927 (Battelle Press, Columbus, OH, 1982).

Key words: condensation; dispersive potential; polycyclic aromatic hydrocarbons; potential energy; quadrupole potential; soot.

Methods of calculating the dispersive part of the intermolecular potential of biomolecular systems of circularly symmetric polycyclic aromatic hydrocarbons are examined. A new, semi-empirical method is utilized to generate the angle dependent dispersive potentials. These dispersive potentials are summed with the electrostatic potentials which arise from quadrupole-quadrupole interactions, and the resulting total potential is used to predict the angle between the planes of the molecules in the most stable dimer configuration for the homologous series benzene, coronene, and circumcoronene. These angles are 90°, 42°, and 36°, respectively, and the well depths at these angles are 2.41, 7.87, and 23.0 kcal/mol.

22281. Imam, M. A.; Fraker, A. C.; Harris, J. S.; Gilmore, C. M. **Influence of heat treatment on the fatigue lives of Ti-6Al-4V and Ti-4.5Al-5Mo-1.5Cr,** *Am. Soc. Test. Mater. Spec. Tech. Publ.* **796,** 105-119 (1983).

Key words: corrosion; fatigue; heat treating; implant materials; microstructures; surgical implant metals; titanium; titanium alloys.

This paper reports on the effects of heat treating on phase composition and fatigue behavior of the Ti-6Al-4V and the Ti-4.5Al-5Mo-1.5Cr alloys. Corrosion-fatigue experiments show that the Ti-

6Al-4V alloy has the longest fatigue life when heat treated at 900°C and quenched. The Ti-4.5Al-5Mo-1.5Cr alloy has an increased fatigue life under higher strain when heat treated at higher temperatures in the α-β region. Comparison of the fatigue lives of the Ti-6Al-4V and Ti-4.5Al-5Mo-1.5Cr alloys in the mill-annealed condition shows that Ti-4.5Al-5Mo-1.5Cr has improved fatigue behavior in the high-cycle region, but Ti-6Al-4V is superior in the low-cycle region.

22282. Levelt Sengers, J. M. H.; Morrison, G.; Chang, R. F. **Critical behavior in fluids and fluid mixtures,** *Fluid Phase Equilibria* **14,** 19-44 (1983).

Key words: critical exponents; dilute mixtures; ethylene; excess properties; fluid mixtures; isobutane; partial molar volumes; scaling laws; steam; supercritical extraction; universality.

The presence of large fluctuations near a critical point leads to thermodynamic anomalies not present in classical, i.e., analytical equations, such as that of van der Waals. We introduce the concepts of universality, critical exponents, scaling laws, "field" and "density" variables, "strong" and "weak" directions. Experimental evidence for the presence of nonclassical critical behavior in fluids and fluid mixtures is presented. A scaled thermodynamic potential represents the thermodynamic data of steam, ethylene and isobutane accurately. It is valid up to 1.07 T_c, and within $\pm 30\%$ from ρ_c. Methods for joining it to an analytical equation are discussed. The generalization to a nonclassical description of fluid mixtures is described, and applications are given. The engineer may require the nonclassical description in custody transfer, design of supercritical power cycles and supercritical extraction. The classical approach is used here to explain peculiarities of dilute mixtures recently reported by several experimenters.

22283. Hunston, D. L.; Rushford, J. L.; Newitt, W. R.; Vandreuil, B. A. **Cure of intaglio printing inks,** Chapter 10 in *Chemorheology of Thermosetting Polymers,* pp. 149-167 (American Chemical Society, Washington, DC, 1983).

Key words: cure; currency; drying; elasticity; ink; intaglio; linseed oil; printing; rheology; thermosetting polymers; tung oil; viscosity.

The intaglio inks used to print currency in the United States contain relatively little solvent and dry primarily by chain extension and cross-linking reactions in the vehicles. To obtain good performance, the initially fluid ink must change rheologically in the manner required to give proper transfer to the plate and then to the paper and to obtain sufficient hardness at the end of the process so that the printed sheets do not smear when stacked. To study these changes, the rheology of two ink formulations with very different press performances was examined, first in the uncured state and then during curing. The uncured inks exhibited complex rheological properties including time dependence, yield behavior, elasticity, and non-linearity. Curing of the inks produced an increase in both viscosity and elasticity. The viscosity change could be roughly fitted to a first order type equation. Comparisons between these results and the performance of the inks on the press show that if the rate at which properties change during cure falls outside a certain range, acceptable print quality cannot be achieved.

22284. Hunston, D. L. **Cure monitoring of thermosetting polymers by an ultrasonic technique,** Paper in *Review of Progress in Quantitative Nondestructive Evaluation, 2B,* D. O. Thompson and D. E. Chimenti, eds., pp. 1711-1729 (Plenum Publ. Corp., 1983).

Key words: adhesives; composites; curing; drying oils; epoxy; polyvinyl chloride; shear wave propagation; strip delay line; thermosetting polymers; thin films; ultrasonics; viscoelasticity.

In the fabrication of components with thermosetting polymers, an essential step is the proper optimization of the cure cycle. In the early phases of the cure the polymer must have the appropriate flow properties to assure the proper wetting, spreading, and forming. It must then harden without excessive build up of residual stresses and flaws or the loss of adhesion at any interfaces that are present. To complicate the situation further, many applications such as composites, adhesives, paints, and protective coatings involve thin films whose cure behavior is significantly different than that for bulk samples. To help address this problem, an ultrasonic shear wave propagation technique has been developed. It is a laboratory device that measures the dynamic shear properties of a thin film in a way which is both nondestructive and nonperturbing to any chemical reactions that may be occurring. The applicability of this test method was demonstrated with cure studies on two model systems: one based on tung oil the other based on an epoxy resin.

22285. Evans, D. D. **Plume flow in a two-layer environment,** *Proc. 21st Natl. Heat Transfer Conf., Fire Dynamics Heat Transfer, Seattle, WA, July 24-28, 1983,* J. G. Quintere, R. L. Alpert and R. A. Altenkirch, eds., pp. 89-95 (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1983).

Key words: compartment fires; fire models; fire plumes; room fires; sprinkler systems.

Methods are developed to determine axial gas flow conditions within a weakly buoyant plume that passes from an ambient quiescent environment, in which the plume originates, to an upper layer at elevated temperature. Emphasis is placed on the development of an easily calculated approximation. The methods are appropriate for inclusion in two layer models of enclosure fires. In particular, they may provide a means of calculating starting conditions for the ceiling jet flow and actuation times for thermally sensitive automatic sprinkler heads located near the compartment ceiling. Calculated results are compared with measurements made in a 1.22 m diameter cylindrical enclosure.

22286. Cutler, R. I.; Mohr, D. L.; Whittaker, J. K.; Yoder, N. R. **A high resolution wire scanner beam profile monitor with a microprocessor data acquisition system,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 2213-2215 (Aug. 1983).

Key words: beam-profile monitoring system; electronics and data acquisition system; NBS-LANL Racetrack Microtron (RTM); wire scanner.

A beam profile monitor has been constructed for the NBS-LANL Racetrack Microtron. The monitor consists of two perpendicular 30 μm diameter carbon wires that are driven through an electron beam by a pneumatic actuator. A long-lifetime, electroformed nickel bellows is used for the linear-motion vacuum feedthrough. Secondary emission current from the wires and a signal from a transducer measuring the position of the wires are simultaneously digitized by a microprocessor to yield beam current density profiles in two dimensions. The wire scanner is designed for use with both pulsed and cw beams.

22287. Cutler, R. I. **Performance of the NBS-LANL RTM injection line vacuum system,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 2904-2905 (Aug. 1983).

Key words: accelerator; cryopump; electron beam transport; NBS-LANL Racetrack Microtron; vacuum measurements; vacuum system.

A 1000 l/sec cryopump is used to provide the hydrocarbon-free vacuum required for the 100 keV electron beam transport line of the NBS-LANL Racetrack Microtron. The beam line is 3.5 cm in diameter and 4 m long. To overcome the low vacuum conductance of the beam line, it is pumped every 1/2 meter by a 15 cm diameter vacuum manifold which is connected to the cryopump. A single cryopump is used rather than several ion pumps to reduce costs and to provide easier starting. An oil-free roughing pump and sorption pump are used in the initial pumpdown. The vacuum system is all metal sealed. Vacuums of 3×10^{-6} Pa are reached in 8 hours from atmospheric pressure without baking out the system, and ultimate vacuums of 5×10^{-7} Pa are achieved.

22288. Costrell, L.; Dawson, W. K. **FASTBUS for data acquisition and control,** *IEEE Trans. Nucl. Sci.* **NS-30,** No. 4, 2147-2151 (Aug. 1983).

Key words: bus system; control; data acquisition; data bus; FASTBUS; standard bus.

FASTBUS is a standardized modular data-bus system for data acquisition, data processing and control applications. It is the result of an interlaboratory development undertaken to meet the needs of the high energy physics community. However, the versatility, speed and addressing capability of FASTBUS make it attractive for many other

types of application.

A FASTBUS system consists of bus Segments which operate independently but dynamically link together as needed for operation passing. This parallel processing feature accounts to a great extent for the high throughput of FASTBUS in multisegment systems. Master modules compete for single or multiple Segment Control through a bus arbitration scheme using assigned priorities. Logical, geographical, secondary and broadcast addressing methods are used to access either data space or control and status register space. Features include block transfers, a sparse data scan and interrupts.

22289. Peterlin, A. **Decay of the spin echo in a pulsed magnetic field gradient NMR,** *Makromol. Chem.* **184,** 2377-2390 (Nov. 1983).

Key words: diffusion; polyethylene melts; pulsed magnetic gradient NMR; spin-echo; time dependence of the diffusion coefficient.

The additional attenuation of the spin echo of a pulsed magnetic field gradient NMR caused by the diffusion of the spins carrying molecules is calculated for a time dependent diffusion coefficient. The cases of a constant D_0, of an exponential decay with time, and an abrupt drop from D_0 to zero at time t_0 are considered. In all cases the time dependence of the experimentally observed attenuation is less steep than that of D. The time scale, however, changes very little. The calculation was based on the consideration that the diffusion transports the precessing spins to a location with a different Larmor frequency so that a complete reversal after the 180° pulse is not possible any more. Hence, any deviation from a straight line in a plot of the excess attenuation versus $\delta^2(1-\delta/3\Delta)$ may be interpreted in terms of a time dependence of the diffusion coefficient.

22290. Feldman, A. **Refraction through a prism,** *Am. J. Phys.* **51,** No. 10, 929-931 (Oct. 1983).

Key words: prism; refraction; refractive index.

A simple formula is derived which describes the refraction of light through a prism for an arbitrary angle of incidence. This formula can be represented by an ellipse whereby the minimum deviation condition and the transmission cutoff due to total internal reflection have a simple geometrical interpretation.

22291. Bowen, R. L. **Advances in dental therapeutics and materials: Experts explore the future,** *J. Am. Dent. Assoc.* **107,** 718-725 (Nov. 1983).

Key words: amalgam; bonding; composites; dental cements; porcelain.

This paper is the response to the question "What advances do you see in the near future (5–10 years) in the area of materials?"

22292. Blue, J. L.; Wilson, C. L. **Two-dimensional analysis of semiconductor devices using general-purpose interactive PDE software,** *IEEE Trans. Electron Devices* **ED-30,** No. 9, 1056-1070 (Sept. 1983).

Key words: adaptive meshes; computer programs; elliptic partial differential equations; finite elements; nonlinear equations; semiconductor devices.

Analyzing currents and fields in VLSI devices requires solving three coupled nonlinear elliptic partial differential equations in two dimensions. Historically, these equations have been solved using a special-purpose program and batch runs on a large fast computer. We use a general-purpose program and interactive runs on a large minicomputer. We discuss the physical formulation of the semiconductor equations and give three example solutions: a short-channel MOSFET near punchthrough, a DMOS power transistor in the ON state, and a beveled p–n junction. These examples demonstrate that solutions to a very general class of semiconductor-device problems can be obtained using these methods.

22293. Bennett, H. S. **Hole and electron mobilities in heavily doped silicon: Comparison of theory and experiment,** *Solid-State Electron.* **26,** No. 12, 1157-1166 (1983).

Key words: carrier scattering mechanisms; electron mobility; heavy doping effects; hole mobility; silicon.

Most device models for *npn* or *pnp* transistors assume that hole (electron) mobilities in *n*-type and *p*-type silicon are equal. Partial-wave phase shift calculations for the contributions of carrier-dopant ion scattering to the carrier mobilities lead to unequal minority hole (electron) and majority hole (electron) mobilities at the same doping density. These calculations are valid over the doping range of 2×10^{19} to 8×10^{19} cm^{-3} in *n*-type and *p*-type silicon and contain the assumptions that the holes and electrons move in isotropic, parabolic energy bands and are scattered by the screened Coulomb potentials of the dopant ions. When the effects of carrier-acoustic phonon and carrier-carrier scatterings are included, these calculations agree to within the spread of experimental value for the majority mobilities reported in the literature. This agreement is a substantial improvement by factors of 2–4 over the results of earlier theories such as first order Born and nondegenerate theories. The results of this work, particularly the inequality of minority and majority carrier mobilities, have implications for the modeling of both bipolar and field effect transistors.

22294. Kim, E. M.; Franzen, D. L. **Two dimensional near-field contouring of optical fiber cores,** *Soc. Photo-Opt. Instrum. Eng.* **355,** 76-83 (1982).

Key words: contour map; digital image encoding; Left-Most-Looking; near-field; optical fiber; radiation patterns; tolerance field.

A microcomputer controlled system is described for measuring the two dimensional near-field radiation pattern from optical fibers. Because radiation measurements may be made in two dimensions, a novel method has been devised whereby a constant intensity contour of the core is mapped. A modified Left-Most-Looking (LML) digital image encoding algorithm is used to map the contour of the fiber core. The iso-intensity map provides information about the tolerance field, in which all of the measured iso-intensity points lie, and core noncircularity. Such information is useful in determining coupling efficiency at splices, connector joints, and terminal points. This paper will discuss the measurement apparatus, accuracy, precision, stability, and method of analysis of the NBS system. In addition, results will be presented on measurements of core diameters, the length dependence of such measurements, wavelength dependence of the radiation patterns, power law fits to the patterns, calibration apparatus, and iso-intensity contours of telecommunications-grade fibers.

22295. Berman, R.; Hardy, N. D.; Sahota, M.; Hust, J. G.; Tainsh, R. J. **Standard reference materials for thermal conductivity below 100 K,** *Proc. Thermal Conductivity 17, Gaithersburg, MD, June 15-18, 1981,* J. G. Hust, ed., pp. 105-116 (Plenum Publ. Corp., 233 Spring Street, New York, NY 10013, 1983).

Key words: electrical resistivity; iron; low temperature; standard reference materials; steel; thermal conductivity; tungsten.

As part of a CODATA sponsored measurement intercomparison program, the thermal conductivities of Standard Reference Materials from NBS were measured by several laboratories. This paper describes the results of these measurements and shows, contrary to previous belief, that large discrepancies (up to 20%) occur at low temperatures as they often do at high temperatures. The materials studied, supplied by NBS-OSRM, are stainless steel, electrolytic iron, and tungsten. These materials were chosen in order to minimize the uncertainty caused by material variability and because of the previous extensive characterization performed by NBS and other laboratories. Measured thermal conductivities at temperatures below 100 K from four laboratories are discussed and compared.

22296. Breant, C.; Baer, T.; Nesbitt, D.; Hall, J. L. **State-dependent hyperfine coupling of HF studied with a frequency-controlled color-center laser spectrometer,** *Proc. Sixth Int. Conf. Laser Spectroscopy, Interlaken, Switzerland, June 27-July 1, 1983,* pp. 138-143 (H. P. Weber and W. Lüthy, Springer-Verlag, New York, NY, Oct. 1983).

Key words: color-center laser; frequency-controlled lasers; high-resolution spectroscopy; hydrogen fluoride; laser stabilization; molecular hyperfine spectroscopy.

The frequency-offset locking technique makes it possible to stabilize a color-center laser (~2.6 μm) to a line width of 1 or 2 kHz while providing a precision frequency-scanning capability. With the high sensitivity afforded by optical heterodyne saturation spectroscopy, we

have recorded the complete hyperfine spectrum of HF from R(0) to P(6). Analysis of these hfs data shows dramatic changes of the spin-rotation constants with vibrational excitation, +17% for $C_{Fluorine}$ and -3% for $C_{Hydrogen}$. Smaller changes are observed for rotational excitation. Theoretical estimates of the changes of hyperfine constants, based on the work of Muenter and Klemperer, are in semiquantitative agreement with our results.

22297. Hollberg, L.; Hall, J. L. **Observation of energy level shifts of Rydberg atoms due to thermal fields,** *Proc. Sixth Int. Conf. Laser Spectroscopy, Interlaken, Switzerland, June 27-July 1, 1983,* pp. 229-232 (H. P. Weber and W. Lüthy, Springer-Verlag, New York, NY, Oct. 1983).

Key words: laser spectroscopy; laser stabilization; optical Ramsey technique; radiative shifts; Rydberg atoms.

We report the first observation of level shifts of Rydberg states due to their coupling with thermal radiation fields. The Rydberg level positions were measured relative to the atomic ground state using two photon optical Ramsey fringe techniques in an atomic beam apparatus. The level shifts were isolated by chopping the blackbody radiation source. The cw dye laser scans were accomplished with high precision frequency control techniques relative to an isolated hfs component in an T_2 line. Appropriate sideband optical heterodyne techniques provided a laser linewidth $\sim$300 Hz and an absolute optical frequency stability of a few kHz for months. The runs analyzed are consistent with the expected T^2 dependence and much data remains to be analyzed.

22298. Ely, J. F.; Olien, N. A. **An overview of fluid thermophysical property research at the National Bureau of Standards,** *Proc. Sixty-Second Conv. Gas Processors Assoc., San Francisco, CA, Mar. 14-19, 1983,* pp. 249-255 (Gas Processors Association, 15 East 5th Street, Tulsa, OK 74103, 1983).

Key words: fluid property research; thermophysical property research NBS facilities.

Accurate fluid property measurements and predictive techniques are essential in high volume fluid processing and metering. A prime example of this importance is that of custody transfer of fluids where uncertainties of a few tenths of one percent in density can translate into millions of dollars of annual billing errors.

The Chemical Engineering Science Division and Thermophysics Division of the National Bureau of Standards are currently engaged in a long range program aimed at the development of a general, highly accurate capability for predicting the thermophysical properties of fluid mixtures.

The program is comprised of an integrated effort in basic fluid theory, benchmark experimental measurements and advanced correlation techniques. Currently, systems of interest include hydrocarbons, carbon dioxide, hydrogen, hydrogen sulfide and ethylene and their mixtures, especially at elevated temperatures and pressures. This presentation will summarize recent results of this program, the current activities and plans for future work.

22299. Kirby, R. K. **Recent activities of the National Bureau of Standards and the American Society for Testing and Materials in developing particulate standard reference materials,** (Proc. Fine Particle Society Fall Meet., 1980, University of Maryland, College Park, MD, Sept. 16-18, 1980), Article in *Particulate Systems Technology and Fundamentals,* pp. 329-334 (Hemisphere Publ. Corp., Washington, DC, 1983).

Key words: ASTM; certified reference material; fine particles; latex spheres; particle size metrology; standard reference material; surface area.

During the past three years a new ASTM Coordinating Committee (S-21) has been formed with the purpose of obtaining the cooperation of industry to assist NBS in the certification of Standard Reference Materials (SRM's) for particle size metrology. These SRM's will probably include monosize particles, distributed size particles, and surface area powders. In general, these SRM's will be used in the calibration of particle sizing equipment, they will provide for traceability in the marketplace, and they can be used to develop accurate secondary reference materials. The progress that has occurred to date in this activity and the NBS SRM program will be discussed.

22300. Clark, A. F. **Thermal expansion,** Chapter 3 in *Materials at Low Temperatures,* pp. 75-132 (American Society for Metals, Metals Park, OH 44073, June 1983).

Key words: composites; data; experimental methods; metals and alloys; nonmetallics; polymers; theory; thermal expansion; thermal expansion coefficient.

The thermal expansion behavior of materials at low temperature is reviewed. The tutorial chapter describes the theory, experimental methods, typical data, and sources and applications of data for thermal expansion. Materials covered are metals and alloys, nonmetallic compounds, glasses and ceramics, polymers, and composites.

22301. Crawford, M. L. **Improving the repeatability of EM susceptibility measurements of electronic components when using TEM cells,** *Proc. SAE Int. Cong. Exposition, Detroit, MI, Feb. 28-Mar. 4, 1983,* pp. 1-8 (Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096, 1983).

Key words: electromagnetic susceptibility measurements; transverse electromagnetic cell.

This paper outlines a systematic approach, using a TEM cell, for evaluating the electromagnetic (EM) radiated susceptibility of electronic equipment. The purpose of the paper is to provide guidelines, for those using TEM cells for performing EM susceptibility measurements, to improve the repeatability and, hence, the value of their test results. The paper describes the test setup, details the step-by-step procedures to use in performing susceptibility measurements, and discusses pertinent information related to the range of application and limitations associated with the use of TEM cells.

22302. Ekin, J. W. **J-B-T-ϵ interaction and strain limits in A15, B1, and C15 crystal structure superconductors,** *IEEE Trans. Magn.* **MAG-19,** No. 3, 900-902 (May 1983).

Key words: A15 superconductors; B1 superconductors; C15 superconductors; mechanical properties; NbN; strain effect; V_2(Hf,Zr).

Experimental evidence is presented which indicates that the elastic strain effect on the critical current of high-field compound superconductors correlates strongly with the type of superconductor crystal structure. Large strain effects are observed in all practical A15 superconductors examined to date, including Nb_3Sn, Nb-Hf/Sn-Ga, Nb_3Ge, Nb_3Al, and V_3Ga. Strain is observed to have no measurable effect, however, on either the critical current or the critical field of superconductors having the B1 crystal structure [NbN] or the C15 crystal structure [V_2(Hf,Zr)]. Strain limits placed on the mechanical design of superconducting devices are evaluated as a function of magnetic field for several A15 superconductors (Nb_3Sn, Nb-Hf/Cu-Sn-Ga, and V_3Ga) and compared with the strain limits imposed by B1 and C15 superconductors. It is shown that the latter materials have mechanical design advantage in applications where the superconductor is subjected to strain in excess of 0.2% (either compressive or tensile).

22303. Cahn, J. W. **Thermodynamics of solid and fluid surfaces,** (Proc. ASM Seminar Interfacial Segregation, Chicago, IL, Oct. 22-23, 1977), Chapter 1 in *Segregation to Interfaces,* pp. 3-23 (American Society of Metals, Metals Park, OH 44073, 1979).

Key words: adsorption; critical phases; eutectics; gradient energy; grain boundaries; interfaces; isostere; solids; surface excess; surface stress; surface tension; thermodynamics.

The thermodynamics of planar solid and fluid surfaces is re-examined. A new notation is developed in which surface excess quantities are expressed as determinants and as such as obviously invariant to arbitrary choices of what constitutes a surface-affected region. The notation is generalized to interfaces such as grain boundaries in which the same phase occurs on both sides. A Gibbs adsorption equation, augmented by solid state terms, surface stress and torque is derived. It leads to twelve Maxwell-type relations, nine of which are new, among surface variables. The Gibbs adsorption equation is also extended to systems containing more than two phases. Rigorous equations for surface quantities along isosteres and along

critical curves are also given. Gradient thermodynamics is briefly discussed.

22304. Ekin, J. W. **Superconductors,** Chapter 13 in *Materials at Low Temperatures,* pp. 465-513 (American Society for Metals, Metals Park, OH 44073, June 1983).

Key words: ac losses; critical current; critical field; critical temperature; induction to superconductors; mechanical properties; stability; superconductor.

An introduction to practical superconductors is presented. Topics covered are critical temperature, critical magnetic field, critical current, conductor fabrication, stability, ac losses, and mechanical properties. An introduction to each property is presented along with typical data on practical materials and a brief treatment of the experimental methods used to measure the property. For quick reference, the chapter contains an overall summary and reference guide to the principal parameters affecting superconductor material selection and multifilamentary composite design.

22305. Vasconcellos, E. C. C.; Wyss, J. C.; Petersen, F. R.; Evenson, K. M. **Frequency measurements of far infrared cw lasing lines in optically pumped $CHCl_2F$,** *Int. J. Infrared Millimeter Waves* **4,** No. 3, 401-406 (1983).

Key words: $CHCl_2F$; CO_2 laser; FIR laser; laser frequency measurement; new laser lines; relative polarization; wavelengths.

The wavelengths, frequencies, and relative polarizations of 15 FIR cw lasing lines obtained by optically pumping $CHCl_2F$ with a cw CO_2 laser have been measured. The lines are in the wavelength range from 340.3 to 905.4 μm and were pumped by P- and R-branch laser lines in the 9 μm band of CO_2.

22306. Hust, J. G. **Thermal conductivity and thermal diffusivity,** Chapter 4 in *Materials at Low Temperatures,* pp. 133-161 (American Society for Metals, Metals Park, OH 44073, 1983).

Key words: alloys; electronic conductivity; lattice conductivity; Lorenz ratio; low temperature; measurement methods; metals; nonmetals; thermal conductivity; thermal diffusivity.

This discussion of thermal conductivity and diffusivity in solids is intended to give the uninitiated an intuitive grasp of a complex and difficult subject. It is based on an empirical-theoretical approach with a minimum of in-depth theoretical rigor. This work includes a discussion of various heat flow mechanisms, a description of common measurement methods, and finally, various sets of illustrative data. Also included is a description of empirical correlations for use as predictive techniques. The temperature range below 300 K is of primary interest.

22307. Faller, J. E.; Koldewyn, W. A. **A prototype measurement of the Newtonian gravitational constant using an active magnetic suspension torsion fiber,** *Proc. 1983 Int. School Symp. Precision Measurement Gravity Experiment, Taipei, Republic of China, Jan. 24-Feb. 2, 1983,* pp. 541-556 (Wei-Tou Ni, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, 1983).

Key words: fundamental constants; gravity; Newtonian gravitational constant.

The use of an active magnetic suspension torsion fiber to measure G is discussed. The problems encountered and our motivation for trying this new approach are discussed.

22308. Reed, R. P.; Tobler, R. L.; Elmer, J. W. **Temperature dependence of flow strength of Fe-20Cr-16Ni-6Mn-0.2N and Fe-18Cr-10Ni-1.5Mn-0.1N (304LN) austenitic steels,** *Proc. Int. Cryogenic Mater. Conf., Kobe, Japan, May 11-14, 1982,* pp. 98-103 (Butterworth & Co. Ltd., P.O. Box 63, Westbury House, Bury Street, Guildford, Surrey, GU2 5BH, UK, Dec. 1982).

Key words: austenitic steels; low temperatures; martensitic transformation; Néel temperatures; yield strength.

The tensile flow strength was investigated in the temperature range 4 to 295 K for two annealed polycrystalline alloys: Fe-20Cr-16Ni-6Mn-0.2N steel and Fe-18Cr-10Ni-0.1N steel (AISI 304LN). Major conclusions are: (1) The temperature dependence of the flow strength may be characterized by a linear dependence of log σ versus T. (2) Temperature-change experiments below 200 K indicate that the same temperature dependence of the flow strength may be achieved by either straining single or multiple specimens. (3) The reported anomalous decreases of the flow strength associated with the Néel temperature and very low temperatures (<20 K) for austenitic steels were not confirmed by this study.

22309. McHenry, H. I.; Elmer, J. W.; Inoue, T. **Fracture properties of a 25Mn austenitic steel and its welds at 4 K,** *Proc. Int. Cryogenic Mater. Conf., Kobe, Japan, May 11-14, 1982,* pp. 413-416 (Butterworth & Co. Ltd., P.O. Box 63, Westbury House, Bury Street, Guildford, Surrey, GU2 5BH, UK, Dec. 1982).

Key words: austenitic steel; cryogenics; fatigue crack propagation; fracture toughness; liquid helium; mechanical properties; tensile properties; welds.

Tensile properties, fracture toughness, and fatigue crack growth rates of 25Mn-5Cr-1Ni steel plates and 25Mn-6.5Cr-2.8Ni welds were measured in liquid helium at 4 K. The yield strengths were 894 MPa for the base metal and 961 MPa for the weld metal. The fracture toughness values measured by the J-integral method were 240 MPa$\sqrt{m}$ for the base metal and 158 MPa$\sqrt{m}$ for the weld. The fatigue crack growth rates of both the base metal and the weld were similar to those of 316 stainless steel plate over the stress intensity range evaluated, 29–80 MPa$\sqrt{m}$. The fracture surfaces of representative specimens were examined by scanning and transmission electron microscopy and magnetic measurements; they were ductile and contained no evidence of α' martensite.

22310. Ledbetter, H. M. **Elastic properties,** Chapter 1 in *Materials at Low Temperatures,* pp. 1-45 (American Society for Metals, Metals Park, OH 44073, 1983).

Key words: bulk modulus; elastic constants; low temperatures; physical property; Poisson's ratio; shear modulus; solid-state thermodynamics; Young's modulus.

In this review the author tried to convey several basic concepts concerning polycrystalline elastic properties and their temperature dependence: a) Elastic constants are physical, not mechanical, properties. b) They relate thermodynamically to other physical properties such as specific heat and thermal expansivity. c) All these properties and many others, such as the Grüneisen constant, can be derived from a general central-force interatomic potential or from the potential energy of a linear chain expanded in atomic displacements where, except for a lattice constant, the expansion coefficients are the elastic constants. d) Perhaps the most important parameter derivable from elastic constants is the Debye characteristic temperature, which relates in turn to various solid-state phenomena. e) Typically, elastic stiffness increases 5 to 15 percent during cooling between ambient and zero temperatures. f) At low temperatures, elastic constants are nearly temperature independent, as required by the third law of thermodynamics. g) Low-temperature elastic constants are important theoretically as checks on interatomic potentials, cohesion theories, and lattice specific heats.

22311. Ledbetter, H. M.; Kriz, R. D. **Elastic-wave surfaces in solids,** *Status Solidi* **114,** 475-480 (1982).

Key words: Christoffel equations; elastic constants; elastic waves; orthorhombic crystals; wave surfaces.

Based on Christoffel-equation solutions, some interesting wave-surface topological features are described for anisotropic media. These features include crossovers of transverse–longitudinal surfaces and continuous transverse–longitudinal mode conversion over a single surface. For othorhombic symmetry (mmm), crossovers of transverse–transverse surfaces occur for all crystals: the transverse surfaces interconnect and form a single surface. Beyond this, some orthorhombic crystals exhibit a longitudinal–transverse crossover that causes all three surfaces to interconnect into a single surface. Crossover of longitudinal and transverse surfaces means that a transverse wave velocity will exceed a longitudinal wave velocity. A longitudinal–transverse mode conversion means that both longitudinal and transverse modes exist on the same wave surface.

22312. Howe, D. A.; Walls, F. L. **A compact hydrogen maser with exceptional long-term stability,** *IEEE Trans. Instrum. Meas.* **IM-32,** No. 1, 218-223 (Mar. 1983).

Key words: clock; frequency stability; frequency standard; hydrogen maser; oscillator; time stability.

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_{011} cavity which is dielectrically loaded by a low-loss alumina (Al_2O_3). The cavity is 14.6 cm outside diameter and 13.7 cm high, and weighs only 4.4 kg. The unloaded-cavity Q factor is about 6000. With a conventional source, hexapole state selector, and four magnetic shields, the volume of the entire hydrogen maser resonator package is only about 20 l.

The FEP-coated quartz bulb which is common in other masers has been replaced by a similar coating on the inside wall of the cavity. This has yielded a simpler design and more rugged hydrogen maser package. The technique for the application of liquid emulsion FEP is discussed.

The cavity and attached endcaps compose 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 most recent stability data compiled from four compact hydrogen masers built at NBS is presented. Comparisons are made against the cesium standard NBS-4 and a time scale comprised of nine commercial cesium standards (denoted as 8s). The drift of the longest running measured maser (H4) is undiscernible when compared against the time scale (UTC) composed of NBS-4 with the 8s time scale for two 69-day measurement durations.

22313. Rafelski, J.; Danos, M. **Perspectives in high energy nuclear collisions,** *GSI-83-6 Report,* pp. 1-80 (Gesellschaft für Schwerionenforschung mbH, Planckstr. 1, Postfach 110541, D-6100 Darmstadt 11, Germany, Aug. 1983).

Key words: elementary particles; gluon; hadron; nuclear collisions; nuclear plasma; quark.

This report has been prepared as a working document for the conception of a research facility devoted to the study of high energy nuclear collisions. Different aspects of hadronic physics to be studied in nuclear collisions are selected, with emphasis placed on the properties and nature of the quark-gluon plasma, the formation of the plasma state in the central region and its anticipated lifetime, and the observability and strangeness content of this new form of nuclear matter.

22314. Bernal, J.; Sullivan, F. **Multi-dimensional volumes, super-reflexivity and normal structure in Banach spaces,** *IL J. Math.* **27,** No. 3, 501-513 (1983).

Key words: abnormal set; local k-structure; normal structure; reflexivity; super-reflexivity; volume.

A study of the relationship between super-reflexivity, normal structure and properties of higher dimensional volumes in Banach spaces. N-dimensional volumes enclosed by $n+1$ vectors in a Banach space are defined as to generalize the usual definition of volumes in three-dimensional Euclidean spaces.

22315. Baltatu, M. E.; Ely, J. F.; Graboski, M. S.; Hanley, H. J. M.; Perkins, R. A.; Sloan, E. D. **Thermal conductivity of coal derived liquids,** *Proc. 1983 Int. Conf. Coal Science, Pittsburgh, PA, Aug. 17, 1983,* pp. 757-760 (International Energy Agency, Pittsburgh, PA, 1983).

Key words: coal liquids; corresponding states; critical parameters; thermal conductivity; transient hot wire technique.

The thermal conductivity of petroleum fractions and of coal derived liquids is calculated by the extended corresponding states procedure of Ely and Hanley. The method requires as input, pseudo critical parameters, a pseudo ideal gas specific heat, and molecular weight. These input parameters are estimated here from the normal boiling point and specific gravity of the fraction using the techniques of Lee-Kesler, Riazi and Winn. The relationship between the final value of the conductivity and the choice of the method discussed. Predicted results are compared with data on three coal liquid samples obtained via the transient hot wire method. Agreement between theory and experiment is generally within 10%. Possible reasons for discrepancies are advanced.

22316. Tung, M. S.; Brown, W. E. **An intermediate state in hydrolysis of amorphous calcium phosphate,** *Calcif. Tissue Int.* **35,** 783-790 (1983).

Key words: amorphous calcium phosphate; apatite; calcification; hydrolysis; octacalcium phosphate.

The hydrolysis of previously prepared amorphous calcium phosphate (ACP) was studied in a solution "saturated" with ACP; this eliminated the initial consumption of acid due to ACP dissolution. The procedure established that conversion of a high-concentration ACP slurry to an apatite involves two processes: the first process consumes acid and indicates the formation of a more acidic calcium phosphate intermediary with the solubility of octacalcium phosphate (OCP); the second process consumes base and indicates the conversion of the intermediary to apatite and, possibly, direct conversion of ACP to apatite. The thermodynamic analysis of the solution composition data suggests that ACP converts into a nonstoichiometric apatite when the OCP-like intermediary is formed, and a stoichiometric apatite is formed when no OCP-like intermediary is involved.

22317. Van Poolen, L. J.; Hust, J. G.; Smith, D. R. **A model of apparent thermal conductivity for glass-fiber insulations,** *Proc. Thermal Conductivity 17, Gaithersburg, MD, June 15-18, 1981,* pp. 777-788 (Plenum Publ. Corp., 233 Spring Street, New York, NY 10013, 1983).

Key words: conduction; convection; glass fibers; insulations; low temperature; model; radiation; thermal conductivity.

The heat transfer through glass-fiber insulations is modeled. The model is based primarily on parallel and independent components of heat transfer due to: a) gas-fiber-gas and b) fiber conduction, as well as, c) radiation, and d) convection. The mathematical model, containing six adjustable parameters, is derived from a physical model of sequential parallel layers of space (gas filled or evacuated) and fibers. The total heat transfer, from which one may derive an apparent thermal conductivity, is a function of the fill gas properties (thermal conductivity, collision diameter, and molecular weight), insulation properties (solid fiber conductivity, bulk density, fiber emittance, and fiber diameter), thermodynamic parameters (mean temperature and pressure), and boundary conditions (specimen thickness, temperature difference, and surface emittance). From data generated at the National Bureau of Standards, Boulder, Colorado, as well as published and unpublished data, the parameters in the model were determined. The functional character of the model using these parameters is presented and compared qualitatively to available data.

22318. Sparks, L. L. **Specific heat,** Chapter 2 in *Materials at Low Temperatures,* pp. 47-73 (American Society for Metals, Metals Park, OH 44073, 1983).

Key words: approximation methods; Debye temperature; metals; polymers; specific heat; superconductors.

Specific heat is defined as the amount of heat needed to raise the temperature of a unit mass a unit of temperature, i.e., $C_x=[dQ/dT]_x$ where the constraint, x, is generally either pressure or volume. C_p for a given material may change by six orders of magnitude in the temperature range $1<T<300$ K. Both conduction electrons and lattice vibrations contribute to the specific heat, with the lattice component being dominate at all but very low and very high temperatures. The Debye model of lattice specific heat along with Sommerfield's quantum approach to the electronic contribution results in the well known representation of the total specific heat, $C=\beta T^3+\alpha T$. Cooperative phenomena such as magnetic spin alignment and superconductivity require additional temperature dependent terms to describe the observed specific heats. While the existing models can be used to predict the specific heats of some materials quite well, caution must be exercised since this is not true for all materials.

22319. Sparks, L. L. **Temperature, strain, and magnetic field measurements,** Chapter 14 in *Materials at Low Temperatures,* pp. 515-571 (American Society for Metals, Metals, Park, OH 44073, 1983).

Key words: cryogenics; filled systems; Hall effect; magnetometers; nuclear magnetic resonance; resistance thermometers; rotating coil; strain gauges; temperature scales; thermocouples.

The measurement of three parameters at low temperature are discussed in this chapter—temperature (T), strain (ϵ), and magnetic field strength (H). Two primary goals are to present information necessary to understand the most widely used devices for measuring T, ϵ, and H, and to discuss techniques and materials used in conjunction with low temperature measurements. The discussion of temperature measurement includes an overview of temperature scales leading to the present IPTS-68 scale. Types of devices considered for low temperature measurement are resistance thermometers, thermocouples, and filled systems. Use of these transducers in the presence of magnetic fields is also discussed. Measurement of strain at low temperatures is frequently accomplished using resistance type strain gauges—this type of sensor is stressed. The temperature dependence of apparent strain and gauge factor are discussed. Strain measurements at low temperature and in magnetic fields are becoming increasingly necessary. The field effect, orientation dependence, and strain-magnetic field interaction observed for certain types of gauges are included. Determination of the magnetic field strength itself may be accomplished using magnetometers based on different principles. The three types discussed in this chapter are based on nuclear magnetic resonance, rotating coil, and Hall effects. Each type has attributes which make it advantageous in particular circumstances. The reference section will allow the interested reader to obtain more detailed information for each of the transducers and techniques.

22320. Rybicki, G. B.; Hummer, D. G. **The specific luminosity of a three-dimensional medium in terms of the escape probability,** *Astrophys. J.* **274,** No. 1, 380-398 (Nov. 1, 1983).

Key words: accretion disks; escape probability methods; radiative transfer; Sobolev approximation; stellar atmospheres.

Radiation emitted by a three-dimensional medium and received by a distant observer is expressed in terms of the *specific luminosity,* which can be evaluated in terms of escape probability functions for the medium. This approach is simpler in many cases than an integration over the plane of the sky, because it allows any symmetries of the problem to be more fully exploited. Integral theorems are derived involving averaged escape probabilities that generalize a theorem of Irons. Analogous results are presented for a three-dimensional line-emitting region in the Sobolev (or large velocity gradient) limit. To illustrate the theory, results for expanding spherical media and differently rotating thin disks are discussed. Computationally useful results for several related escape probability functions are given.

22321. Norcross, D. W. **First nonadiabatic correction in model-potential theory,** *Phys. Rev. A* **28,** No. 5, 3095-3097 (Nov. 1983).

Key words: long range interactions; model potentials.

The derivation of the first nonadiabatic correction in a model potential for one or more electrons outside a spherically symmetric core is considered. Previous derivations of this term employed an additional appeal to perturbation theory. It is shown that this is not an essential restriction. Earlier conclusions that no three-body (two electrons plus core) term of this type exists are confirmed. An alternative derivation of this term, with the same conclusion, is sketched. The question of the appropriate normalization of the eigenfunctions of the model Schrödinger equation is also addressed.

22322. Margolis, S. A.; Longenbach, P. J. **Separation of structually similar, biologically active peptides from their impurities,** *J. High Resolut. Chromatogr. Chromatogr. Commu.* **2,** 10092-10093 (May 1979).

Key words: angiotensin I and II; HPLC; liquid chromatography; peptide analysis; peptide hormones; resolution of impurities.

Angiotensin I and other biologically active peptides have been analyzed by HPLC. The solvent system developed was shown to separate closely related peptides and to resolve non-peptide impurities which accumulate during the purification process and which are dissolved from the serum stopper.

22323. Diller, D. E. **Measurements of the viscosity of compressed gaseous and liquid nitrogen,** *Physica* **119A,** 92-100 (1983).

Key words: compressed gaseous nitrogen; compressed liquid nitrogen; density dependence; extended corresponding states model; isotherms; piezoelectric crystal viscometer; saturated liquid nitrogen; shear viscosity coefficient.

The shear viscosity coefficients of compressed gaseous and liquid nitrogen have been measured with a torsional piezoelectric quartz crystal viscometer at temperatures between 90 and 300 K and at pressures up to 30 MPa (4350 psia). The estimated imprecision and experimental error of the measurements are less than one percent and two percent respectively. The measurements have been compared with other measurements; with a correlating equation, previously proposed for calculating the viscosities of pure compressed gaseous and liquid nitrogen; and with an extended corresponding states model, previously proposed for calculating the viscosities of fluid mixtures. Differences between our measurements, other experimental data, the correlating equation and the extended corresponding states model are discussed.

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
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: Physical Standards and Fundamental Constants
Measurement Science and Technology: Policy and State-of-the-Art Surveys
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
Technology Incentives
Thermodynamics and Chemical Kinetics
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.

Acoustics and Sound

TN1113-3. Flynn, D. R.; Yaniv, S. L. **Highway noise criteria study: Relations among frequency rating procedures.** *Natl. Bur. Stand. (U.S.) Tech. Note 1113-3;* 1983 February. 57 p. SN003-003-02474-1.

NBSIR 82-2610. Yaniv, S. L.; Flynn, D. R. **Highway noise criteria study: Executive summary.** 1982 October. 38 p. Available from: NTIS; PB 83-149831.

21604. Burnett, E. D.; Corliss, E. L. R.; Nedzelnitsky, V. **Research problems in coupler and *in situ* measurements on hearing aids,** Paper in *The Vanderbilt Hearing-Aid Report,* pp. 67-73 (Monographs in Contemporary Audiology, 6796 Market Street, Upper Darby, PA, 19082, Dec. 1982).

21613. Proctor, T. M., Jr. **Some details on the NBS conical transducer,** *J. Acoust. Emiss.* **1,** No. 3, 173-178 (1982).

21635. Bartel, T. W.; Yaniv, S. L. **Curvature of sound decays in partially reverberant rooms,** *J. Acoust. Soc. Am.* **72,** No. 6, 1838-1844 (Dec. 1982).

21785. Zahn, M.; Forster, E. O.; Kelley, E. F.; Hebner, R. E., Jr. **Hydrodynamic shock wave propagation after electrical breakdown,** *J. Electrostat.* **12,** 535-546 (1982).

Analytical Chemistry

SP260-83. Bowers, G. N., Jr.; Alvarez, R.; Cali, J. P.; Eberhardt, K. R.; Reeder, D. J.; Schaffer, R.; Uriano, G. A.; Elser, R.; Ewen, L. M.; McComb, R. B.; Rej, R.; Shaw, L. M. **Standard reference materials: The measurement of the catalytic (activity) concentration of seven enzymes in NBS human serum SRM 909.** *Natl. Bur. Stand. (U.S.) Spec. Publ. 260-83;* 1983 June. 108 p. SN003-003-02499-6.

NBSIR 83-2690. Fatiadi, A. J. **Priority toxic pollutants in human urine: Their occurrence and analysis.** 1983 June. 63 p. Available from: NTIS; PB 83-225888.

21548. Moody, J. R.; Beary, E. S. **Purified reagents for trace metal analysis,** *Talanta* **29,** 1003-1010 (1982).

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21578. Moody, J. R. **NBS clean laboratories for trace element analysis,** *Analyt. Chem.* **54,** No. 13, 1358A-1376A (Nov. 1982).

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21641. Davidson, R. M.; Margolis, S. A.; White V, E.; Coxon, B.; Oppenheimer, N. J. **A new, facile synthesis of 2-amino-(pento- and hexo-furano)oxazoline derivatives,** *Carbohydr. Res.* **111,** C16-C19 (1983).

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21956. Kelly, W. R.; Fassett, J. D. **Determination of picogram quantities of uranium in biological tissues by isotope dilution thermal ionization mass spectrometry with ion counting detection,** *Analyt. Chem.* **55,** No. 7, 1040-1044 (1983).

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linewidth; microelectronics; micrometrology; optical metrology; optical microscopy; photomasks; silicon; VLSI; integrated circuits; *21852.*

linewidth calibration; linewidth measurements; linewidth standard; micrometrology; optical microscopy; photomask; semiconductor technology; antireflective chromium photomask; chromium photomask; coincidence shearing micrometer; filar micrometer; image-shearing micrometer; integrated circuits; line-spacing measurements; *21664.*

linewidth measurements; linewidth standard; micrometrology; optical microscopy; photomask; semiconductor technology; antireflective chromium photomask; chromium photomask; coincidence shearing micrometer; filar micrometer; image-shearing micrometer; integrated circuits; line-spacing measurements; linewidth calibration; *21664.*

linewidth measurements; microlithography; microscopy; optical metrology; coherence; edge detection; *21573.*

line widths; theoretical calculations; wavelengths; x ray; crystal diffraction; high atomic number; *21602.*

linewidth standard; micrometrology; optical microscopy; photomask; semiconductor technology; antireflective chromium photomask; chromium photomask; coincidence shearing micrometer; filar micrometer; image-shearing micrometer; integrated circuits; line-spacing measurements; linewidth calibration; linewidth measurements; *21664.*

linewidth uniformity; lithography; microelectronic devices; test chip; cross-bridge sheet resistor; electrical alignment test structure; integrated circuit; integrated circuit test structures; level-to-level registration; linewidth; *21570.*

linseed oil; printing; rheology; thermosetting polymers; tung oil; viscosity; cure; currency; drying; elasticity; ink; intaglio; *22283.*

linseed oil; printing; rheology; tung oil; viscoelasticity; viscosity; cure; drying; intaglio ink; *NBSIR 83-2691.*

liquefaction; gravel drains; *SP651*; 1983 April. 124-149.

liquefaction; pipeline; seismicity; solids; standards; structural engineering; structural response; tsunami; wind loads; winds; accelerograph; codes; design criteria; disaster; earthquake hazards; earthquakes; geotechnical engineering; ground failure; *SP651.*

liquefaction; sandy soils; strain levels; stress levels; cohesion in soil; *SP658*; 1983 July. III-119–III-132.

liquefaction; standard penetration tests; vibratory cone penetrometer; artificial vibration; impact loadings; *SP651*; 1983 April. 541-555.

liquefaction; visco-elastic shear-beam analysis; embankments; *SP651*; 1983 April. 218-241.

liquefaction potential; pore water pressure; soil liquefaction; *SP651*; 1983 April. 172-192.

liquefied natural gas; archimedes; calibration; densimeter; density; *21835.*

liquefied natural gas; LNG densimeter test facility; absolute densimeter; calculation method; correlation method; density measurement; *J. Res. 88(3)*: 163-170; 1983 May-June.

liquefied natural gas; magnetic suspension densimeter; multicomponent mixtures; prediction methods; pure fluids; binary mixtures; density; experimental data; *Monogr. 172.*

liquefied natural gas; metering; methane; metrology; natural gas; PVT; thermophysical properties; transport properties; custody transfer; density; flow metering; fluid properties; heating value; hydrocarbons; *21822.*

liquefied natural gas (LNG); multicomponent mixtures; Clausius-Mossotti function; density; dielectric constant; *22227.*

liquid; model; momentum; partially-filled; pipe; solid; solid-liquid channel flow; steady; uniform; velocity; analysis; flow; force; *J. Res. 88(4)*: 261-288; 1983 July-August.

liquid; molecular band shape; theoretical spectrum; far infrared; induced absorption; *21962.*

liquid breakdown; SF_6; space charge; transformer oil; cables; composite insulation; dc fields; high voltage; incipient fault; insulation; *NBSIR 83-2705.*

liquid chemical dosimetry; pararosaniline cyanide; radiation processing; radiochromic dosimetry; dimethyl sulfoxide; gamma radiation; hexahydroxyethyl pararosaniline cyanide; leucocyanide dyes; *21971.*

liquid chromatography; methyltin hydrides; purge and trap sampling; redox; tetramethyltin; atomic absorption detector; biomethylation; Chesapeake Bay; estuarine organotin transport; flame photometric detector; gas chromatography; kinetics; *21903.*

liquid chromatography; monomeric phase; octadecylsilane; polycyclic aromatic hydrocarbons (PAH); polymeric phase; reversed-phase LC; selectivity; surface coverage; *22141.*

liquid chromatography; motor oil; PCBs; standard reference material; transformer oil; wallcoated open-tubular column; electron capture detection; gas chromatography; *21791.*

liquid chromatography; peptide analysis; peptide hormones; resolution of impurities; angiotensin I and II; HPLC; *22322.*

liquid chromatography (LC); liquid crystal stationary phases; mass spectrometry; polycyclic aromatic sulfur heterocycles; coal liquid; gas chromatography (GC); *21558.*

liquid chromatography (LC); mass spectrometry (MS); polycyclic aromatic hydrocarbons (PAH); SRM's; air particulate matter; biological testing; chemical fractionation; fluorescence detection; gas chromatography (GC); *NBSIR 82-2595.*

liquid chromatography/mass spectrometry (LC/MS); preconcentration; trace analysis; ultrasonic; *21926.*

liquid crystal stationary phases; mass spectrometry; polycyclic aromatic sulfur heterocycles; coal liquid; gas chromatography (GC); liquid chromatography (LC); *21558.*

liquid fuels; particle sizes; powders; alumina; aluminum oxides; diffusion flames; extinction; heptanes; *NBS-GCR-82-412.*

liquid helium; mechanical properties; tensile properties; welds; austenitic steel; cryogenics; fatigue crack propagation; fracture toughness; *22309.*

liquid infiltration; mechanical properties; metallurgy Nb_3Sn; powder; uniaxial strain; critical current density; *22245.*

liquid insulation; magnetic fields; partial discharges; SF_6; solid insulation; transformer oil; electric fields; gaseous insulation; interfaces; *NBSIR 83-2761.*

liquid-measuring devices; measures; scales; specifications; taximeters; tolerances; user requirements; volume-measuring devices; weights; grain moisture; length-measuring devices; *H44, 1984.*

liquid membranes; liquid surfactant membranes; mathematical modeling; membrane transport; separations; carrier-mediated transport; coupled-transport; facilitated transport; ion transport; *21833.*

liquid metal cooling; thermal distortion of mirrors; cooled mirrors; high-power mirrors; *SP638*; 1983 September. 328-338.

liquid mixtures; methane; mixtures; nitrogen; octane; phase equilibria; thermodynamic properties; thermodynamic surface; VLE; butane; critical phenomena; dew-bubble curves; *22025.*

liquid nitrogen; ultrasonic; cryogenic; flow measurement; flowmeters; gyroscopic; *21873.*

liquid phases; thickness; binary solutions; ellipsometry; intermolecular potential; *21761.*

liquid rubbers; mechanisms; microstructure; toughening; epoxy resins; fracture; *22118.*

liquid rubbers; toughening; yield; crack modelling; epoxy resins; fracture; *22119.*

liquid rubidium; liquid state; local order in liquids; metastable liquid; molecular dynamics; nucleation; *21916.*

liquid rubidium; liquid state; molecular dynamics; pair correlation function; self-diffusion coefficient; supercooled liquid; transverse current correlations; Lennard-Jones liquid; *21586.*

liquids; prebreakdown phenomena; streamers; electrical breakdown; hexane; high speed photography; *22124.*

liquids; shock waves; transformer oil; breakdown; dielectrics; high voltage; insulation; *21785.*

liquids; solids; breakdown; composite insulation; dielectrics; electric field calculation; electro-optics; high voltage; insulation; interfaces; Kerr effect; *NBSIR 82-2629.*

liquid scintillation; NaI(Tl) well crystals; positron emitters; sodium-22; standardization; fluorine-18; Ge(Li) spectrometer; ionization chamber; *22081.*

liquid scintillation counter; luminol; lyoluminescence; lyoluminescence enhancement by radiation sensitization; lyoluminescence glow curve fitting; saccharides; chemiluminescence; *NBSIR 83-2734.*

liquid state; local order in liquids; metastable liquid; molecular

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APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).
Auburn: Auburn University, Ralph Brown Draughon Library (1907).
Birmingham:
- Birmingham Public Library (1895).
- Birmingham Southern College Library (1932).
- Jefferson State Junior College, James B. Allen Library (1970).
- Miles College, C. A. Kirkendoll Learning Resource Center (1980).
- Samford University Library (1884).

Enterprise: Enterprise State Junior College, Learning Resources Center (1967).
Fayette: Brewer State Junior College, Learning Resources Center Library (1979).
Florence: University of North Alabama, Collier Library (1932).
Gadsden: Gadsden Public Library (1963).
Huntsville: University of Alabama in Huntsville Library (1964).
Jacksonville: Jacksonville State University Library (1929).
Mobile:
- Mobile Public Library (1963).
- Spring Hill College, Thomas Byrne Memorial Library (1937).
- University of South Alabama Library (1968).

Montgomery:
- Alabama State Department of Archives and History Library (1884).
- Alabama Supreme Court and State Law Library (1884).
- Auburn University at Montgomery Library (1971)–REGIONAL.

Maxwell A.F. Base: Air University Library (1963).
Normal: Alabama Agricultural and Mechanical College, J. F. Drake Memorial Learning Resources Center (1963).
Troy: Troy State University Library (1963).
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
University:
- University of Alabama Library (1860)–REGIONAL.
- University of Alabama, School of Law Library (1967).

ALASKA

Anchorage:
- Anchorage Municipal Libraries, Z. J. Loussac Public Library (1978).
- Supreme Court of Alaska Library (1973).
- University of Alaska at Anchorage Library (1961).
- U.S. Department of Interior, Alaska Resources Library (1981).

Fairbanks: University of Alaska, Elmer E. Rasmuson Library (1922).
Juneau:
- Alaska State Library (1900).
- University of Alaska-Juneau Library (1981).

Ketchikan: Ketchikan Community College Library (1970).

ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).
Flagstaff: Northern Arizona University Library (1937).
Mesa: Mesa Public Library (1983).
Phoenix:
- Department of Library, Archives, and Public Records (unknown)–REGIONAL.
- Grand Canyon College, Fleming Library (1978).
- Phoenix Public Library (1917).

Prescott: Yavapai College Library (1976).
Tempe:
- Arizona State University, College of Law Library (1977).
- Arizona State University Library (1944).

Thatcher: Eastern Arizona College Library (1963).
Tucson:
- Tucson Public Library (1970).
- University of Arizona Library (1907)–REGIONAL.

Yuma: Yuma City-County Library (1963).

ARKANSAS

Arkadelphia: Ouachita Baptist University, Riley Library (1963).
Batesville: Arkansas College Library (1963).
Clarksville: College of the Ozarks, Dobson Memorial Library (1925).
Conway: Hendrix College, Olin C. Bailey Library (1903).
Fayetteville:
- University of Arkansas Universities Libraries (1907).
- University of Arkansas, School of Law Library (1978).

Little Rock:
- Arkansas State Library–REGIONAL. (1978).
- Arkansas Supreme Court Library (1962).
- Little Rock Public Library (1953).
- University of Arkansas at Little Rock Library (1973).
- University of Arkansas at Little Rock Law Library (1979).

Magnolia: Southern Arkansas University, Magale Library (1956).
Monticello: University of Arkansas at Monticello Library (1956).
Pine Bluff: University of Arkansas at Pine Bluff, Watson Memorial Library (1976).
Russellville: Arkansas Tech University, Tomlinson Library (1925).
Searcy: Harding University, Beaumont Memorial Library (1963).
State University: Arkansas State University, Dean B. Ellis Library (1913).
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

Anaheim: Anaheim Public Library (1963).
Arcadia: Arcadia Public Library (1975).
Arcata: Humboldt State University Library (1963).
Bakersfield:
- California State College, Bakersfield Library (1974).
- Kern County, Beale Memorial Library (1943).

Berkeley:
- University of California, Law Library (1963).
- University of California, General Library (1907).

Carson:
- California State University, Dominguez Hills Educational Resources Center (1973).
- Carson Regional Library (1973).

Chico: California State University at Chico Library (1962).
Claremont: Claremont Colleges' Libraries, Honnold Library (1913).
Coalinga: West Hills Community College Library (1978).
Compton: Compton Library (1972).
Culver City: Culver City Library (1966).
Davis:
- University of California, Shields Library (1953).
- University of California at Davis, Law Library (1972).

Downey: Downey City Library (1963).
Fresno:
- California State University, Henry Madden Library (1962).
- Fresno County Free Library (1920).

Fullerton: California State University at Fullerton Library (1963).
Garden Grove: Garden Grove Regional Library (1963).
Gardena: Gardena Public Library (1966).
Hayward: California State University at Hayward Library (1963).
Huntington Park: Huntington Park Library, San Antonio Region (1970).
Inglewood: Inglewood Public Library (1963).
Irvine: University of California at Irvine, General Library (1963).
La Jolla: University of California at San Diego, Central University Library (1963).
Lakewood: Angelo Iacoboni Public Library (1970).
Lancaster: Lancaster Regional Library (1967).
La Verne: University of La Verne, College of Law Library (1979).
Long Beach:
- California State University at Long Beach Library (1962).
- Long Beach Public Library (1933).

Los Angeles:
- California State University at Los Angeles, John F. Kennedy Memorial Library (1956).
- Los Angeles County Law Library (1963).
- Los Angeles Public Library (1891).

Loyola Marymount University, Charles Von der Ahe Library (1933).
Loyola Law School, Law Library (1979).
Occidental College Library (1941).
Pepperdine University Library (1963).
Southwestern University, School of Law Library (1975).
University of California at Los Angeles Research Library (1932).
University of California, Los Angeles, Law Library (1958).
University of Southern California, Doheny Memorial Library (1933).
University of Southern California, Law Library (1978).
U.S. Court of Appeals, 9th Circuit Library (1981).
Whittier College, School of Law Library (1978).
Menlo Park: Department of Interior, Geological Survey Library (1962).
Montebello: Montebello Library (1966).
Monterey: U.S. Naval Postgraduate School, Dudley Knox Library (1963).
Monterey Park: Bruggemeyer Memorial Library (1964).
Northridge: California State University at Northridge, Oviatt Library (1958).
Norwalk: Norwalk Public Library (1973).
Oakland:
Mills College Library (1966).
Oakland Public Library (1923).
Ontario: Ontario City Library (1974).
Palm Springs: Palm Springs Public Library (1980).
Pasadena:
California Institute of Technology, Millikan Memorial Library (1933).
Pasadena Public Library (1963).
Pleasant Hill: Contra Costa County Library (1964).
Redding: Shasta County Library (1956).
Redlands: University of Redlands, Armacost Library (1933).
Redwood City: Redwood City Public Library (1966).
Reseda: West Valley Regional Branch Library (1966).
Richmond: Richmond Public Library (1943).
Riverside:
Riverside Public Library (1947).
University of California at Riverside Library (1963).
Sacramento:
California State Library (1895)–REGIONAL.
California State University at Sacramento Library (1963).
Sacramento County Law Library (1963).
Sacramento Public Library (1880).
University of the Pacific, McGeorge School of Law Library (1978).
San Bernardino: San Bernardino County Free Library (1964).
San Diego:
San Diego County Law Library (1973).
San Diego County Library (1966).
San Diego Public Library (1895).
San Diego State University Library (1962).
University of San Diego, Kratter Law Library (1967).
San Francisco:
Golden Gate University, School of Law Library (1979).
Hastings College of Law Library (1972).
Mechanics' Institute Library (1889).
San Francisco Public Library (1889).
San Francisco State University, J. Paul Leonard Library (1955).
Supreme Court of California Library (1979).
U.S. Court of Appeals, Ninth Circuit Library (1971).
University of San Francisco, Richard A. Gleeson Library (1963).
San Jose: San Jose State University Library (1962).
San Leandro: San Leandro Community Library Center (1961).
San Luis Obispo: California Polytechnic State University Library (1969).
San Rafael: Marin County Free Library (1975).
Santa Ana:
Orange County Law Library (1975).
Santa Ana Public Library (1959).
Santa Barbara: University of California at Santa Barbara Library (1960).
Santa Clara: University of Santa Clara, Orradre Library (1963).
Santa Cruz: University of California at Santa Cruz, McHenry Library (1963).
Santa Rosa: Sonoma County Library (1896).
Stanford:
Stanford University Libraries (1895).
Stanford University, Robert Crown Law Library (1978).
Stockton: Public Library of Stockton and San Joaquin County (1884).
Thousand Oaks: California Lutheran College Library (1964).
Torrance: Torrance Civic Center Library (1969).
Turlock: California State College, Stanislaus Library (1964).
Vallejo: Solano County, John F. Kennedy Library (1982).
Valencia: Valencia Regional Library (1972).
Ventura: Ventura County Library (1975).
Visalia: Tulare County Free Library (1967).
Walnut: Mount San Antonio College Library (1966).
West Covina: West Covina Regional Library (1966).
Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

Balboa Heights: Panama Canal Commission, Library Services Branch (1963).

COLORADO

Alamosa: Adams State College, Learning Resources Center (1963).
Boulder: University of Colorado at Boulder, Government Publications Library (1879)–REGIONAL.
Colorado Springs:
Colorado College, Tutt Library (1880).
University of Colorado at Colorado Springs, Library (1974).
Denver:
Auraria Library (1978).
Colorado State Library (unknown).
Colorado Supreme Court Library (1978).
Denver Public Library (1884)–REGIONAL.
Department of the Interior, Water and Power Resources Service Library (1962).
Regis College, Dayton Memorial Library (1915).
University of Denver, Penrose Library (1909).
University of Denver, School of Law Library (1978).
U.S. Court of Appeals, Tenth Circuit Library (1973).
Fort Collins: Colorado State University Libraries (1907).
Golden: Colorado School of Mines, Arthur Lakes Library (1939).
Grand Junction: Mesa County Public Library (1975).
Greeley: University of Northern Colorado, James A. Michener Library (1966).
Gunnison: Western State College, Leslie J. Savage Library (1932).
La Junta: Otero Junior College, Wheeler Library (1963).
Lakewood: Jefferson County Public Library, Lakewood Library (1968).
Pueblo:
Pueblo Library District (1893).
University of Southern Colorado Library (1965).
U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

Bridgeport:
Bridgeport Public Library (1884).
University of Bridgeport School of Law Library (1979).
Danbury: Western Connecticut State University, Ruth A. Haas Library (1967).
Danielson: Quinebaug Valley Community College Library (1975).
Enfield: Enfield Central Library (1967).
Hartford:
Connecticut State Library (unknown)–REGIONAL.
Hartford Public Library (1945).
Trinity College Library (1895).
Middletown: Wesleyan University, Olin Library (1906).
Mystic: Mystic Seaport Museum Inc., G. W. Blunt White Library (1964).
New Britain: Central Connecticut State University, Elihu Burritt Library (1973).
New Haven:
Southern Connecticut State University, Hilton C. Buley Library (1968).
Yale Law Library (1981).

Yale University Library (1859).
New London:
Connecticut College Library (1926).
U.S. Coast Guard Academy Library (1939).
Stamford: The Ferguson Library (1973).
Storrs: University of Connecticut Library (1907).
Waterbury:
Post College, Traurig Library (1977).
Silas Bronson Public Library (1869).
West Hartford: University of Connecticut, School of Law Library (1978).
West Haven: University of New Haven, Peterson Library (1971).

DELAWARE

Dover:
Delaware State College, William C. Jason Library (1962).
State Law Library in Kent County (unknown).
Georgetown:
Delaware Technical and Community College Library (1968).
Sussex County Law Library (1976).
Newark: University of Delaware Library (1907).
Wilmington:
Delaware Law School Library (1976).
New Castle County Law Library (1974).

DISTRICT OF COLUMBIA

Washington:
Administrative Conference of the United States Library (1977).
Advisory Commission on Intergovernmental Relations Library (1972).
American University, Washington College of Law Library (1983).
Antioch School of Law Library (1982).
Catholic University of America, Robert J. White Law Library (1979).
Civil Aeronautics Board Library (1974).
Department of the Army Library (1969).
Department of Commerce Library (1955).
Department of Energy Library (1963).
Department of Health and Human Services (1954).
Department of Housing and Urban Development Library (1969).
Department of the Interior Library (1895).
Department of Justice Main Library (1895).
Department of Labor Library (1976).
Department of the Navy Library (1895).
Department of State Library (1895).
Department of State Law Library (1966).
Department of Transportation Main Library (1982).
Department of Transportation, National Highway Traffic Safety Administration Library (1968).
Department of Transportation, U.S. Coast Guard Law Library (1982).
Department of the Treasury Library (1895).
District of Columbia Court of Appeals Library (1981).
District of Columbia Public Library (1943).
Executive Office of the President, Office of Administration, Library and Information Service Division (1965).
Federal Deposit Insurance Corporation Library (1972).
Federal Election Commission Library (1975).
Federal Labor Relations Authority Law Library (1982).
Federal Mine Safety & Health Review Commission Library (1979).
Federal Reserve System, Board of Governors Research Library (1978).
Federal Reserve System Law Library (1976).
General Accounting Office Library (1974).
General Services Administration Library (1975).
Georgetown University Library (1969).
Georgetown University Law Center, Fred O. Dennis Law Library (1978).
George Washington University, Melvin Gelman Library (1983).
George Washington University, National Law Center, Jacob Burns Law Library (1978).
Library of Congress, Congressional Research Service (1978).
Library of Congress, Serial and Government Publications (1977).
Merit Systems Protection Board Library (1979).
National Defense University Library (1895).
University of the District of Columbia Library (1970).
U.S. Court of Appeals, Judges' Library (1975).
U.S. Office of Personnel Management Library (1963).
U.S. Postal Service Library (1895).
U.S. Senate Library (1979).
U.S. Supreme Court Library (1978).
Veterans' Administration, Central Office Library (1967).

FLORIDA

Boca Raton: Florida Atlantic University, S. E. Wimberly Library (1963).
Clearwater: Clearwater Public Library (1972).
Coral Gables: University of Miami Library (1939).
Daytona Beach: Volusia County Library Center (1963).
De Land: Stetson University, duPont-Ball Library (1887).
Fort Lauderdale:
Broward County Library (1967).
Nova University, Center for Study of Law Library (1967).
Fort Pierce: Indian River Community College Library (1975).
Gainesville:
University of Florida, College of Law Library (1978).
University of Florida Libraries (1907)-REGIONAL.
Jacksonville:
Haydon Burns Library (1914).
Jacksonville University, Swisher Library (1962).
University of North Florida, Thomas G. Carpenter Library (1972).
Lakeland: Lakeland Public Library (1928).
Leesburg: Lake-Sumter Community College Library (1963).
Melbourne: Florida Institute of Technology Library (1963).
Miami:
Florida International University Library (1970).
Miami-Dade Public Library (1952).
North Miami: Florida International University, North Miami Campus Library (1977).
Opa Locka: Biscayne College Library (1966).
Orlando: University of Central Florida Library (1966).
Palatka: St. Johns River Community College Library (1963).
Pensacola: University of West Florida, John C. Pace Library (1966).
Port Charlotte: Charlotte County Library System (1973).
St. Petersburg:
St. Petersburg Public Library (1965).
Stetson University College of Law, Charles A. Dana Library (1975).
Sarasota: Selby Public Library (1970).
Tallahassee:
Florida Agricultural and Mechanical University, Coleman Learning Resources Center (1936).
Florida State University, College of Law Library (1978).
Florida State University, Robert M. Strozier Library (1941). (1941).
Florida Supreme Court Library (1974).
State Library of Florida (1929).
Tampa:
Tampa-Hillsborough County Public Library (1965).
University of South Florida Library (1962).
University of Tampa, Merl Kelce Library (1953).
Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

Albany: Albany-Dougherty Public Library (1964).
Americus: Georgia Southwestern College, James Earl Carter Library (1966).
Athens:
University of Georgia Libraries (1907)-REGIONAL.
University of Georgia, School of Law Library (1979).
Atlanta:
Atlanta Public Library (1880).
Atlanta University Center, Robert W. Woodruff Library (1962).
Emory University, Woodruff Library (1928).
Emory University, School of Law Library (1968).

Georgia Institute of Technology, Price Gilbert Memorial Library (1963).
Georgia State Library (unknown).
Georgia State University, College of Law Library (1983).
Georgia State University, William Russell Pullen Library (1970).
U.S. Court of Appeals, 5th Circuit Library (1980).
Augusta: Augusta College, Reese Library (1962).
Brunswick: Brunswick-Glynn County Regional Library (1965).
Carrollton: West Georgia College, Irvine Sullivan Ingram Library (1962).
Columbus: Columbus College, Simon Schwob Memorial Library (1975).
Dahlonega: North Georgia College, Stewart Library (1939).
Dalton: Dalton Junior College Library (1978).
Decatur: DeKalb Community College, South Campus Learning Resources Center (1973).
Macon:
Mercer University, Stetson Memorial Library (1964).
Mercer University, Walter F. George School of Law Library (1978).
Marietta: Kennesaw College Memorial Library (1968).
Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).
Mount Berry: Berry College Memorial Library (1970).
Savannah: Chatham-Effingham Liberty Regional Library (1857).
Statesboro: Georgia Southern College Library (1939).
Valdosta: Valdosta State College Library (1956).

GUAM

Agana: Nieves M. Flores Memorial Library (1962).
Mangilao: University of Guam, Robert F. Kennedy Memorial Library (1978).

HAWAII

Hilo: University of Hawaii at Hilo Library (1962).
Honolulu:
Hawaii Medical Library, Inc. (1968).
Hawaii State Library (1929).
Municipal Reference & Records Center (1965).
Supreme Court Law Library (1973).
University of Hawaii Library (1907)-REGIONAL.
University of Hawaii, School of Law Library (1978).
Laie: Brigham Young University, Hawaii Campus, Joseph F. Smith Library (1964).
Lihue: Kauai Regional Library (1967).
Pearl City: Leeward Community College Library (1967).
Wailuku: Maui Public Library (1962).

IDAHO

Boise:
Boise Public Library and Information Center (1929).
Boise State University Library (1966).
Idaho State Law Library (unknown).
Idaho State Library (1971).
Caldwell: College of Idaho, Terteling Library (1930).
Moscow:
University of Idaho, College of Law Library (1978).
University of Idaho Library (1907)-REGIONAL.
Pocatello: Idaho State University Library (1908).
Rexburg: Ricks College, David O. McKay Library (1946).
Twin Falls: College of Southern Idaho Library (1970).

ILLINOIS

Bloomington: Illinois Wesleyan University Libraries (1964).
Carbondale:
Southern Illinois University, Morris Library (1932).
Southern Illinois University, School of Law Library (1978).
Carlinville: Blackburn College, Lumpkin Library (1954).
Carterville: Shawnee Library System (1971).
Champaign: University of Illinois, Law Library (1965).
Charleston: Eastern Illinois University, Booth Library (1962).
Chicago:
Chicago Public Library (1876).
Chicago State University, Paul and Emily Douglas Library (1954).
DePaul University, Law Library (1979).
Field Museum of Natural History Library (1963).
Illinois Institute of Technology, Chicago-Kent College of Law Library (1978).
Illinois Institute of Technology, Kemper Library (1982).
John Crerar Library (1909).
John Marshall Law School Library (1981).
Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).
Loyola University, School of Law Library (1979).
Northeastern Illinois University Library (1961).
Northwestern University, School of Law Library (1978).
University of Chicago, Law Library (1964).
University of Chicago Library (1897).
University of Illinois at Chicago Circle Library (1957).
William J. Campbell Library of the U.S. Courts (1979).
Decatur: Decatur Public Library (1954).
De Kalb:
Northern Illinois University, College of Law Library (1978).
Northern Illinois University, Founders' Memorial Library (1960).
Des Plaines: Oakton Community College, Learning Resource Center (1976).
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 (1957).
Kankakee: Olivet Nazarene College, Benner Library and Learning Resource Center (1946).
Lake Forest: Lake Forest College, Donnelley Library (1962).
Lebanon: McKendree College, Holman Library (1968).
Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).
Macomb: Western Illinois University Libraries (1962).
Moline: Black Hawk College, Learning Resources Center (1970).
Monmouth: Monmouth College, Hewes Library (1860).
Mt. Carmel: Wabash Valley College, Bauer Media Center (1975).
Mt. Prospect: Mt. Prospect Public Library (1977).
Normal: Illinois State University, Milner Library (1877).
Oak Park: Oak Park Public Library (1963).
Oglesby: Illinois Valley Community College, Jacobs Memorial Library (1976).
Palos Hills: Moraine Valley Community College Library (1972).
Park Forest South: Governors' State University Library (1974).
Peoria:
Bradley University, Cullom-Davis Library (1963).
Peoria Public Library (1883).
River Forest: Rosary College, Rebecca Crown Library (1966).
Rockford: Rockford Public Library (1895).
Romeoville: Lewis University Library (1952).
Springfield: Illinois State Library (unknown)-REGIONAL.
Streamwood: Poplar Creek Public Library District (1980).
Urbana: University of Illinois Library (1907).
Wheaton: Wheaton College Library (1964).
Woodstock: Woodstock Public Library (1963).

INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).
Bloomington:
Indiana University Library (1881).
Indiana University, School of Law Library (1978).
Crawfordsville: Wabash College, Lilly Library (1906).
Evansville:
Evansville and Vanderburgh County Public Library (1928).
Indiana State University, Evansville Campus Library (1969).
Fort Wayne:
Indiana-Purdue Universities, Helmke Library (1965).
Allen County Public Library (1896).

Franklin: Franklin College Library (1976).
Gary:
Gary Public Library (1943).
Indiana University, Northwest Campus Library (1966).
Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College, Duggan Library (1892).
Huntington: Huntington College, Loew Alumni Library (1964).
Indianapolis:
Butler University, Irwin Library (1965).
Indianapolis-Marion County Public Library (1906).
Indiana State Library (unknown)–REGIONAL.
Indiana Supreme Court, Law Library (1975).
Indiana University, School of Law Library (1967).
Indiana University-Purdue University Library (1979).
Kokomo: Indiana University at Kokomo, Learning Resource Center (1969).
Lafayette: Purdue University Libraries and Audio-Visual Center (1907).
Muncie:
Ball State University Library (1959).
Muncie Public Library (1906).
New Albany: Indiana University, Southeastern Campus Library (1965).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
Earlham College, Lilly Library (1964).
Morrison-Reeves Library (1906).
South Bend: Indiana University at South Bend Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso:
Valparaiso University, Moellering Memorial Library (1930).
Valparaiso University, Law Library (1978).

IOWA

Ames: Iowa State University Library (1907).
Cedar Falls: University of Northern Iowa Library (1946).
Council Bluffs:
Free Public Library (1885).
Iowa Western Community College, Herbert Hoover Library (1972).
Davenport: Davenport Public Library (1973).
Des Moines:
Drake University, Cowles Library (1966).
Drake University, Law Library (1972).
Public Library of Des Moines (1888).
State Library of Iowa (unknown).
Dubuque:
Carnegie-Stout Public Library (unknown).
Loras College, Wahlert Memorial Library (1967).
Fayette: Upper Iowa University, Henderson-Wilder Library (1974).
Grinnell: Grinnell College Library (1874).
Iowa City:
University of Iowa College of Law, Law Library (1968).
University of Iowa Libraries (1884)–REGIONAL.
Lamoni: Graceland College, Frederick Madison Smith Library (1927).
Mason City: North Iowa Area Community College Library (1976).
Mount Vernon: Cornell College, Russell D. Cole Library (1896).
Orange City: Northwestern College, Ramaker Library (1970).
Sioux City: Sioux City Public Library (1894).

KANSAS

Atchison: Benedictine College Library, North Campus (1965).
Baldwin City: Baker University, Collins Library (1908).
Colby: Colby Community College, H. F. Davis Memorial Library (1968).
Emporia: Emporia State University, William Allen White Library (1909).
Fort Scott: Fort Scott Community College, Learning Resources Center Library (1979).
Hays: Fort Hays State University, Forsyth Library (1926).
Hutchinson: Hutchinson Public Library (1963).
Lawrence:
University of Kansas, Law Library (1971).
University of Kansas, Spencer Research Library (1869)–REGIONAL.
Manhattan: Kansas State University, Farrell Library (1907).
Pittsburg: Pittsburg State University, Leonard H. Axe Library (1952).
Salina: Kansas Wesleyan University, Memorial Library (1930).
Shawnee Mission: Johnson County Library (1979).
Topeka:
Kansas State Historical Society Library (1877).
Kansas State Library (unknown).
Kansas Supreme Court Law Library (1975).
Washburn University of Topeka, Law Library (1971).
Wichita: Wichita State University Ablah Library (1901).

KENTUCKY

Ashland: Boyd County Public Library (1946).
Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
Bowling Green: Western Kentucky University, Helm-Cravens Graduate Center and Library (1934).
Crestview Hills: Thomas More College Library (1970).
Danville: Centre College, Grace Doherty Library (1884).
Frankfort:
Kentucky Department of Libraries and Archives (1967).
Kentucky State Law Library (unknown).
Kentucky State University, Blazer Library (1972).
Highland Heights: Northern Kentucky University, W. Frank Steely Library (1973).
Hopkinsville: Hopkinsville Community College Library (1976).
Lexington:
University of Kentucky Law Library (1968).
University of Kentucky Libraries (1907)–REGIONAL.
Louisville:
Louisville Free Public Library (1904).
University of Louisville, Ekstrom Library (1925).
University of Louisville, Law Library (1975).
Morehead: Morehead State University, Camden-Carroll Library (1955).
Murray: Murray State University, Waterfield Library (1924).
Owensboro: Kentucky Wesleyan College Library Learning Center (1966).
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

LOUISIANA

Baton Rouge:
Louisiana State Library (1976).
Louisiana State University, Middleton Library (1907)–REGIONAL.
Louisiana State University, Paul M. Hebert Law Center Library (1929).
Louisiana State University Library (1907)–REGIONAL.
Southern University Law School Library (1979).
Southern University Library (1952).
Eunice: Louisiana State University at Eunice, LeDoux Library (1969).
Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).
Lafayette: University of Southwestern Louisiana Library (1938).
Lake Charles: McNeese State University, Lether E. Frazar Memorial Library (1941).
Monroe: Northeast Louisiana University, Sandel Library (1963).
Natchitoches: Northwestern State University, Watson Memorial Library (1887).
New Orleans:
Law Library of Louisiana (unknown).
Loyola University Library (1942).
Loyola University, Law Library (1978).
New Orleans Public Library (1883).
Our Lady of Holy Cross College Library (1982).
Southern University in New Orleans Library (1962).
Tulane University, Howard-Tilton Memorial Library (1942).
Tulane University Law Library (1976).

University of New Orleans Earl K. Long Library (1963).
U.S. Court of Appeals, Fifth Circuit Library (1973).
Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).
Ruston: Louisiana Technical University, Prescott Memorial Library (1896)-REGIONAL.
Shreveport:
Louisiana State University at Shreveport Library (1967).
Shreve Memorial Library (1923).
Thibodaux: Nicholls State University, Ellender Memorial Library (1962).

MAINE

Augusta:
Maine Law and Legislative Reference Library (1973).
Maine State Library (unknown).
Bangor: Bangor Public Library (1884).
Brunswick: Bowdoin College Library (1884).
Castine: Maine Maritime Academy, Nutting Memorial Library (1969).
Lewiston: Bates College, George and Helen Ladd Library (1883).
Orono: University of Maine, Raymond H. Fogler Library (1907)-REGIONAL.
Portland:
Portland Public Library (1884).
University of Maine School of Law Library (1964).
Presque Isle: University of Maine at Presque Isle, Library/Learning Resources Center (1979).
Springvale: Nasson College Library (1961).
Waterville: Colby College, Miller Library (1884).

MARYLAND

Annapolis:
Maryland State Law Library (unknown).
U.S. Naval Academy, Nimitz Library (1895).
Baltimore:
Enoch Pratt Free Library (1887).
Johns Hopkins University, Milton S. Eisenhower Library (1882).
Morgan State College, Soper Library (1940).
University of Baltimore, University Library (1973).
University of Baltimore Law Library (1980).
University of Maryland School of Law, Marshall Law Library (1969).
U.S. Court of Appeals, 4th Circuit Library (1982).
Bel Air: Harford Community College Library (1967).
Beltsville: Department of Agriculture, National Agricultural Library (1895).
Bethesda: Department of Health and Human Services, National Library of Medicine (1978).
Catonsville: University of Maryland, Baltimore County, University Library (1971).
Chestertown: Washington College, Clifton M. Miller Library (1891).
College Park: University of Maryland, McKeldin Library (1925)-REGIONAL.
Cumberland: Allegany Community College Library (1974).
Frostburg: Frostburg State College Library (1967).
Patuxent River: U.S. Naval Air Station Library (1968).
Rockville: Montgomery County Department of Public Libraries (1951).
Salisbury: Salisbury State College, Blackwell Library (1965).
Towson:
Goucher College, Julia Rogers Library (1966).
Towson State University, Cook Library (1979).
Westminster: Western Maryland College, Hoover Library (1886).

MASSACHUSETTS

Amherst:
Amherst College Library (1884).
University of Massachusetts, Goodell Library (1907).
Boston:
Boston Athenaeum Library (unknown).
Boston Public Library (1859)-REGIONAL.
Boston University School of Law, Pappas Law Library (1979).
Northeastern University Dodge Library (1962).
State Library of Massachusetts (unknown).
Suffolk University, Law Library (1979).
Supreme Judicial Court, Social Law Library (1979).
U.S. Court of Appeals, First Circuit Library (1978).
Brookline: Public Library of Brookline (1925).
Cambridge:
Harvard College Library (1860).
Harvard Law School Library (1981).
Massachusetts Institute of Technology Libraries (1946).
Chestnut Hill: Boston College, Bapst Library (1963).
Chicopee: College of Our Lady of the Elms, Alumnae Library (1969).
Lowell: University of Lowell, Alumni-Lydon Library (1952).
Lynn: Lynn Public Library (1953).
Marlborough: Marlborough Public Library (1971).
Medford: Tufts University Library (1899).
Milton: Curry College, Levin Library (1972).
New Bedford: New Bedford Free Public Library (1858).
Newton Centre: Boston College Law School Library (1979).
North Dartmouth: Southeastern Massachusetts University Library (1965).
North Easton: Stonehill College, Cushing-Martin Library (1962).
Springfield:
Springfield City Library (1966).
Western New England College, Law Library (1978).
Waltham:
Brandeis University Library (1965).
Waltham Public Library (1943).
Wellesley: Wellesley College Library (1943).
Wenham: Gordon College, Winn Library (1963).
Williamstown: Williams College Library (unknown).
Worcester:
American Antiquarian Society Library (1814).
University of Massachusetts Medical Center, Lamar Soutter Library (1972).
Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).
Allendale: Grand Valley State College, Zumberge Library (1963).
Alma: Alma College Library (1963).
Ann Arbor:
University of Michigan, Harlan Hatcher Library (1884).
University of Michigan, Law Library (1978).
Benton Harbor: Benton Harbor Public Library (1907).
Bloomfield Hills: Cranbrook Institute of Science Library (1940).
Dearborn:
Henry Ford Centennial Library (1969).
Henry Ford Community College Library (1957).
Detroit:
Detroit College of Law Library (1979).
Detroit Public Library (1868)-REGIONAL.
Marygrove College Library (1965).
Mercy College of Detroit Library (1965).
University of Detroit Library (1884).
University of Detroit, School of Law Library (1978).
Wayne State University, G. Flint Purdy Library (1937).
Wayne State University, Arthur Neef Law Library (1971).
Dowagiac: Southwestern Michigan College, Matthews Library (1971).
East Lansing: Michigan State University Library (1907).
Farmington Hills: Oakland Community College, Martin L. King Learning Resources Center, (1968).
Flint:
Flint Public Library (1967).
University of Michigan-Flint Library (1959).
Grand Rapids:
Calvin College & Seminary Library (1967).
Grand Rapids Public Library (1876).
Houghton: Michigan Technological University Library (1876).
Jackson: Jackson District Library (1965).
Kalamazoo:
Kalamazoo Public Library (1907).
Western Michigan University, Dwight B. Waldo Library (1963).

Lansing:
Michigan State Library (unknown)-REGIONAL.
Thomas M. Cooley Law School Library (1978).
Livonia: Schoolcraft College Library (1962).
Madison Heights: Madison Heights Public Library (1982).
Marquette: Northern Michigan University, Olson Library (1963).
Monroe: Monroe County Library System (1974).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Olivet: Olivet College Library (1974).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Sault Ste. Marie: Lake Superior State College, Kenneth Shouldice Library (1982).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Learning Resources Center (1963).
Warren: Warren Public Library, Arthur J. Miller Branch (1973).
Wayne: Wayne Oakland Library Federation (1957).
Ypsilanti: Eastern Michigan University Library (1965).

MICRONESIA

Community College of Micronesia Library (1982).

MINNESOTA

Bemidji: Bemidji State University, A. C. Clark Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Cottage Grove: Washington County Library-Park Grove (1983).
Duluth: Duluth Public Library (1909).
Edina: Southdale-Hennepin Area Library (1971)
Mankato: Mankato State University Library (1962).
Minneapolis:
Anoka County Library (1971).
Minneapolis Public Library (1893).
University of Minnesota, Law School Library (1978).
University of Minnesota, Wilson Library (1907)-REGIONAL.
Moorhead: Moorhead State University Library (1956).
Morris: University of Minnesota, Morris, Rodney Briggs Library (1963).
Northfield:
Carleton College Library (1930).
St. Olaf College, Rolvaag Memorial Library (1930).
St. Cloud: St. Cloud State University, Learning Resources Center (1962).
St. Paul:
Hamline University, School of Law Library (1978).
Minnesota Historical Society Library (1867).
Minnesota State Law Library (unknown).
St. Paul Public Library (1914).
University of Minnesota, St. Paul Campus Library (1974).
William Mitchell College of Law Library (1979).
St. Peter: Gustavus Adolphus College Library (1941).
Willmar: Crow River Regional Library (1958).
Winona: Winona State University, Maxwell Library (1969).

MISSISSIPPI

Cleveland: Delta State University, W. B. Roberts Library (1975).
Columbus: Mississippi State University for Women, John Clayton Fant Memorial Library (1929).
Hattiesburg: University of Southern Mississippi, Joseph A. Cook Memorial Library (1935).
Jackson:
Jackson State University, Henry Thomas Sampson Library (1968).
Millsaps College, Millsaps-Wilson Library (1963).
Mississippi College, School of Law Library (1977).
Mississippi Library Commission (1947).
Mississippi State Library (unknown).
Lorman: Alcorn State University Library (1970).
Mississippi State: Mississippi State University, Mitchell Memorial Library (1907).
University:
University of Mississippi Library (1833)-REGIONAL.
University of Mississippi, Law Library (1967).

MISSOURI

Cape Girardeau: Southeast Missouri State University, Kent Library (1916).
Columbia:
University of Missouri at Columbia Library (1862).
University of Missouri-Columbia, Law Library (1978).
Fayette: Central Methodist College, George M. Smiley Library (1962).
Fulton: Westminster College, Reeves Library (1875).
Jefferson City:
Lincoln University, Inman E. Page Library (1944).
Missouri State Library (1963).
Missouri Supreme Court Library (unknown).
Joplin: Missouri Southern State College Library (1966).
Kansas City:
Kansas City Public Library (1881).
Rockhurst College, Greenlease Library (1917).
University of Missouri at Kansas City, General Library (1938).
University of Missouri-Kansas City, Leon E. Bloch Law Library (1978).
Kirksville: Northeast Missouri State University, Pickler Memorial Library (1966).
Liberty: William Jewell College, Charles F. Curry Library (1900).
Maryville: Northwest Missouri State University, Wells Library (1982).
Rolla: University of Missouri-Rolla, Curtis Laws Wilson Library (1907).
St. Charles: Lindenwood Colleges, Margaret Leggat Butler Library (1973).
St. Joseph: St. Joseph Public Library (1891).
St. Louis:
Maryville College Library (1976).
St. Louis County Library (1970).
St. Louis Public Library (1866).
St. Louis University Law Library (1967).
St. Louis University, Pius XII Memorial Library (1966).
University of Missouri at St. Louis, Thomas Jefferson Library (1966).
U.S. Court of Appeals, Eighth Circuit Library (1972).
Washington University, John M. Olin Library (1906).
Washington University Law Library (1978).
Springfield:
Drury College Walker Library (1874).
Southwest Missouri State University Library (1963).
Warrensburg: Central Missouri State University, Ward Edwards Library (1914).

MONTANA

Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Renne Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Havre: Northern Montana College Library (1980).
Helena:
Carroll College Library (1974).
Montana Historical Society Library (unknown).
Montana State Library (1966).
State Law Library of Montana (1977).
Missoula: University of Montana Maurene & Mike Mansfield Library (1909)-REGIONAL.

NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).
Crete: Doane College, Perkins Library (1944).
Fremont: Midland Lutheran College Luther Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).

Lincoln:
- Nebraska Library Commission (1972)–REGIONAL.
- Nebraska State Library (unknown).
- University of Nebraska-Lincoln, College of Law Library (1981).
- University of Nebraska-Lincoln, D. L. Love Memorial Library (1907)–REGIONAL.

Omaha:
- Creighton University, Alumni Memorial Library (1964).
- Creighton University Law Library (1979).
- Omaha Public Library, W. Dale Clark Library (1880).
- University of Nebraska at Omaha, University Library (1939).

Scottsbluff: Scottsbluff Public Library (1925).
Wayne: Wayne State College, U.S. Conn Library (1970).

NEVADA

Carson City:
- Nevada State Library (unknown).
- Nevada Supreme Court Library (1973).

Las Vegas:
- Clark County Library District (1974).
- University of Nevada at Las Vegas, James Dickinson Library (1959).

Reno:
- National Judicial College, Law Library (1979).
- Nevada Historical Society Library (1974).
- University of Nevada Library (1907)–REGIONAL.
- Washoe County Library (1980).

NEW HAMPSHIRE

Concord:
- Franklin Pierce Law Center Library (1973).
- New Hampshire State Library (unknown).

Durham: University of New Hampshire Library (1907).
Hanover: Dartmouth College Library (1884).
Henniker: New England College Danforth Library (1966).
Manchester:
- Manchester City Library (1884).
- New Hampshire College, H. A. B. Shapiro Memorial Library (1976).
- St. Anselm's College, Geisel Library (1963).

Nashua: Nashua Public Library (1971).

NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).
Bloomfield: Bloomfield Public Library (1965).
Bridgeton: Cumberland County Library (1966).
Camden:
- Rutgers University, Camden Library (1966).
- Rutgers University, School of Law Library (1979).

Convent Station: College of St. Elizabeth, Mahoney Library (1938).
East Brunswick: East Brunswick Public Library (1977).
East Orange: East Orange Public Library (1966).
Elizabeth: Free Public Library of Elizabeth (1895).
Glassboro: Glassboro State College, Savitz Learning Resource Center (1963).
Hackensack: Johnson Free Public Library (1966).
Irvington: Free Public Library of Irvington (1966).
Jersey City:
- Jersey City Public Library (1879).
- Jersey City State College, Forrest A. Irwin Library (1963).

Lawrenceville: Rider College, Franklin F. Moore Library (1975).
Madison: Drew University, Rose Memorial Library (1939).
Mahwah: Ramapo College Library (1971).
Mount Holly: Burlington County Library (1966).
New Brunswick:
- New Brunswick Free Public Library (1908).
- Rutgers University Alexander Library (1907).

Newark:
- Newark Public Library (1906)–REGIONAL.
- Rutgers, The State University, John Cotton Dana Library (1966).
- Rutgers, The State University, Law School, Newark (1979).
- Seton Hall University Law Library (1979).

Passaic: Passaic Public Library (1964).
Pemberton: Burlington County College Library (1979).
Phillipsburg: Phillipsburg Free Public Library (1976).
Plainfield: Plainfield Public Library (1971).
Pomona: Stockton State College Library (1972).
Princeton: Princeton University Library (1884).
Randolph Township: County College of Morris Sherman H. Masten Learning Resource Center (1975).
Rutherford: Fairleigh Dickinson University, Messler Library (1953).
Shrewsbury: Monmouth County Library (1968).
South Orange: Seton Hall University, McLaughlin Library (1947).
Teaneck: Fairleigh Dickinson University, Teaneck/Hackensack Campus Library (1963).
Toms River: Ocean County College, Learning Resources Center (1966).
Trenton:
- New Jersey State Library (unknown).
- Trenton Free Public Library (1902).

Union: Kean College of New Jersey, Nancy Thompson Library (1973).
Upper Montclair: Montclair State College, Harry S. Sprague Library (1967).
Wayne: Wayne Public Library (1972).
West Long Beach: Monmouth College, Guggenheim Memorial Library (1963).
Woodbridge: Free Public Library of Woodbridge (1965).

NEW MEXICO

Albuquerque:
- University of New Mexico, Medical Center Library (1973).
- University of New Mexico, School of Law Library (1973).
- University of New Mexico, General Library (1896)–REGIONAL.

Hobbs: New Mexico Junior College, Pannell Library (1969).
Las Cruces: New Mexico State University Library (1907).
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).
Portales: Eastern New Mexico University, Golden Library (1962).
Santa Fe:
- New Mexico State Library (1960)–REGIONAL.
- New Mexico Supreme Court Law Library (unknown).

Silver City: Western New Mexico University, Miller Library (1972).

NEW YORK

Albany:
- Albany Law School Library (1979).
- New York State Library (unknown)–REGIONAL.
- State University of New York at Albany, University Library (1964).

Auburn: Seymour Library (1972).
Bayside: Queensborough Community College Library (1972).
Binghamton: State University of New York at Binghamton, Glenn G. Bartle Library (1962).
Brockport: State University of New York at Brockport, Drake Memorial Library (1967).
Bronx:
- Fordham University Library (1937).
- Herbert H. Lehman College Library (1967).
- New York Public Library, Mott Haven Branch (1973).
- State University of New York, Maritime College, Stephen B. Luce Library (1947).

Brooklyn:
- Brooklyn College Library (1936).
- Brooklyn Law School Library (1974).
- Brooklyn Public Library (1908).
- Polytechnic Institute of New York, Spicer Library (1963).
- Pratt Institute Library (1891).
- State University of New York, Downstate Medical Center Library (1958).

Buffalo:
- Buffalo and Erie County Public Library (1895).
- State University of New York at Buffalo, Charles B. Sears Law Library (1978).

State University of New York at Buffalo, Lockwood Memorial Library (1963).
Canton: St. Lawrence University, Owen D. Young Library (1920).
Cheektowaga: Cheektowaga Public Library, Reinstein Memorial Branch (1978).
Corning: Corning Community College, Arthur A. Houghton, Jr., Library (1963).
Cortland: State University of New York at Cortland, Memorial Library (1964).
Delhi: State University Agricultural and Technical College Library (1970).
Douglaston: Cathedral College Library (1971).
East Islip: East Islip Public Library (1973).
Elmira: Elmira College, Gannett Tripp Learning Center (1956).
Farmingdale: State University of New York at Farmingdale Library (1917).
Flushing: Queens College, Paul Klapper Library (1939).
Garden City: Adelphi University, Swirbul Library (1966).
Geneseo: State University of New York at Geneseo, Milne Library (1967).
Greenvale: Long Island University, B. Davis Schwartz Memorial Library (1964).
Hamilton: Colgate University, Everett Needham Case Library (1902).
Hempstead:
Hofstra University Library (1964).
Hofstra University, School of Law Library (1979).
Ithaca:
Cornell University Library (1907).
Cornell Law Library (1978).
New York State College of Agriculture and Human Economics, Albert R. Mann Library (1943).
Jamaica:
Queens Borough Public Library (1926).
St. John's University Library (1956).
St. John's University, School of Law Library (1978).
Kings Point: U.S. Merchant Marine Academy Library (1962).
Long Island City: Fiorello H. LaGuardia Community College Library (1981).
Mount Vernon: Mount Vernon Public Library (1962).
New Paltz: State University College at New Paltz, Sojourner Truth Library (1965).
New York City:
Cardoza Law School Library (1979).
City University of New York, City College Library (1884).
College of Insurance Library (1965).
Columbia University Libraries (1882).
Columbia University, School of Law Library (1981).
Cooper Union for the Advancement of Science and Arts Library (1930).
Medical Library Center of New York (1976).
New York Law Institute Library (1909).
New York Law School Library (1979).
New York Public Library, Astor Branch (1907).
New York Public Library, Lenox Branch (1884).
New York University Law Library (1902).
New York University, Elmer Holmes Bobst Library (1967).
U.S. Court of Appeals, Second Circuit Library (1976).
Yeshiva University, Pollack Library (1979).
Newburgh: Newburgh Free Library (1909).
Niagara Falls: Niagara Falls Public Library (1976).
Oakdale: Dowling College Library (1965).
Oneonta: State University College at Oneonta, James M. Milne Library (1966).
Oswego: State University College at Oswego, Penfield Library (1966).
Plattsburgh: State University College at Plattsburgh, Benjamin F. Feinberg Library (1967).
Potsdam:
Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).
State University College at Potsdam, Frederick W. Crumb Memorial Library (1964).
Poughkeepsie: Vassar College Library (1943).
Purchase: State University of New York, College at Purchase Library (1969).
Rochester:
Rochester Public Library (1963).
University of Rochester Rush Rhees Library (1880).
St. Bonaventure: St. Bonaventure University, Friedsam Memorial Library (1938).
Saratoga Springs: Skidmore College Library (1964).
Schenectady: Union College, Schaffer Library (1901).
Southampton: Southampton College Library (1973).
Staten Island: Wagner College, Horrmann Library (1953).
Stony Brook: State University of New York at Stony Brook, Main Library (1963).
Syracuse:
Onondaga County Public Library (1978).
Syracuse University Library (1878).
Syracuse University, William C. Ruger Law Library (1978).
Troy: Troy Public Library (1869).
Uniondale: Nassau Library System (1965).
Utica:
Utica Public Library (1885).
SUNY College of Technology Library (1977).
West Point: U.S. Military Academy Cadet Library (unknown).
White Plains: Pace University, Law School Library (1978).
Yonkers:
Sarah Lawrence College Library (1969).
Yonkers Public Library, Getty Square Branch (1910).
Yorktown Heights: Mercy College Library (1976).

NORTH CAROLINA

Asheville: University of North Carolina, D. Hiden Ramsey Library (1965).
Boiling Springs: Gardner-Webb College, Dover Memorial Library (1974).
Boone: Appalachian State University Library (1963).
Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).
Chapel Hill:
University of North Carolina at Chapel Hill, Wilson Library (1884)-REGIONAL.
University of North Carolina Law Library (1978).
Charlotte:
Public Library of Charlotte and Mecklenburg County (1964).
Queens College, Everett Library (1927).
University of North Carolina at Charlotte, Atkins Library (1964).
Cullowhee: Western Carolina University, Hunter Library (1953).
Davidson: Davidson College Library (1893).
Durham:
Duke University, School of Law Library (1978).
Duke University, William R. Perkins Library (1890).
North Carolina Central University, Law Library (1979).
North Carolina Central University, James E. Shepard Memorial Library (1973).
Elon College: Iris Holt McEwen Library (1971).
Fayetteville: Fayetteville State University, Charles W. 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 (1971).
Mount Olive: Mount Olive College, Moye Library (1971).
Murfreesboro: Chowan College, Whitaker Library (1963).
Pembroke: Pembroke State University, Mary H. Livermore Library (1956).
Raleigh:
Department of Cultural Resources, Division of State Library (unknown).
North Carolina State University, D. H. Hill Library (1923).
North Carolina Supreme Court Library (1972).
Wake County Public Library (1969).
Rocky Mount: North Carolina Wesleyan College Library (1969).
Salisbury: Catawba College Library (1925).
Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).

Wilson: Atlantic Christian College, Hackney Library (1930).
Winston-Salem:
Forsyth County Public Library (1954).
Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

Bismarck:
North Dakota State Library (1971).
North Dakota Supreme Court Law Library (unknown).
State Historical Society of North Dakota Library (1907).
Veterans' Memorial Public Library (1967).
Dickinson: Dickinson State College, Stoxen Library (1968).
Fargo:
Fargo Public Library (1964).
North Dakota State University Library (1907)–REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library.
Grand Forks: University of North Dakota, Chester Fritz Library (1890).
Minot: Minot State College, Memorial Library (1925).
Valley City: Valley City State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).
Akron:
Akron-Summit Public Library (1952).
University of Akron, Bierce Library (1963).
University of Akron, C. Blake McDowell Law Center, School of Law Library (1978).
Alliance: Mount Union College Library (1888).
Ashland: Ashland College Library (1938).
Athens: Ohio University Library (1886).
Batavia: University of Cincinnati at Batavia, Clermont General and Technical College Library (1973).
Bluffton: Bluffton College, Musselman Library (1951).
Bowling Green: Bowling Green State University Library (1933).
Canton: Malone College, Everett L. Cattell Library (1970).
Chardon: Geauga County Public Library (1971).
Cincinnati:
Public Library of Cincinnati and Hamilton County (1884).
University of Cincinnati, Central Library (1929).
University of Cincinnati, College of Law, Marx Law Library (1978).
Cleveland:
Case Western Reserve University, Freiberger Library (1913).
Case Western Reserve University, School of Law Library (1979).
Cleveland Heights-University Heights Public Library (1970).
Cleveland Public Library (1886).
Cleveland State University, Cleveland-Marshall College of Law, Joseph W. Bartunek III Law Library (1978).
Cleveland State University Library (1966).
John Carroll University, Grasselli Library (1963).
Municipal Reference Library (1970).
Columbus:
Capital University Law School Library (1980).
Capital University Library (1968).
Ohio State University Libraries (1907).
Ohio Supreme Court Law Library (1973).
Public Library of Columbus and Franklin County (1885).
State Library of Ohio (unknown)–REGIONAL.
Dayton:
Dayton and Montgomery County Public Library (1909).
University of Dayton, Roesch Library (1969).
Wright State University Library (1965).
Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).
Elyria: Elyria Public Library (1966).
Findlay: Findlay College, Shafer Library (1969).
Gambier: Kenyon College Library (1873).
Granville: Denison University Libraries, William H. Doane Library (1884).
Hiram: Hiram College, Teachout-Price Memorial Library (1874).
Kent: Kent State University Libraries (1962).
Marietta: Marietta College, Dawes Memorial Library (1884).
Marion: Marion Public Library (1979).
Middletown: Miami University-Middletown, Gardner-Harvey Library (1970).
New Concord: Muskingum College Library (1966).
Oberlin: Oberlin College Library (1858).
Oxford: Miami University at Oxford, King Library (1909).
Portsmouth: Portsmouth Public Library (unknown).
Rio Grande: Rio Grande College and Community College, Jeanette Albiez Davis Library (1966).
Springfield: Warder Public Library (1884).
Steubenville:
Public Library of Steubenville and Jefferson County (1950).
College of Steubenville, Starvaggi Memorial Library (1971).
Tiffin: Heidelberg College, Beeghly Library (1964).
Toledo:
Toledo-Lucas County Public Library (1884).
University of Toledo, College of Law Library (1981).
University of Toledo Library (1963).
Westerville: Otterbein College Courtright Memorial Library (1967).
Wooster: College of Wooster, Andrews Library (1966).
Youngstown:
Public Library of Youngstown and Mahoning County (1923).
Youngstown State University, William F. Maag Library (1971).

OKLAHOMA

Ada: East Central Oklahoma State University, Linscheid Library (1914).
Alva: Northwestern Oklahoma State University Library (1907).
Bartlesville: U.S. Department of Energy, Bartlesville Energy Research Center Library (1962).
Bethany: Bethany Nazarene College, R. T. Williams Library (1971).
Durant: Southeastern Oklahoma State University Library (1929).
Edmond: Central State University Library (1934).
Enid: Public Library of Enid and Garfield County (1908).
Langston: Langston University, G. Lamar Harrison Library (1941).
Muskogee: Muskogee Public Library (1971).
Norman:
University of Oklahoma Libraries, Bizzell Memorial Library (1893).
University of Oklahoma, Law Library (1978).
Oklahoma City:
Metropolitan Library System (1974).
Oklahoma City University Library (1963).
Oklahoma Department of Libraries (1893)–REGIONAL.
Shawnee: Oklahoma Baptist University Library (1933).
Stillwater: Oklahoma State University Library (1907)–REGIONAL.
Tahlequah: Northeastern Oklahoma State University, John Vaughan Library (1923).
Tulsa:
Tulsa City-County Library System (1963).
University of Tulsa College of Law Library (1979).
University of Tulsa, McFarlin Library (1929).
Weatherford: Southwestern Oklahoma State University, Al Harris Library (1958).

OREGON

Ashland: Southern Oregon State College Library (1953).
Corvallis: Oregon State University Library (1907).
Eugene:
University of Oregon Law Library (1979).
University of Oregon Library (1883).
Forest Grove: Pacific University, Harvey W. Scott Library (1897).
Klamath Falls: Oregon Institute of Technology, Learning and Resources Center (1982).
La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).
McMinnville: Linfield College, Northup Library (1965).
Monmouth: Western Oregon State College Library (1967).
Portland:
Lewis and Clark College, Aubrey R. Watzek Library (1967).
Library Association of Portland (1884).
Northwestern School of Law, Paul L. Boley Law Library (1979).
Portland State University Library (1963)–REGIONAL.

Reed College Library (1912).
U.S. Department of Energy, Bonneville Power Administration Library (1962).
Salem:
Oregon State Library (unknown).
Oregon Supreme Court Library (1974).
Willamette University, College of Law Library (1979).
Willamette University, Main Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).
Altoona: Altoona Area Public Library (1969).
Bethel Park: Bethel Park Public Library (1980).
Bethlehem: Lehigh University Libraries, Linderman Library (1876).
Blue Bell: Montgomery County Community College, Learning Resources Center (1975).
Bradford: University of Pittsburgh at Bradford (1979).
Carlisle:
Dickinson College, Boyd Lee Spahr Library (1947).
Dickinson School of Law, Sheeley-Lee Law Library (1978).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1967).
Collegeville: Ursinus College, Myrin Library (1963).
Coraopolis: Robert Morris College Library (1978).
Doylestown: Bucks County Free Library (1970).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie County Library System (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: State Library of Pennsylvania (unknown)–REGIONAL.
Haverford: Haverford College, Magill Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria County Library System (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Lawrence Lee Pelletier Library (1907).
Millersville: Millersville State College, Helen A. Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
Drexel University Library (1963).
Free Library of Philadelphia (1897).
St. Joseph's University, Drexel Library (1974).
Temple University, Paley Library (1947).
Temple University Law Library (1979).
Thomas Jefferson University, Scott Memorial Library (1978).
U.S. Court of Appeals, Third Circuit Library (1973).
University of Pennsylvania, Biddle Law Library (1974).
University of Pennsylvania Library (1886).
Pittsburgh:
Allegheny County Law Library (1977).
Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
Carnegie Library of Pittsburgh (1895).
Duquesne University Law Library (1978).
La Roche College, John J. Wright Library (1974).
University of Pittsburgh, Hillman Library (1910).
University of Pittsburgh Law Library (1979).
U.S. Department of Interior, Bureau of Mines Library (1962).
Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).
Slippery Rock: Slippery Rock State College, Bailey Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Libraries (1907).
Villanova: Villanova University Law School, Pulling Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, U. Grant Miller Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College, D. Leonard Corgan Library (1949).
Williamsport: Lycoming College Library (1970).
York: York College of Pennsylvania, Schmidt Library (1963).
Youngwood: Westmoreland County Community College, Learning Resources Center (1972).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce:
Catholic University of Puerto Rico, Encarnacion Valdes Library (1966).
Catholic University of Puerto Rico, School of Law Library (1978).
Rio Piedras: University of Puerto Rico, General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: U.S. Naval War College Library (1963).
Providence:
Brown University, John D. Rockefeller, Jr. Library (unknown).
Providence College, Phillips Memorial Library (1969).
Providence Public Library (1884).
Rhode Island College, James P. Adams Library (1965).
Rhode Island State Law Library (1979).
Rhode Island State Library (before 1895).
Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).
Woonsocket: Woonsocket Harris Public Library (1977).

SOUTH CAROLINA

Charleston:
Baptist College at Charleston, L. Mendel Rivers Library (1967).
The Citadel, Daniel Library (1962).
College of Charleston, Robert Scott Small Library (1869).
Clemson: Clemson University Library (1893).
Columbia:
Benedict College, Payton Learning Resources Center (1969).
South Carolina State Library (before 1895).
University of South Carolina, Thomas Cooper Library (1884).
Conway: University of South Carolina, Coastal Carolina College, Kimbel Library (1974).
Due West: Erskine College, McCain Library (1968).
Florence:
Florence County Library (1967).
Francis Marion College, James A. Rogers Library (1970).
Greenville:
Furman University Library (1962).
Greenville County Library (1966).
Greenwood: Lander College, Larry A. Jackson Library (1967).
Orangeburg: South Carolina State College, Miller F. Whittaker Library (1953).
Rock Hill: Winthrop College, Dacus Library (1896).
Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).
Brookings: South Dakota State University, H. M. Briggs Library (1889).
Pierre:
South Dakota State Library (1973).
South Dakota Supreme Court Library (1978).

Rapid City:
Rapid City Public Library (1963).
South Dakota School of Mines and Technology, Devereaux Library (1963).
Sioux Falls:
Augustana College, Mikkelsen Library and Learning Resource Center (1969).
Sioux Falls Public Library (1903).
Spearfish: Black Hills State College Library Learning Center (1942).
Vermillion: University of South Dakota, I. D. Weeks Library (1889).
Yankton: Yankton College, James Lloyd Library (1904).

TENNESSEE

Bristol: King College, E. W. King Library (1970).
Chattanooga:
Chattanooga-Hamilton County Bicentennial Library (1908).
U.S. Tennessee Valley Authority Technical Library (1976).
Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).
Cleveland: Cleveland State Community College Library (1973).
Columbia: Columbia State Community College, John W. Finney Memorial Library (1973).
Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).
Jackson: Lambuth College, Luther L. Gobbel Library (1967).
Jefferson City: Carson-Newman College Library (1964).
Johnson City: East Tennessee State University, Sherrod Library (1942).
Knoxville:
Public Libraries Knoxville-Knox County, Lawson McGhee Library (1973).
University of Tennessee at Knoxville, James D. Hoskins Library (1907).
University of Tennessee Law Library (1971).
Martin: University of Tennessee at Martin, Paul Meek Library (1957).
Memphis:
Memphis-Shelby County Public Library and Information Center (1896).
Memphis State University, Cecil C. Humphreys School of Law Library (1979).
Memphis State University, John W. Brister Library (1966).
Murfreesboro: Middle Tennessee State University, Todd Library (1912).
Nashville:
Fisk University Library (1965).
Public Library of Nashville and Davidson County (1884).
Tennessee State Law Library (1976).
Tennessee State Library and Archives (unknown).
Tennessee State University, Brown-Daniel Library (1972).
Vanderbilt University Law Library (1976).
Vanderbilt University Library (1884).
Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

Abilene:
Abilene Christian University, Margaret and Herman Brown Library (1978).
Hardin-Simmons University, Rupert and Pauline Richardson Library (1940).
Arlington:
Arlington Public Library (1970).
University of Texas at Arlington Library (1963).
Austin:
Texas State Law Library (1972).
Texas State Library (unknown)-REGIONAL.
University of Texas at Austin, Perry-Castaneda Library (1884).
University of Texas at Austin, Lyndon B. Johnson School of Public Affairs Library (1966).
University of Texas at Austin, Tarlton Law Library (1965).
Baytown: Lee College Library (1970).
Beaumont: Lamar University, Mary and John Gray Library (1957).
Brownwood: Howard Payne University, Walker Memorial Library (1964).
Canyon: West Texas State University, Cornett Library (1928).
College Station: Texas Agricultural and Mechanical University Library (1907).
Commerce: East Texas State University Library (1937).
Corpus Christi: Corpus Christi State University Library (1976).
Corsicana: Navarro College, Gaston T. Gooch Library (1965).
Dallas:
Bishop College, Zale Library (1966).
Dallas Baptist College, Vance Memorial Library (1967).
Dallas Public Library (1900).
Southern Methodist University, Fondren Library (1925).
University of Texas Health Science Center-Dallas Library (1975).
Denton: North Texas State University Library (1948).
Edinburg: Pan American University Library (1959).
El Paso:
El Paso Public Library (1906).
University of Texas at El Paso Library (1966).
Fort Worth:
Fort Worth Public Library (1905).
Texas Christian University, Mary 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).
South Texas College of Law Library (1981).
Texas Southern University, Thurgood Marshall School of Law Library (1982).
University of Houston at Clear Lake City Library (1980).
University of Houston Library (1957).
University of Houston, School of Law Library (1979).
Huntsville: Sam Houston State University Library (1949).
Irving: Irving Public Library System (1974).
Kingsville: Texas Arts and Industries University, Jernigan Library (1944).
Laredo: Laredo Junior College, Harold R. Yeary Library (1970).
Longview: Nicholson Memorial Public Library (1961).
Lubbock:
Texas Tech University Library (1935)-REGIONAL.
Texas Tech University, School of Law Library (1978).
Marshall: Wiley College, Thomas Winston Cole, Sr. Library (1962).
Nacogdoches: Stephen F. Austin State University, Steen Library (1965).
Plainview: Wayland Baptist University, Van Howeling Memorial Library (1963).
Richardson: University of Texas at Dallas Library (1972).
San Angelo: Angelo State University, Porter Henderson Library (1964).
San Antonio:
San Antonio College Library (1972).
San Antonio Public Library, (1899).
St. Mary's University, Academic Library (1964).
St. Mary's University, Law Library (1982).
Trinity University Library (1964).
University of Texas at San Antonio Library (1973).
San Marcos: Southwest Texas State University Library (1955).
Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana Community College, Palmer Memorial Library (1963).
Victoria: Victoria College/University of Houston, Victoria Campus Library (1973).
Waco:
Baylor University, Law Library (1982).
Baylor University, Moody Memorial Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College, Lucy A. Phillips Library (1963).
Logan: Utah State University, Merrill Library and Learning Resources Center (1907)-REGIONAL.
Ogden: Weber State College, Stewart Library (1962).
Provo:
Brigham Young University, Harold B. Lee Library (1908).
Brigham Young University, J. Reuben Clark Law Library (1972).

Salt Lake City:
University of Utah, Eccles Health Sciences Library (1970).
University of Utah, Law Library (1966).
University of Utah, Marriott Library (1893).
Utah State Library (unknown).
Utah State Supreme Court, Law Library (1975).

VERMONT

Burlington: University of Vermont, Bailey/Howe Library (1907).
Castleton: Castleton State College, Calvin Coolidge Library (1969).
Johnson: Johnson State College, John Dewey Library (1955).
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).
Middlebury: Middlebury College, Egbert Starr Library (1884).
Montpelier: Vermont Department of Libraries (before 1895).
Northfield: Norwich University Library (1908).
South Royalton: Vermont Law School Library (1978).

VIRGIN ISLANDS

St. Croix: Florence Williams Public Library (1974).
St. Thomas:
College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).
Enid M. Baa Library and Archives (1968).

VIRGINIA

Alexandria: Dept. of the Navy, General Law Library (1963).
Arlington: George Mason University School of Law Library (1981).
Blacksburg: Virginia Polytechnic Institute and State University, Carol M. Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
University of Virginia, Alderman Library (1910)–REGIONAL.
University of Virginia Law School, Arthur J. Morris Law Library (1964).
Chesapeake: Chesapeake Public Library (1970).
Danville: Danville Community College, Learning Resources Center (1969).
Emory: Emory and Henry College, Kelly Library (1884).
Fairfax: George Mason University, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Hampton: Hampton Institute, Huntington Memorial Library (1977).
Harrisonburg: James Madison University, Madison Memorial Library (1973).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
Virginia Military Institute, Preston Library (1874).
Washington and Lee University, University Library (1910).
Washington and Lee University, Wilbur C. Hall Law Library (1978).
Martinsville: Patrick Henry Community College Library (1971).
Norfolk:
Norfolk Public Library (1895).
Old Dominion University Library (1963).
U.S. Armed Forces Staff College Library (1963).
Petersburg: Virginia State University, Johnston Memorial Library (1907).
Quantico:
Federal Bureau of Investigation, Academy Library (1970).
Marine Corps Education Center, James Carson Breckinridge Library (1967).
Reston: Department of the Interior, Geological Survey, National Center Library (1962).
Richmond:
University of Richmond, Boatwright Memorial Library (1900).
University of Richmond, Law School Library (1982).
U.S. Court of Appeals, Fourth Circuit Library (1973).
Virginia Commonwealth University, James Branch Cabell Library (1971).
Virginia State Law Library (1973).
Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg:
College of William and Mary, Marshall-Wythe Law Library (1978).
College of William and Mary, Swem Library (1936).
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

WASHINGTON

Bellingham: Western Washington University, Mabel Zoe Wilson Library (1963).
Cheney: Eastern Washington University, JFK Library (1966).
Ellensberg: Central Washington University Library (1962).
Everett: Everett Public Library (1914).
Olympia:
Evergreen State College, Daniel J. Evans Library (1972).
Washington State Law Library (1979).
Washington State Library (unknown)–REGIONAL.
Port Angeles: North Olympic Library System (1965).
Pullman: Washington State University Library (1907).
Seattle:
Seattle Public Library (1908).
University of Washington Libraries (1890).
University of Washington, Mary Gould Gallagher Law Library (1969).
U.S. Court of Appeals, 9th Circuit Library (1981).
Spokane:
Gonzaga University, School of Law Library (1979).
Spokane Public Library (1910).
Tacoma:
Tacoma Public Library (1894).
University of Puget Sound, Collins Memorial Library (1938).
University of Puget Sound, School of Law Library (1978).
Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Bluefield: Bluefield State College, Hardway Library (1972).
Charleston:
Kanawha County Public Library (1952).
West Virginia Library Commission (unknown).
West Virginia Supreme Court Law Library (1977).
Elkins: Davis and Elkins College Library (1913).
Fairmont: Fairmont State College Library (1884).
Glenville: Glenville State College, Robert F. Kidd Library (1966).
Huntington: Marshall University, James E. Morrrow Library (1925).
Institute:
West Virginia College of Graduate Studies Library (1977)
West Virginia State College, Drain-Jordan Library (1907).
Morgantown: West Virginia University Library (1907)–REGIONAL.
Salem: Salem College Library (1921).
Shepherdstown: Shepherd College, Ruth Scarborough Library (1971).
Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Seeley G. Mudd Library (1869).
Beloit: Beloit College, Col. Robert H. Morse Library (1888).
Eau Claire: University of Wisconsin-Eau Claire, William D. McIntyre Library (1951).
Fond du Lac: Fond du Lac Public Library (1966).
Green Bay: University of Wisconsin-Green Bay, Library Learning Center (1968).
La Crosse:
La Crosse Public Library (1883).
University of Wisconsin-La Crosse, Murphy Library (1965).

Madison:
Madison Public Library (1965).
State Historical Society of Wisconsin Library (1870)–REGIONAL, in cooperation with University of Wisconsin-Madison.
University of Wisconsin-Madison Law Library (1981).
University of Wisconsin-Madison, Memorial Library (1939).
Wisconsin State Law Library (unknown).
Milwaukee:
Alverno College Library/Media Center (1971).
Medical College of Wisconsin, Inc., Todd Wehr Library (1980).
Milwaukee County Law Library (1934).
Milwaukee Public Library (1861)–REGIONAL.
Mount Mary College Library (1964).
University of Wisconsin-Milwaukee Library (1960).
Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library (1956).
Platteville: University of Wisconsin-Platteville, Karrmann Library (1964).
Racine: Racine Public Library (1898).
Ripon: Ripon College Library (1982).
River Falls: University of Wisconsin-River Falls, Chalmer Davee Library (1962).
Stevens Point: University of Wisconsin-Stevens Point, Learning Resources Center (1951).
Superior:
Superior Public Library (1908).
University of Wisconsin-Superior, Jim Dan Hill Library (1935).
Waukesha: Waukesha Public Library (1966).
Wausau: Marathon County Public Library (1971).
Whitewater: University of Wisconsin-Whitewater, Harold Anderson Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).
Cheyenne:
Wyoming State Law Library (1977).
Wyoming State Library (unknown)–REGIONAL.
Gillette: George Amos Memorial Library (1980).
Laramie:
University of Wyoming, Coe Library (1907).
University of Wyoming Law Library (1978).
Powell: Northwest Community College, John Taggart Hinckley Library (1967).
Riverton: Central Wyoming College Library (1969).
Rock Springs: Western Wyoming College Library (1969).
Sheridan: Sheridan College Griffith Library (1963).

APPENDIX B. LIST OF DISTRICT OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

NORTHEASTERN REGION I

Eric B. Outwater
Regional Director

CONNECTICUT

*** Hartford**—Eric B. Outwater, Director, Room 610-B, Federal Office Building, 450 Main Street 06103, Area Code 203 Tel 244-3530, FTS 244-3530

MAINE

• **Augusta (Boston, Massachusetts District)**— 1 Memorial Circle, Casco Bank Bldg. 04330, Area Code 207 Tel 622-8249, FTS 833-6249

MASSACHUSETTS

Boston—Francis J. O'Connor, Director 10th Floor, 441 Stuart Street 02116, Area Code 617 Tel 223-2312, FTS 223-2312

NEW HAMPSHIRE

Serviced by Boston District Office

NEW YORK

Buffalo—Robert F. Magee, Director, 1312 Federal Building, 111 West Huron Street 14202, Area Code 716 Tel 846-4191, FTS 437-4191

• **Rochester**—183 E. Main St., Rm. 666, 16404, Area Code 716 Tel. 263-6480, FTS 963-6480

New York— (Vacant) Room 3718, Federal Office Building, 26 Federal Plaza, Foley Square 10278, Area Code 212 Tel 264-0634, FTS 264-0600

RHODE ISLAND

• **Providence (Boston, Massachusetts District)**—7 Jackson Walkway 02903, Area Code 401 Tel 277-2605, ext. 22, FTS 838-4482

VERMONT

Serviced by Boston District Office

MID-ATLANTIC REGION II

Thomas J. Murray
Regional Director

DELAWARE

Serviced by Philadelphia District Office

DISTRICT OF COLUMBIA

Serviced by Baltimore District Office

MARYLAND

Baltimore— (Vacant) 415 U.S. Customhouse, Gay and Lombard Streets 21202, Area Code 301 Tel 962-3560, FTS 922-3560

• **Rockville**—101 Monroe St., 15th Floor, 20850, Area Code 301 Tel. 251-2345

MID-ATLANTIC REGION II (cont'd)

NEW JERSEY

*** Trenton**—Thomas J. Murray, Director, Capitol Plaza, 8th Fl., 240 West State St., 08608, Area Code 609 Tel 989-2100, FTS 483-2100

PENNSYLVANIA

Philadelphia—Robert E. Kistler, Director, 9448 Federal Building, 600 Arch Street 19106 Area Code 215 Tel 597-2866, FTS 597-2866

Pittsburgh—William M. Bradley, Director, 2002 Federal Building, 1000 Liberty Avenue 15222, Area Code 412 Tel 644-2850, FTS 722-2850

APPALACHIAN REGION III

Joel B. New
Regional Director

KENTUCKY

Louisville—Donald R. Henderson, Director, Room 636B, U.S. Post Office and Courthouse Building 40202, Area Code 502 Tel 582-5066, FTS 352-5066

NORTH CAROLINA

*** Greensboro**—Joel B. New, Director, 203 Federal Building, West Market Street, P.O. Box 1950 27402, Area Code 919 Tel 378-5345, FTS 699-5345

• **Raleigh**—Dobbs Bldg., Rm. 294, 430 N. Salisbury St., 27611, Area Code 919 Tel. 755-4687, FTS 672-4687

SOUTH CAROLINA

Columbia—Johnny E. Brown, Director, Strom Thurmond Fed. Bldg., Suite 172, 1835 Assembly Street 29201 Area Code 803 Tel 765-5345, FTS 677-5345

• **Charleston**—505 Federal Building, 334 Meeting Street 29403, Area Code 803 Tel 677-4361, FTS 677-4361

• **Greenville**—P.O. Box 5823, Station B, 29606, Area Code 803 235-5919

TENNESSEE

Nashville—Jim Charlet, Director, Suite 1427, One Commerce Place, 37239, Area Code 615 Tel. 251-5161, FTS 852-5161

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VIRGINIA

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