

News Briefs

General Developments

STANDARDS FOR OLDER ERW PIPE NOT WARRANTED

Special standards for the inspection and operation of pipelines with older steel pipe made by electric resistance welding (ERW) are not warranted due to the very low number of annual failures said NIST in a special report to Congress. However, NIST recommends periodic hydrostatic testing in critical risk locations to eliminate large flaws, and the use of damage control systems with pressure and flow monitoring sensors, remote control valves, and product containment structures. The recommendations were made after a review of failures in approximately 575,000 miles of natural gas and hazardous liquid transmission lines. The assessment was made after a 1988 pipeline failure in Maries County, MO, that resulted in a spill of more than 800,000 gallons of crude oil. NIST was asked to conduct an independent assessment of the metallurgical analysis of the failed pipe and to consider whether special standards should apply to the inspection of older pipelines, and to make specific recommendations. For a copy of An Assessment of the Performance and Reliability of Older ERW Pipelines (NISTIR 89-4136), send a self-addressed mailing label to: Public Information Division, NIST, A903 Administration Bldg., Gaithersburg, MD 20899; telephone: 301/975-2762.

FIRST OSI/ISDN TRIAL SUCCESSFUL

A recent trial combining two major communications technologies was pronounced "successful" by NIST. NIST initiated the trial, held at Mather Air Force Base in California, to determine whether Integrated Services Digital Network (ISDN) technology should be included in version two of the

Government Open Systems Interconnection (OSI) Profile (GOSIP). Products from five different vendors were included. After August 1990, federal agencies must use the GOSIP specifications in procuring certain networking or telecommunications products. NIST is proposing to revise GOSIP to include ISDN functions as well as several new applications. Before doing so, the institute wanted to be sure that ISDN can support OSI applications.

NEW DATABASE WILL COMPILE OSI TEST RESULTS

In a move to speed the development and use of commercial networking products in industry and government, NIST and partners from private industry are developing a computerized database of commercial products that have implemented successfully the Open Systems Interconnection (OSI) standards and are interoperable. The participating vendors will test their products using OSINET, an experimental computer network coordinated by NIST. In approximately 3 months, users will have free, on-line access to the results. For further information on the OSINET Testing and Registration Service, write to Gerard Mulvenna, NIST, B217 Technology Bldg., Gaithersburg, MD 20899.

IMPROVING PURITY OF DIODE LASERS

Using optical feedback and electronic techniques, NIST scientists have achieved a 10,000-fold improvement in the color purity of commercial diode lasers. Typical diode lasers have spectral linewidths—the range of colors emitted—that are tens of megahertz wide; NIST scientists obtained linewidths of less than 1 kHz. The techniques also automatically stabilize the laser's oscillation frequency. The narrow linewidths and frequency stabilization make the diode lasers, which have low cost and high efficiency, attractive for applications in high-resolution spectroscopy and precision measurements.

Narrow laser linewidth will also be a key feature in the next generation of lightwave communication technologies. Additional studies involving modification of the diode lasers—such as changes in the antireflective coatings—will be undertaken. Two papers outlining some of the techniques are available from Jo Emery, NIST, Division 104, Boulder, CO 80303; telephone: 303/497-3237.

TWO-WAY TIME TRANSFERS BY SATELLITE

The use of geostationary, commercial communication satellites is a cost-effective way of comparing or synchronizing distant clocks at the highest levels of precision and accuracy. Equipment costs are low, satellite space is abundant, and data reduction is simple. For about \$100 per week in satellite lease charges, a precision of 0.5 ns is obtainable. Three recent technical papers authored or coauthored by NIST scientists discuss the fundamentals of two-way time transfers, time transfers between North America and Europe, and NIST-U.S. Naval Observatory experience in two-way time transfer over approximately 2 years. For copies of these papers, contact Jo Emery, NIST, Division 104, Boulder, CO 80303; telephone: 303/497-3237.

NEW INSTRUMENT IMPROVES TRACE METAL ANALYSIS

A chelation ion chromatographic instrument that allows new levels of speed, accuracy, and precision for trace metal analysis has been developed by NIST and private industry. With the system, analytical measurements that would be impossible by traditional ion chromatographic methods can be made on complex samples. The technique separates "transition metals"—nickel or copper, for example—from specimens such as human and plant tissue, body fluids, and environmental samples. The system permits analysis of transition elements at levels as low as parts per billion, and it is 10 to 100 times faster than conventional open-column methods. Research with the instrument so far has concentrated on analysis of biological and biomedical samples with a goal of determining factors such as whether toxic levels of nickel or vanadium are present in human tissues exposed to fossil fuel emissions. One potential advantage of the system is that it allows ultra-trace (nanogram-level) analyses to be made in laboratories designed for only trace (microgram-level) analyses, thus eliminating some expensive and tedious clean room procedures.

VOLUMES VII AND VIII OF PHASE DIAGRAMS FOR CERAMISTS COMPLETED

The data input, evaluation, and typesetting of the seventh and eighth volumes in the series Phase Diagrams for Ceramists have been completed. Production of the series of publications is a joint effort of NIST and the American Ceramic Society. ACerS employees work in the data center under the direct supervision of Ceramics Division personnel, collecting published papers containing phase diagrams, maintaining a bibliographic database, digitizing the diagrams, and entering them in a graphics database. The diagrams and references are evaluated by contributing editors outside NIST who provide commentaries. The bibliography, commentary texts, and digitized diagrams form a large computer database which is the basis of the published volumes and of computer databases currently being considered for dissemination to users.

The final editing steps, computer-typesetting of the text material, pagination, and index generation are all performed at NIST. Each volume contains about 1,000 diagrams. The diagrams in Volume VII comprise a variety of salt systems, largely halides and oxyanions of the halogens, but also covering sulfates, nitrates, hydroxides, carbonates, etc. The chemical systems included in Volume VIII include oxide and salt systems containing water studied under high pressures.

LABORATORY TESTING OF ULTRASONIC SYSTEM FOR ROLL-BY INSPECTION OF RAILROAD WHEELS

An ultrasonic system for roll-by inspection of railroad wheels currently is undergoing extensive laboratory testing. The system consists of: a transducer embedded in the head of a rail; analog electronics for generation and reception of ultrasonic signals; digital electronics for signal processing; and a lap-top computer for data collection and storage.

The transducer generates and receives signals propagating in the tread of a railroad wheel as the wheel rolls by. The signals are of two types: echoes from defects, and signals traveling completely around the wheel (round-trip signals). The digital electronics record peak amplitudes and arrival times of both echoes and round-trip signals. These data are put into a microcontroller, where the effects of attenuation in the wheel are compensated

for, as well as any variability in coupling the ultrasonic signals between the transducer and the wheel. An algorithm programmed in the microcontroller will then predict the size of any defects in the tread and decide whether the defect is above or below critical size.

NEUTRON SCATTERING STUDY OF CHROMATOGRAPHIC SURFACES

Surface-modified silica is an important material for chromatographic separation processes. A prime example of this is the bonding of trimethylsilyl (TMS) groups to silica surface oxygens via the reaction of trimethylchlorosilane with surface silanol groups. As a result, the affinity of the silica surface is changed from hydrophilic to hydrophobic. In order to more fully understand the nature of this surface modification, a collaborative effort among scientists at NIST was undertaken to characterize the bonding of TMS adsorbates to silica substrates.

The TMS vibrational spectra in the range 0-230 meV were obtained as a function of temperature by incoherent inelastic neutron scattering (IINS). The spectra exhibited similar, identifiable features: intense peaks at approximately 2.5 and 20 meV due to the trimethylsilyl and methyl torsional modes, respectively; weak features between 30 and 80 meV due to the different skeletal modes; more pronounced peaks between 80 and 120 meV due mainly to the Si-C-H bending modes; and higher-energy peaks at approximately 160 and 180 meV due to the H-C-H bending modes. Acceptable spectral fits by normal coordinate analysis indicated the presence of significant intramolecular interactions.

The temperature dependence of the broadening of IINS vibrational features and quasielastic neutron scattering spectra between 4 and 300 K confirmed that rapid trimethylsilyl group rotational motions were present at 80 K and below, with the methyl group rotational motions (observable at higher temperatures) already virtually frozen out at this temperature.

This work is part of a long-term program in which the particular sensitivity of neutron-scattering to hydrogen dynamics is utilized to elucidate adsorption/absorption-related phenomena.

NIST DEVELOPS TRITIUM (HT) GENERATION SYSTEM FOR TESTING ATMOSPHERIC HT MONITORS

NIST chemists have developed a stable tritium generation system for use in testing monitors designed to determine tritium in the atmosphere. Tri-

tium, a radioactive isotope of hydrogen with a 12-year half life, is present in trace concentrations in the atmosphere, primarily as a result of the atmospheric testing of nuclear weapons in the 1960s. These measurements are needed to establish a known baseline for atmospheric tritium.

Molecular hydrogen in the form of HT, i.e., a molecule containing one atom of normal hydrogen and one atom of tritium, is a useful monitor for tracing atmospheric processes. The tritium generation system produces HT in air at concentrations from 1 to 10 times the current background level (about 8×10^{-10} microcuries per liter of air). This is accomplished by precise mixing of two controlled gas flows, one from an argon-tritium mixture of known radioactivity concentration, and the other from a stream of clean tritium-free air. The system has a total output flow of about 1 L/min, and was designed and evaluated to test atmospheric HT monitors that have an input flow of less than 0.85 L/min.

QUANTUM BEHAVIOR OF ULTRACOLD ATOMIC COLLISIONS

Over the past several years scientists at NIST have improved techniques for cooling and trapping small samples of neutral atoms at temperatures less than 1 mK. Recent theoretical work has shown under what conditions atomic collision rates can limit the density and lifetime of cold neutral atom traps. This work indicates that atoms colliding with very low energy do not act like classical "billiard balls." Rather, their quantum wave-like nature strongly affects the collision rate coefficients. Criteria was developed to determine the characteristic temperature for the onset of quantum threshold behavior as temperature approaches zero. This characteristic temperature is strongly dependent on the atomic mass and the strength of the interatomic forces. It is greater than 1 K for light H atoms, but drops to 300 μ K for heavy Cs atoms, in the range of most trap experiments. Methods were developed to calculate the quantum threshold behavior of low-temperature rate coefficients and has obtained simple formulas for estimating their magnitudes. One conclusion is that, even though velocities are very small, collision rates can be as large or larger than typical values at room temperature.

GROUP FORMED TO DEMONSTRATE WORLDWIDE INTEROPERABILITY OF OSI STANDARDS

Established by National Computer System Laboratory (NCSL) in 1984, OSINET is a cooperative

government/industry research network which fosters the development, promotion, and use of commercial open system interconnection (OSI) products. At a meeting in Sydney, Australia, OSINET representatives met with delegates from four other regional networks to form a cooperative association called OSIone. The purpose of the new group is to demonstrate to the international business community the worldwide interoperability available in products built in accordance with international OSI standards. OSIone includes representatives from regional networks in Europe (EurOSInet), Japan (INTAPnet), Singapore (OSNET), and Australia (OSIcom).

To present the new technology to a large potential customer base, OSIone intends to build a library of demonstration scripts which will enable public exhibitions to be held in all OSIone regions with a minimum of preparation. Also planned are major exhibitions in regions represented by one OSIone organization with satellite demonstrations and support by the other OSIone membership. A CeBIT '90 event in Hanover, West Germany, in March 1990, will launch the OSIone, with demonstrations in other OSIone regions to be scheduled in the following 18 months. The demonstrations will focus initially on the needs of the international users of message handling systems but will be enhanced to cover the full spectrum of OSI applications.

ENHANCEMENT OF INFORMATION RESOURCE DICTIONARY SYSTEM (IRDS) STANDARD PROPOSED

A draft American National Standard for an IRDS services interface that was developed with NCSL assistance currently is undergoing public review. The services interface is being considered as an extension of Federal Information Processing Standard (FIPS) 156, Information Resource Dictionary System, which specifies two user interfaces: the command language and the panel interface. The proposed services interface addresses the additional need for a programmatic interface through which software external to the IRDS can populate, access, and maintain the contents of an IRDS dictionary and its schema.

The services interface will enable an IRDS to be used as a database of information resource descriptions by a wide variety of software tools that are employed in the management of information resources. Any programming language or system that provides an external call mechanism and that supports character, integer, and real data types can

use the services interface. Some examples of external software that could make use of the provided services are programming language compilers directly extracting data definitions; SQL and NDL database management systems maintaining database definitions; computer-aided software engineering tools; information locator/retrieval systems; application development systems; text editors; report writers; and open system interconnection systems maintaining directory information.

THEORETICAL STUDY OF SUPERCONDUCTOR MAGNETIZATION COMPLETED

NIST scientists have completed a theoretical study on the magnetization of infinite long type-II superconducting wires having rectangular cross section. The work shows that the equations for magnetization as a function of field may be simplified, by taking different limits, to equations for simple geometries (slab and cylinder) or equations for constant J_c (Bean model). A useful result is that, even for the Kim model for critical-current density (J_c) as a function of magnetic field, J_c may be deduced from magnetization measurements for any of these geometries. The work is based on critical-state theory and the Kim model. The theoretically derived hysteresis loops of magnetization versus field resemble experimental data for both traditional and high-temperature superconductors.

MODELS FOR HIGH DOPING AND CARRIER DENSITIES IN GALLIUM ARSENIDE CONFIRMED

NIST scientists recently completed calculations to determine the modifications to the conduction and valence bands of gallium arsenide (GaAs) that occur as a result of either high doping, high carrier densities, or both, conditions encountered in practical devices. These results now have been confirmed by two groups. Prof. M. S. Lundstrom at Purdue University has utilized the NIST-predicted asymmetry between the effects of dopant ions in n- and p-type GaAs to make more efficient solar cells and bipolar transistors. His team's experimental results show reasonable numerical agreement with the NIST model data. Prof. A. Compaan at the University of Toledo has made photoluminescence measurements on heavily doped n-type GaAs that are in good agreement with the NIST predictions. In charge-neutral material the ionized dopant and carrier densities are equal, and the band states are shifted in energy because of the interaction of the carriers with the dopant ions and with each other. There is a distortion of the band shapes, and

entirely new functions for the densities of electron states result. These NIST results are important to device modelers and designers.

HIGH-CURRENT, WIDEBAND TRANSCONDUCTANCE AMPLIFIER DEVELOPED

To meet an increasing number of requests to NIST for a variety of calibrations at higher currents and higher frequencies than were previously available, a high-current, wideband transconductance amplifier has been developed. Three companies have already expressed interest in developing commercial versions. The amplifier provides a stable output current up to 35 A rms at 100 kHz with an output compliance voltage of 5 V rms. The 3-dB bandwidth is 1 MHz, and the gain instability is less than ± 10 ppm/min. Although commercial transconductance amplifiers exist that can deliver currents well in excess of 35 A, available instruments are limited to a few kHz at these high current levels and are not sufficiently stable for many calibration applications for which the amplifier is to be used. These include calibrating thermal current converters, precision current sources, ammeters, current transformers, and shunts, including ac/dc difference determinations on high-current, wideband shunts.

AC VOLTAGE LABORATORY INTERCOMPARISON TESTS CONDUCTED USING NIST-DEVELOPED DSS

NIST scientists recently conducted an ac voltage intercomparison to determine the consistency of ac voltage measurements made at various industry and government standards laboratories. The transport standard used for the evaluation was a division-developed digitally synthesized sinusoidal voltage source (DSS) whose rms value is calculated by measuring the dc level of each of the steps used to synthesize the sine wave. The DSS principle provides an alternative to the conventional thermal voltage converter as a dc to ac reference. The uncertainty of the calculated voltage at 7 V rms is typically within ± 10 ppm from 15 Hz to 7.8 kHz. Preliminary measurements made at each of the participating laboratories agree with the calculated value to within ± 20 ppm, a result which is interpreted as showing that at 7 V, in the low audio-frequency range, the ac voltage measurement capability at these laboratories (using various techniques) is near the state of the art.

CONSORTIUM FORMED TO FUND NIST DEVELOPMENT OF MIMIC METROLOGY

NIST has formed with industry and other government participants a consortium that is providing

funds for NIST development of the metrology required for the production and application of microwave monolithic integrated circuits (MIMICs). MIMICs are needed to exploit microwave and millimeter-wave technology in civilian fields as diverse as direct television broadcast by satellite and on-board radar for alerting operators of automobiles and other vehicles of potential collisions. MIMICs are also needed for advanced military communications, countermeasures, and radar systems.

The goals of the consortium are to involve the major U.S. companies and government organizations that fabricate and test MIMICs in the development of test methods and protocols that would make available selected on-chip measurements and lead to dramatic reductions in testing costs. The methods are necessary to provide a practical technology for defense electronics, to remove a major barrier to civilian commercial applications, and to improve the U.S. competitive position. At its first formal meeting, the Board of Directors selected three initial projects: thermal characterization of gallium arsenide integrated circuits, traceability for on-wafer S-parameter measurements, and improvement of/traceability for on-wafer noise measurements.

NIST PARTICIPATES IN MASS FIRE EXPERIMENT

In a jointly supported project by various U.S. and Canadian agencies, NIST participated in a mass fire experiment outside of Chappleau, Ontario, about 400 miles northwest of Toronto. An objective of NIST's participation in this study is to assess predictive models describing mass fires in order to better evaluate the consequences of urban conflagrations. In this experiment, a prescribed burn, or designed fire ignition by jelled gasoline dropped from a helicopter, created concentric ring fires over portions of the 400 hectare (or approximately 1,000 acres) tract of harvested forest debris. The initial fire spread in discrete patches over a region of about 50 hectares and caused a plume to rise to approximately 15,000 to 20,000 ft. A condensation cumulus cloud formed and later a small thunderstorm resulted downwind. Flames on the ground reached a maximum of approximately 40 ft. The multi-agency project team made measurements of the temperatures, velocities, and combustion-product concentrations of the fire and set up tower mounted video cameras that recorded ground conditions in the fire. NIST plans to work with some of the data to develop a dynamic estimate of the

energy release rate of the fire and the region undergoing active combustion. The results will be used to compare predicted fire induced ground velocities with measured values.

THREE CASE STUDIES RELEASED ON QUALITY STRATEGY

The Malcolm Baldrige National Quality Award Office has released three case studies on total quality management prepared by the award's first-year winners. The reports, available from NIST, are titled: "The Motorola Story"; "Performance Leadership Through Total Quality: A Case Study in Quality Improvement (Westinghouse)"; and "The Development of the Globe Metallurgical Quality System." According to Curt W. Reimann, director of the Baldrige Quality Award Office, "The reports offer some of the finest examples of quality practices today. Together they make a major contribution to the literature on how the award's rigorous criteria apply to companies practicing total quality management. They should also serve as a guide for implementing total quality management at corporations for many years to come." The reports are available from the Malcolm Baldrige National Quality Award Office, NIST, A1123 Administration Bldg., Gaithersburg, MD 20899. Requests should be accompanied by a self-addressed, stamped 12.5"×9.5" envelope with \$1.45 postage affixed.

STUDY ON NATIONAL PROGRAMS IN MATERIALS PUBLISHED

Materials experts from industry, universities, and government argue in a new report that the national programs of other nations in technology development, related to materials science and engineering, have made Europe and Japan fully competitive, and in some cases, able to surpass the United States. The study on national comparisons was conducted by Panel 3 of the Committee on Materials Science and Engineering (COMMSE) commissioned by the National Research Council. The report by Panel 3, deals with many facets of materials science and engineering as practiced in the United States and other countries. It contains information from a survey of national programs for science and technology and materials science and engineering, and it elaborates on the administrative structures to carry out research and development. For a copy of the report by Panel 3, International Cooperation and Competition in Materials Science and Engineering (NISTIR 89-4041), send a self-addressed mailing label to Samuel Schneider, NIST, B309 Materials Building, Gaithersburg, MD 20899; telephone: 301/975-5657.

NEW APPLICATION OF AN ION-EXCHANGE MEMBRANE

Efficient methods to separate and purify bioproducts are an important factor in a commercially successful biotechnology. One attractive, low-energy approach to bioseparation is membrane-based separation. In a recent paper, NIST researchers report on the successful use of perfluorosulfonic acid (PFSA) membranes for isolating amino acids—used in products from food additives to pharmaceuticals— from aqueous solutions. "We have cast a thin PFSA film on a porous support and obtained greatly increased fluxes of amino acids. In addition, the composite membrane exhibited good mechanical strength because of the support film," they report. Further research is needed before PFSA can be used commercially. For a copy of the paper, contact Jo Emery, NIST, Division 104, Boulder, CO 80303; telephone: 303/497-3237. Ask for paper no. 50-89.

NIST WORK CITED BY NOBEL COMMITTEE

When the Royal Swedish Academy of Sciences announced the Nobel Prize in Physics in October 1989, for research related to atomic clocks, they cited work at NIST's Boulder, CO, laboratories. Norman F. Ramsey of Harvard University received the prize for discovering the theoretical basis for current cesium atomic clocks; Hans G. Dehmelt of the University of Washington and Wolfgang Paul of the University of Bonn shared the Nobel for developing the ion trap technique which makes it possible to study a single electron or a single ion with extreme precision. In referring to the latter work, the Nobel committee said "this opened the way to a new kind of spectroscopy, which has been further refined and applied particularly at the National Institute of Standards and Technology ... in Boulder, Colorado." Researchers in NIST's Time and Frequency Division are doing research based on this technique which could some day result in atomic clocks that will neither gain nor lose a second in 10 billion years, or roughly the age of the universe. Professor Ramsey also has close ties with NIST. He has been a member of the NIST statutory Visiting Committee and in the 1986-87 academic year he was a visiting fellow at the Joint Institute for Laboratory Astrophysics (JILA) and is currently a Fellow-Adjoint at JILA. JILA is a cooperative research effort between NIST and the University of Colorado.

TWO NEW NIST PRECISION MEASUREMENT GRANTS AWARDED FOR FY 90

Since 1970, NIST has awarded Precision Measurement Grants to scientists in academic institutions, primarily for experimental work in precision measurement and fundamental constants areas important to the science of measurement. NIST sponsors these grants to promote and encourage fundamental research in the field of measurement science in U.S. colleges and universities, and to foster contacts between NIST scientists and those researchers in the academic community who are actively engaged in such work.

Two new \$30,000 NIST Precision Measurement Grants have been awarded for fiscal year 1990. The recipients are Steven Chu of Stanford University and Edward E. Eyler of the University of Delaware. The recipients were selected from among an initial group of 20 candidates by both an outside advisory committee.

Chu's project, "Precision Optical Spectroscopy of Positronium," will determine the 1^3S-2^3S interval in positronium (Ps, the e^+e^- atom) via two photon laser spectroscopy with a relative uncertainty approaching 1 part in 10^{10} , thereby providing one of the best tests of the two-body problem in quantum electrodynamics. Agreement between theory and experiment at this level can be used to set an upper limit (at the same level) on the particle-antiparticle mass difference of the electron and positron, thus critically testing the CPT theorem (charge conjugation, space inversion or parity, and time reversal invariance).

Eyler's project, "Far Ultraviolet Spectroscopy with Single-Frequency Lasers," will develop and characterize intense tunable single frequency laser sources in selected regions of the far ultraviolet (50-200 nm) suitable for precision two-photon spectroscopy. The lasers will be used to measure the 1^1S-2^1S interval in atomic helium with an accuracy approaching 6 parts in 10^9 , thereby providing a precise experimental test of recent calculations of Lamb shift and relativistic corrections in the groundstate of helium and establishing a much improved set of calibration lines for vacuum ultraviolet spectroscopy in this region.

LASER-DRIVEN REACTIONS ON SEMICONDUCTOR SURFACES

Chemical reactions at semiconductor surfaces play a central role in the fabrication of electronic circuit components. In recent years, there has been a great deal of interest in the use of lasers to initiate and control these surface reactions. In order to evaluate

processing alternatives for the future, it is critical to understand the underlying principles of optical excitations that are presently used to selectively induce reactions.

Recent NIST work has addressed the reaction mechanism and desorption dynamics involved in the optically driven removal of NO from silicon. These experiments have demonstrated that the carriers generated within the semiconductor during the optical excitation process are directly responsible for the desorption of adsorbed NO.

In these experiments, laser radiation above the band gap of the semiconductor is incident on an adsorbate-covered sample. As a result of the excitation of the substrate, a small fraction of adsorbed NO is ejected from the surface. Using a second laser to detect the desorbed NO, it is possible to characterize the energy content of the removed species. While the laser-induced temperature rise of the substrate is negligible (<1 K), it has been determined that the energy of the ejected NO deviates substantially from predictions of equilibrium theory. The temperature characterizing the kinetic energy exceeds the surface temperature by a factor of 10 and the vibrational temperature varies from 10 to 30 times the surface temperature as the NO coverage is increased. The other degrees of freedom of the desorbed NO have substantially less energy than the vibrations and translations.

FEDERAL INFORMATION PROCESSING STANDARD (FIPS) FOR ELECTRONIC DATA INTERCHANGE (EDI) PROPOSED

National Computer Systems Laboratory (NCSL) has proposed a new FIPS adopting national and international standards for EDI for use by federal agencies. This FIPS will adopt families of standards known as X12 and EDIFACT, which were developed by Accredited Standards Committee X12 on EDI and by the United Nations Economic Commission for Europe, Working Party (Four) on Facilitation of International Trade Procedures.

In electronic data interchange, information traditionally conveyed on paper documents is provided in an electronic format according to established rules and procedures. The formatted data may be transmitted to one or more recipients over telecommunications lines or physically transported on storage media.

The data on each type of document are transmitted together as a standard formatted message type or "transaction set." Underlying standards, integral to the use of the message type standards, define data types, data elements, data segments, and

message transmission envelopes. The message type standards together with the underlying standards form a family of interconnected standards that must be treated together as a whole. The standardization of message formats, and of data segments and elements within the messages, makes possible the formulation, decomposition, and processing of the messages by computer.

NIST INITIATES "DESIGN FOR QUALITY" COURSE

NIST scientists have developed and initiated a course for engineers on design for quality. The importance of designed experimentation—a systematic and rigorous plan for conducting an empirical investigation—is gaining increasing appreciation in the scientific and engineering communities. NIST has a unique vantage point, founded in measurement science, for disseminating the technology of designed experiments to engineers. Widespread development and use of this technology are dominant reasons for Japanese breakthroughs in quality engineering.

The course runs over several days and covers specific designs for three classes of engineering problems: 1) how to determine if a scientific/engineering modification has significantly improved the response; 2) how to ferret out systematically the most important factors from a large number of potential factors; and 3) how to converge to an optimal operating condition starting from a "best guess" setting. The course is being given in the fall of 1989 for NIST staff and in the spring of 1990 for engineers from local industry. The course is a feature of NIST's effort to support industry in its pursuit of quality and productivity goals.

CEMENT MICROSTRUCTURE MODEL USED BY MICHIGAN STATE UNIVERSITY

The cement microstructure model, developed by NIST to simulate the development of microstructure as cement reacts with water, is the first model to be installed on the NIST Cementitious Materials Modeling Laboratory, a computer facility designed for mathematical modeling of cementitious materials. The modeling laboratory is associated with the Northwestern University Center for the Science and Technology of Advanced Cement-Based Materials and can be remotely accessed by researchers. Other models dealing with the hydration, microstructure, properties, and performance of cement-based materials will be added to the modeling laboratory.

TWO U.S. COMPANIES RECEIVE TOP QUALITY AWARD

Milliken & Company and Xerox Corporation's Business Products and Systems, two U.S. manufacturing companies, received the 1989 Malcolm Baldrige National Quality Award on November 2 for superior quality in their management systems. President Bush, who presented the awards, praised the two companies for "leading the resurgence in American business leadership." Improvements in quality and service by American companies are "national priorities as never before," Bush said. The award, named after former Commerce Secretary Malcolm Baldrige, was established by legislation passed in August 1987. It promotes national awareness about the importance of improving total quality management and recognizes quality achievements of U.S. companies. The 1988 winners were Motorola Inc., the Commercial Nuclear Fuel Division of Westinghouse Electric Corp., and Globe Metallurgical Inc. The award is managed by NIST, with the active involvement of the private sector. For information on applying for the award, contact the Malcolm Baldrige National Quality Award Office, NIST, A1123 Administration Building, Gaithersburg, MD 20899.

COPPER REDUCES TOXICITY OF BURNING POLYURETHANE

Adding a minute amount of copper to flexible polyurethane foam, widely used as padding in upholstered furniture, can reduce the toxicity of smoke during a fire, say researchers at the NIST Center for Fire Research. Hydrogen cyanide (HCN), a colorless, highly toxic gas, is among the toxicants that can be produced when nitrogen-containing materials—such as polyurethane foam—burn. NIST researchers found that adding as little as 0.1 percent of copper to the foam significantly reduced both the atmospheric concentration of hydrogen cyanide and the toxicity of the smoke. For several years, the project has been sponsored partially by the International Copper Association Ltd. In the upcoming year, the Society of the Plastics Industry also will be lending support. According to the National Fire Protection Association, each year in the United States about 1,600 people die in 70,000 fires that begin with a cigarette that is dropped onto furniture, the bulk of which contains polyurethane foam. Overall, about 6,000 people die in fires in the United States each year. Most of these deaths are due to smoke inhalation and not to burns.

LOOKING AT WAYS TO ASSESS STRUCTURAL PERFORMANCE

Reliable, economical devices are needed to measure the behavior of structures during events such as earthquakes or strong winds or to assess the day-to-day condition of a structure. At present field measuring devices tend to be costly and need almost constant monitoring as well as frequent equipment servicing and calibration. In some cases, they produce questionable data or malfunction during critical events such as earthquakes. In a meeting held last fall, experts from around the world convened at NIST to discuss these problems and some new materials and improved technology that could have a dramatic impact on the reliability and versatility of measurement devices. In addition, the experts formulated recommendations for future research. A report, *Sensors and Measurement Techniques for Assessing Structural Performance—Proceedings of an International Workshop (NISTIR 89-4153)*, is available from the National Technical Information Service, Springfield, VA 22161. Order by PB#89-235865 for \$15.95 prepaid.

ACCURATE GAUGING OF FOOD COMPONENTS IS AIM OF RMs

Scientists are continually striving to make accurate measurements of nutrients and contaminants in food samples. But they need standards to ensure the reliability of instruments and analytical methods—preferably standards containing a variety of foods representative of an American diet. A reference material (RM) now available from NIST offers just such a dietary composite complete with values for a variety of nutritional and potentially toxic components. The material contains listed concentrations of 17 elements—potassium, sodium, iron, zinc, and selenium, to name a few—as well as ash, fat, protein, total sugar, and starch. Food chemists can analyze the RM as they would any food sample and compare their results with the numbers provided. The material, known as Mixed Diet (RM 8431A), is available for \$114 from the Office of Standard Reference Materials, NIST, B311 Chemistry Building, Gaithersburg, MD 20899; telephone: 301/975-6776.

QUALITY CONTROL NEEDED FOR LONG-LASTING CONCRETE

In a study for the U.S. Nuclear Regulatory Commission (NRC), researchers at NIST are attempting to determine if concrete can be formulated to last up to 500 years. The NRC is responsible for developing a strategy for storing low-level radioactive

waste. One approach being considered by NRC involves storing radioactive wastes in underground concrete vaults that will be required to last 500 years. NIST analyzed the major degradation processes likely to affect the vaults and recommended ways to predict the service life of concrete. Based on available knowledge, says NIST, it seems likely that concrete can be formulated which should have a service life of 500 years in the expected environments. NIST cautions that such a lifetime can be achieved only if the concrete materials meet carefully defined specifications and good construction practices are followed. *Service Life of Concrete (NISTIR 89-4086)* is available from the National Technical Information Service, Springfield, VA 22161. Order by PB#89-215362/AS for \$21.95 prepaid.

WEIGHTS AND MEASURES HANDBOOKS REVISED

Two handbooks have been revised by NIST to reflect changes adopted at the 74th Annual Meeting of the National Conference on Weights and Measures (NCWM) held in Seattle, WA. NCWM is an organization of state, county, and city weights and measures enforcement officials, which was established in 1905. NIST, which is a non-regulatory agency, provides technical support to NCWM through its Office of Weights and Measures.

NIST Handbook 44-1990. The major changes to NIST Handbook 44-1990, *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*, include a revised section on liquid measuring devices that establishes a requirement for equipment capable of computing the cash/credit pricing of retail motor fuel. NCWM also adopted a specification permitting the use of electronic data audit trails as security seals for electronic devices that are to be considered the equivalent to the physical sealing of other devices with lead and wire seals or pressure-sensitive seals.

NIST Handbook 130-1990. A new regulation was adopted for the maximum allowable variation (MAV) for polyethylene sheeting. Individual packages of poly sheeting cannot be short weight or short in thickness by more than an MAV of 4 percent of the labeled weight or thickness. NIST Handbook 130-1990., *Uniform Laws and Regulations*, also has a revision to the Uniform Regulation for the Method of Sale of Commodities that covers stuffed items such as meat, fish, seafood, and poultry as combination foods. The quantity representation may be in terms of the total weight of the

product or combination, and a quantity representation need not be made for each element provided that a statement listing the ingredients in order of their predominance by weight is shown on the label. This handbook also contains a new method of sale requirement for home liquid oxygen used for respiration. A ticket must be provided showing the weight of the cylinder before filling, after filling, and the net weight of the oxygen delivered.

Copies of the handbooks are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order Handbook 44-1990 by stock no. 003-00302964-5, \$16 prepaid, and Handbook 130-1990 by stock no. 003-003-02962-9, \$10 prepaid.

INTERNATIONAL TEMPERATURE SCALE OF 1990 ADOPTED

A new temperature scale, the International Temperature Scale of 1990 (ITS-90), was formally adopted by the Comité International des Poids et Mesures (CIPM) meeting September 26-28, 1989, at the Bureau International des Poids et Mesures (BIPM). The new temperature scale incorporates important advances developed at NIST to improve the accuracy of temperature measurements common in industrial process technologies and to extend the internationally recognized temperature scale to lower temperatures that are increasingly essential to emerging technologies. The ITS-90 became the official international temperature scale on January 1, 1990, the same date changes affecting the use of some practical/electrical units were implemented. This new scale supersedes the present scales, the International Practical Temperature Scale of 1968 (IPTS-68) and the 1976 Provisional 0.5 K to 30 K Temperature Scale (EPT-76). The ITS-90 extends upward from 0.65 K, and temperatures on this scale, compared with those on the IPTS-68, are in much better agreement with thermodynamic values. The new scale has subranges and alternative definitions in certain ranges that greatly facilitate its use, and it has much improved continuity, precision, and reproducibility throughout its ranges. NIST scientists have worked with industrial users through the National Conference of Standards Laboratories to assure that U.S. industry can meet the new temperature-related requirements of international trade.

NIST PUBLISHES GOVERNMENT OPEN SYSTEMS INTERCONNECTION PROFILE (GOSIP) USERS' GUIDE

To assist federal agencies in planning for the introduction of GOSIP-compliant products into the

workplace, NIST has published Special Publication 500-163, Government Open Systems Interconnection Profile Users' Guide. GOSIP was issued as a Federal Information Processing Standard in August 1988 and becomes mandatory for use in federal procurements after August 15, 1990. For use by federal procurement specialists, technical specialists, and managers, the guide provides tutorial information on Open Systems Interconnection (OSI) protocols as well as information on OSI registration, OSI procurement, GOSIP technical evaluation, and GOSIP transition strategies.

CONTINUOUS SPEECH DATABASE DEVELOPED

In collaboration with industry, NIST has developed a continuous speech database in CD-ROM (compact disk-read only memory) format. The database consists of a corpus of recorded speech for use in designing and evaluating algorithms for continuous speech recognition. Speaker-independent, speaker-adaptive, and speaker-dependent recognition modes are accommodated. The corpus, a collection of recorded speech, contains oral readings of sentences from a 1000-word language model of a naval resource management task built around existing interactive database and graphics programs.

The first two in a series of four disks are available for sale by the National Technical Information Service, with the balance of the corpus to be released shortly.

FEDERAL INFORMATION PROCESSING STANDARD (FIPS) PROPOSED FOR FIBER DISTRIBUTED DATA INTERFACE (FDDI)

A new FIPS adopting voluntary industry standards for FDDI has been proposed for federal agency use. The FDDI is a layered standard for a 100 Mbits fiber optic token ring local area network (LAN). The FDDI network allows up to 500 stations connected by up to 200 km of fiber and is particularly suited as a "backbone" network interconnecting other, lower data-rate LANs. It also supports applications inherently requiring high bandwidth, such as image processing with engineering workstations and connecting storage servers to powerful computers as well as other applications whose size and data transfer requirements exceed the capacity of other LANs.

NIST TEST SYSTEM PROVIDES NEW CAPABILITIES FOR NONDESTRUCTIVE EVALUATION OF POWER TRANSISTORS

A new NIST nondestructive test system for power transistors that can accommodate up to 100 A and switch up to 2000 V has been applied to two major NASA programs, the space shuttle transportation system and the Hubble space telescope. The system responds to the need to evaluate new power transistors developed during the last decade. The NASA applications are for the gyroscope controller of the space telescope and for the main engine controller of the space shuttle. NIST offers documentation sufficient to build the system, including photographs, a complete circuit description, and a circuit diagram. In the system's normal mode of operation, the transistor under test is placed in series with an inductive load and turned on for a period of time needed to obtain a selected collector or drain current. When the transistor is turned off, its collector voltage increases abruptly. As this voltage increases, the system senses the onset of breakdown and quickly shunts the transistor to prevent it from being destroyed. In addition to providing voltage breakdown points, the system has provision for viewing current and voltage waveforms on an oscilloscope or capturing them in a transient digitizer.

MBE SYSTEM OPERATIONAL

NIST's molecular-beam epitaxy (MBE) laboratory is now operational. NIST scientists have completed testing the system and carrying out qualification growth-rate and doping calibration runs for gallium arsenide. This primary MBE system is dedicated to growing III-V compound semiconductors and has the capability to grow layers of gallium arsenide, aluminum arsenide, and indium arsenide of controlled thicknesses on a substrate.

Device structures that can be grown in the MBE system include heterojunction bipolar transistors, field-effect transistors, resonant tunnel diodes, and high-electron-mobility transistors (HEMTs), used in millimeter-wave and microwave circuits. HEMT devices have already been grown. In addition, NIST will fabricate quantum-Hall-effect devices for new resistance standards from material grown in the MBE system. Another planned use is in the development of methods and Standard Reference Materials for the determination of dopant concentration and the mole fraction of aluminum in aluminum arsenide.

SYSTEM FOR ON-MACHINE FAST PART PROBING DEVELOPED BY NIST

As part of a quality-in-automation project, NIST has developed a system that allows fast on-machine part probing using touch-trigger probes. On-machine part probing is used for process-intermittent measurements of the part being made on a machine tool. The information from such measurements is used to modify the cutting process parameters to achieve better part accuracy or for statistical process control. Probing cycles currently implemented by machine-tool controllers use slow feed rates of about 5 in/min and are slow in transferring the data to external medium, usually via RS-232 serial interfaces. The time spent for this kind of gauging operation reduces available machining time. The new system is based on a single-chip microcomputer. When this system is inserted between the machine feedback system and the controller, it allows probing with feed rates up to at least 100 in/min and uses parallel interfaces to transfer data to a PC for analysis. With this system, the probing time is reduced by a factor of three.

HEARING ANNOUNCED ON FEDERAL ROLE IN STANDARDS

Whether or not the U.S. standards systems, as they now exist, adequately serve the nation's trading needs in today's international markets will be the topic of a special public hearing on April 3, 1990. Marketing, manufacturing, engineering, and design professionals are invited to testify at the NIST-sponsored hearing. They will be asked to comment on what the U.S. role should be in international standards, describe any problems associated with the acceptance of U.S. products in foreign markets, assess the current situation, and provide suggestions for improvement, especially regarding mechanisms for coordination of U.S. participation in international standards activities. Information and comments will be used to make recommendations to the Secretary of Commerce to improve the effectiveness of U.S. participation in international standards-related activities. A written request to participate in the hearing should be submitted by March 22, 1990, to Dr. Stanley I. Warshaw, Office of Standards Services, NIST, A603 Administration Building, Gaithersburg, MD 20899; telephone: 301/975-4000. The hearing will be held at 9:30 a.m. in the auditorium of the Department of Commerce in Washington, DC. Individuals unable to attend may submit written comments to Warshaw.

Calibration Services

IMPROVED DIGITAL AC VOLTAGE SOURCE DEVELOPED

NIST researchers have developed an instrument that provides a portable digitally synthesized ac voltage source with many potential applications, including the calibration of high-accuracy digital voltmeters. As a calibration tool, the instrument, known as NIST DSS-3, is an improvement over other voltage sources. Commercially available digitally synthesized sources were not designed to be used as voltage standards for calibrations, and analog voltage standards are about 10 times less accurate. The NIST instrument also can be used to evaluate thermal voltage converter-based measurement systems and for on-line ac voltage calibration of automatic test equipment. Because it refers ac voltage to dc voltage standards, the instrument may be calibrated in the user's laboratory with dc standards only. This saves the cost of sending the instrument out for calibration. Future revisions to the instrument may include integrating faster components (digital-to-analog converters, switches, and amplifiers) and digital signal processing chips into the instrument's design.

OXYGEN CALIBRATION FACTOR ADOPTED INTERNATIONALLY

The accuracy of measuring oxygen in silicon wafers, which is tightly specified by integrated circuit manufacturers when they buy silicon, has been improved substantially by the recent adoption around the world of the results of an international interlaboratory experiment in which NIST was a participating laboratory. NIST's role was to manage the conduct of the experiment and carry out the complete data analysis. The value determined by the experiment is the calibration factor used to calculate the interstitial oxygen content of silicon from room-temperature infrared absorption measurements. The ASTM, the Deutsches Institut für Normung in West Germany, and the Japan Electronics Industry Development Association (JEIDA) have now each accepted that result and are revising their standard measurement methods to reflect the change; JEIDA is reissuing certificates for its reference materials (primarily distributed in Japan). The accuracy of the new result is 3 percent, while previously used values were only accurate to about 10 percent at best. Producers of silicon wafers thus are now better able to

meet their customers' needs. Since the new result has been accepted throughout the free world, differences in measurements resulting from the use of one standard method by the producer and another by the purchaser should not arise, and a potential nontariff barrier to international trade is avoided.

NIST ANNOUNCES MILLIMETER-WAVE SERVICES

In response to industry needs, NIST has expanded the theory and practice of its antenna near-field scanning method by establishing antenna measurement services at millimeter-wave frequencies (above 30 GHz). Services are now offered for antenna gain and polarization to 65 GHz and for antenna pattern to 50 GHz. The new services use planar scanning, in which a well-characterized measurement probe scans across a plane at a fixed distance from the plane of the antenna. At higher operational frequencies, the errors in the computed far-field pattern introduced by errors in probe position become more significant. NIST has developed special software programs to correct the final results, once the positional error has been determined over the scanning plane. To arrange for a calibration, contact Allen Newell, telephone: 303/497-3743 or Kathy Hillen, NIST, Div. 723.10, Boulder, CO 80303; telephone: 303/497-3753. Copies of paper 46-89, which describes these services, can be obtained from Jo Emery, NIST, Div. 104, Boulder, CO 80303; telephone: 303/497-3237.

Standard Reference Materials

NIST ANNOUNCES CHARPY V-NOTCH IMPACT TEST PROGRAM

The most widely used standard for predicting the behavior of steel used in structures and other products has been transferred to NIST from the U.S. Army Materials Technology Laboratory, Watertown, MA. NIST will continue worldwide service with certified standard reference materials (SRMs) and impact test machine evaluations for the Charpy V-notch test. Each SRM unit consists of five identical V-notched blocks, 10×10×54 mm in size and a questionnaire on the impact machine. After the five test blocks are broken, the 10 halves are sent with the questionnaire to the NIST Fracture and Deformation Division, Boulder, CO. The broken

specimens are then examined to verify that proper procedures have been followed, and then the performance of the test machine may be certified. SRM 2092, Certified Low-Energy Samples for Charpy V-Notch Test Machines with an average fracture energy between 11 and 15 ft/lb, and SRM 2096, Certified High-Energy Samples for Charpy V-Notch Test Machines with an average fracture energy between 66 and 78 ft/lb, are available for \$150 per each SRM set from the Office of Standard Reference Materials, NIST, B311 Chemistry Building, Gaithersburg, MD 20899; telephone: 301/975-OSRM (6776).

Standard Reference Data

MIPROPS PROGRAM NOW AVAILABLE ONLINE, WORLDWIDE

A computer program for calculating the thermophysical properties of 12 important organic and inorganic industrial fluids, developed by NIST, now is available worldwide to subscribers of STN International (Scientific and Technical Network), an online private sector retrieval service. MIPROPS is designed for use in performing quick calculations on the properties of helium, argon, oxygen, nitrogen, hydrogen, and nitrogen trifluoride as well as the hydrocarbons, methane, ethane, ethylene, propane, isobutane, and normal butane. The new online program is based on NBS Standard Reference Database 12, *Interactive FORTRAN Programs to Calculate Thermophysical Properties of Fluids, MIPROPS, 1986*. For information on the availability of MIPROPS through STN, or MIPROPS for lease on a computer-readable magnetic tape or floppy disk, contact the Office of Standard Reference Data, NIST, A323 Physics Building, Gaithersburg, MD 20899; telephone: 301/975-2208.

EXAMINING HALOGENATED HYDROCARBONS

Since fully halogenated chlorofluorocarbons (CFCs) have proven destructive to the Earth's ozone layer, scientists worldwide are on an intensive search for suitable substitutes for CFCs as refrigerants. NIST researchers have prepared two new papers as part of the science and technology review that will form the basis for a reassessment of the Montreal Protocol, which limits the production of certain CFCs. The papers examine thermo-

physical property data of halogenated hydrocarbons as possible substitutes. These data are needed to determine whether halogenated hydrocarbons will best serve as replacements for the many uses of CFCs. One paper examines nine halogenated hydrocarbons and finds a mixed bag with property data "ranging from well-documented, high-accuracy measurements from published sources to completely undocumented values listed on anonymous data sheets." The second paper sets out criteria for the ideal refrigerant and notes that hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) "remaining as the most promising coincident candidates for replacement working fluids." For copies of the papers, contact Jo Emery, NIST, Division 104, Boulder, CO 80303; telephone: 303/497-3237. Ask for papers no. 48-89.

EDUCATIONAL VERSION OF DIPPR DATABASE AVAILABLE

A special educational version of DIPPR (Design Institute for Physical Property Data) Data Compilation of Pure Compounds, 1989, is available for chemistry students on diskette or tape. The new database provides students with quick access to important information on the behavior of substances and their reactions under various pressures and temperatures. It contains evaluated data on 39 properties for 100 chemical compounds most frequently used in classroom exercises. For the chemicals selected, data are provided on their thermodynamic, physical, and transport properties. Designed specifically as a teaching tool, the database is not for research use because of the limited number of available chemicals. *NIST Standard Reference Database 11A, DIPPR, Student (Educational) Data Compilation of Pure Compound Properties, 1989* is available for \$75 from the Office of Standard Reference Data, NIST, A323 Physics Building, Gaithersburg, MD 20899; telephone: 301/975-2208.

X-RAY PHOTOELECTRON SPECTROSCOPY DATABASE RELEASED

A new standard reference database is available for surface scientists, tribologists, and analytical chemists using x-ray photoelectron methods to analyze surfaces of materials to determine wear, friction, and resistance to corrosion, *NIST Standard Reference Database 20, X-Ray Photoelectron Spectroscopy* gives easy access to critically evaluated photoelectron and Auger spectral data on more than 13,000 measurements from the literature through 1985. The "user-friendly" program allows

for searches on photoelectron and Auger lines as well as chemical shifts to be made by element, line energy, and other variables. Users can easily identify unknown measured lines by matching them to previous measurements. The database is designed for personal computers (PCs) and runs on any MS-DOS or PC-DOS computer using a 2.1 or later disk operating system. It is available on a 3-1/2 or 5-1/4-in floppy disk that requires 5 megabytes of storage space. The database is available for \$495 from the Office of Standard Reference Data, NIST, A323 Physics Building, Gaithersburg, MD 20899; telephone: 301/975-2208.

**STANDARD REFERENCE DATA PUBLISHES
COMPILATION OF OCTANOL-WATER
PARTITION COEFFICIENTS**

A critical compilation of octanol-water partition coefficients for 611 organic compounds appears in the latest issue of the Journal of Physical and Chemical Reference Data. This quantity, which is a measure of the way a chemical compound distributes itself between water and octanol, has been found to correlate well with the biological activity of many toxic substances and drugs. The correlation results from the similarity of octanol to the lipids which form an important part of the cells of animal organisms. Thus the octanol-water partition coefficient allows one to estimate how much of a substance will be transferred from the bloodstream to the body cells, where damage can occur if the substance is toxic (or beneficial effects can result if the substance is a pharmaceutical). For this reason, such data are widely used in modeling the fate of environmental pollutants, designing new drugs, and many similar applications.

The new compilation represents the most careful evaluation of this property to date. Data from 265 references were evaluated, and recommended values, including uncertainties, are given for all compounds. This database provides a sound foundation for developing predictive methods for more complex substances for which measurements have not been made. The compilation is expected to get wide use by chemists, biologists, and environmental scientists.