National Institute of Standards and Technology

NIST Research Reports

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NIST Special Publication 765

On the cover: The supersonic inert gas metal atomizer (SIGMA) is used in an intelligent processing of materials program at NIST. The cooperative program is aimed at automating the production of rapidly solidified metal powders. From left to right are Frank Biancaniello, James Ingram of Hoeganaes Corp., and Stephen Ridder. See article on page 10.

NIST Research Reports

U.S. DEPARTMENT OF COMMERCE
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The National Bureau of Standards became the National Institute of Standards and Technology on August 23, 1988, under the Omnibus Trade and Competitiveness Act. NIST retains all NBS functions. Its new programs will encourage improved use of technology by U.S. industry.

NIST

Research Update

Industry To Study Bioseparations at NIST

Cell Technology Inc., of Boulder, Colo., has established a Research Associate Program at NIST's Boulder laboratories to study bioproduct separation utilizing aqueous two-phase extraction and electrophoresis. The University of Colorado (CU) and the Colorado Advanced Technology Institute are also participants in the program. Cell Technology has a product, Imuvert, derived from the Gram-negative bacterium *Serratia marcescens*, which has shown encouraging results in regressing tumors. The company currently uses ultracentrifuges to separate components of the bacterium but this produces only small amounts of ribosomes and vesicles, the desired product. A CU graduate research assistant will work at NIST to determine whether or not vesicles and ribosomes can be separated in larger quantities from other cellular debris using aqueous two-phase extraction or electrophoresis. The NIST Research Associate Program provides an opportunity for scientists and engineers from companies and other organizations to work with NIST researchers on programs of mutual interest.

Final Rule Issued on Toy Firearms

The Technology Administration of the U.S. Commerce Department issued a final rule, effective May 5, 1989, which prohibits the manufacturing, entering into commerce, shipping, transporting, or receipt of any toy, imitation, or look-alike firearm unless it contains or has affixed to it a marking approved by the Secretary of Commerce. The final rule specifies the markings established under Section 4 of the Federal Energy Management Improvement Act of 1988. The law does not apply to traditional BB, paint ball, or pellet-firing air guns that expel a projectile through the force of compressed air, compressed gas, mechanical firing action, or any combination. The rule also waives marking requirements for any toy, look-alike, or imitation firearm that will be used only in the theatrical, movie, or television industries. For further details, contact: Stanley I. Warshaw, NIST, A603 Administration Bldg., Gaithersburg, MD 20899, 301/975-4000.

Materials Aimed at Improving Pesticide, PCB Analyses

Scientists seeking to develop or validate the accuracy of analytical methods for measuring selected pesticides, polychlorinated biphenyls (PCB's), and alpha-tocopherol (a form of vitamin E) in fish and other fatty food products should find a new Standard Reference Material (SRM) useful. The SRM contains certified concentrations of six chlorinated pesticides (hexachlorobenzene, alpha-HCH, trans-chlordane, cis-chlordane, trans-nonachlor, and dieldrin), five individual PCB's, and the nutrient alpha-tocopherol in cod liver oil. In addition to containing the certified components, the SRM also has noncertified concentrations of six dioxin compounds and a related compound, octachlorodibenzofuran. The new material, SRM 1588, Organics in Cod Liver Oil, is available for $199 per set of five sealed vials from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-6776.

Gas Kinetics Database Available

A new computerized database with an extensive compilation of information on the rates of chemical reactions important to research chemists, environmental scientists, and combustion engineers has been developed by NIST scientists. Available on a floppy disk for personal computers (PC's), it contains data on the rates of approximately 2,000 chemical reactions with more than 5,300 individual data entries. The database is an important tool for modeling combustion systems or chemical processes occurring in the atmosphere. This type of data is necessary in understanding the reactions of chemicals and their role in depleting the Earth's ozone layer. A special software option allows users to display rapidly in a single graphic all of the rate constants determined for a single chemical reaction as a function of temperature. These plots showing all of the available information are useful for revealing discrepancies in experimental results. NIST Standard Reference Database 17, Gas Kinetics, is available for $190 from the Office of Standard Reference Data, NIST, A320 Physics Bldg., Gaithersburg, MD 20899, 301/975-2208.

200 Labs Accredited for Asbestos

More than 200 labs received the first accreditations to perform analyses for asbestos content in bulk insulation and building materials under the new National Voluntary Laboratory Accreditation Program (NVLAP) for bulk asbestos in schools. The labs have demonstrated their competence to analyze bulk material samples by polarized light microscopy using test method procedures specified by the Environmental Protection Agency. Approximately 500 other labs are being evaluated to determine their ability to meet NVLAP requirements. The accredited labs have undergone an on-site assessment performed by a technical expert in optical microscopy and have demonstrated full compliance with NIST technical evaluation criteria. The labs also have successfully participated in the first round of proficiency testing in which they were required to determine the presence and type of asbestos in precharacterized quality assurance materials developed by NIST. For information on NVLAP, contact: National Voluntary Laboratory Accreditation Program, NIST, Bldg. 411, Gaithersburg, MD 20899, 301/975-4016.

World's Smallest Prism Made

Researchers at the NIST laboratories in Boulder, Colo., have created what they believe to be the smallest optical prism ever made. The microscopic glass prism is only 0.005 inch on a side—about the thickness of a heavy sheet of paper. Barely visible to the naked eye, the "microprism" may be used in microoptics and fiber optics research and instrumentation—for example, as a test probe for making accurate measurements of the performance characteristics of optical fibers in the tight confines of an integrated optical circuit. Besides being measuring tools, microprisms might also eventually have applications as actual elements in miniaturized optical circuits. Zongjian Sun, a guest scientist at NIST from Tongji University of Shanghai, People's Republic of China, developed the procedure to grind the infinitesimal prism in conjunction with Robert Gallawa, a physicist in NIST's Electromagnetic Technology Division.

New Low-Alloy Steel Calibration Standard Available

A new standard for checking and calibrating oxygen and nitrogen analyzers in the steel industry has been developed under a cooperative program between ASTM and NIST. Information on concentrations of these gases is important to the properties of steel because they contribute markedly to steel brittleness and therefore to the strength and durability of steels. Standard Reference Material (SRM) 1754, Oxygen and Nitrogen in Low-Alloy Steel, AISI 4320, is in rod form, 0.95 cm x 0.95 cm x 10.2 cm. It was certified through the NIST/ASTM Research Associate Program involving nine industrial laboratories. SRM 1754 is available for $119 per unit of 1 rod from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-6776.

NIST Studying Burning of Crude Oil Spills

Can an oil spill be cleaned up by burning? What happens when oil on water burns? How much smoke is produced? What are the physical and chemical properties of the smoke? These are some of the questions NIST researchers are attempting to answer in a project to evaluate combustion of oil spills on water. In a recent paper, the researchers discussed the results of their preliminary laboratory tests on three different crude oils. One of the primary thrusts of the research is to measure the amount of selected chemical components in the smoke from a crude oil fire. The researchers measured the quantity of several polynuclear aromatic (PAH) compounds in both the original crude oil and the smoke. (PAH compounds in crude oil are of environmental concern because some have been reported to cause cancer in animals.) The NIST researchers found that the amount of PAH compounds in the smoke nearly equaled that in the original oil burned. The researchers also have developed a preliminary computer model that can help predict how smoke from a burning oil spill will be dispersed. The work is being done in collaboration with the U.S. Department of the Interior and Environment Canada.

'ZIP' Will Find Most Economic Levels of Insulation

How much insulation should be installed in a house? A new computer program called ZIP can help find the answer. Quick and easy to use, ZIP can provide customized estimates of the most economic levels of thermal insulation for building components such as attics, walls, floors, crawlspaces, and basements. ZIP determines these estimates by searching internal data files containing local weather information and energy and insulation costs all keyed to the user's postal ZIP code. The program and supporting files are contained on a single diskette and will run on MS-DOS systems with 256K of RAM. ZIP was designed by NIST in conjunction with the Department of Energy's Oak Ridge National Laboratory. The disk is available from several sources including MTS Software, 3534 Knollstone, St. Louis, MO 63135, 314/524-2202 for $5 and PC-SIG, 1030D East Duane Ave., Sunnyvale, CA 94086, 408/730-9291 for $6. It also is available from the National Technical Information Service, Springfield, VA 22161; call 703/487-4600 for ordering information.

Material Can Help Pinpoint Nicotine Exposure

Researchers studying human exposure to cigarette smoke—both active and passive exposure—need to ensure that the methods they use to track the concentration of nicotine by-products in urine samples are reliable. A new bottled reference material (RM), issued jointly by NIST and the Environmental Protection Agency, can assist laboratories in validating urine measurement methods. It is designed for determining levels of cotinine, which is the major urinary metabolite of nicotine. With the new material, laboratory personnel can test the reliability of instruments and methods by analyzing the RM the same way as a urine sample and comparing results with the ones listed for the RM. The new material is sold in a kit that includes vials of freeze-dried urine, each containing cotinine at one of three levels: blank, low, and high. These quantities are typical of, respectively, nonsmokers with no exposure to cigarette smoke, nonsmokers with passive exposure to smoke, and smokers. RM 8444 costs $148 and is available from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-6776.

Measuring High-Temperature Superconductors

NIST researchers have developed a novel apparatus for variable-temperature measurements of high-temperature superconductors. Termed a cryogenic bathysphere, it can rapidly (in 10 minutes) test superconductors over a range of temperatures from 300 to 4 K, or it can be used to stabilize the temperature at a given value. The tiny (3-centimeter width) device has no moving parts and can be used in compact spaces such as shipping Dewars and small-bore high-field magnets. The apparatus has been tested successfully in liquid helium and liquid nitrogen by measuring the resistance-versus-temperature curves of several superconductors. A paper describing a prototype device is available from Jo Emery, NIST, Division 104, Boulder, CO 80303.

NIST Invites Vendors for GOSIP Evaluation Project

The National Computer Systems Laboratory at NIST is developing guidelines to help users evaluate different implementations of GOSIP (Government Open Systems Interconnection Profile) applications. To help expedite the project, vendors are invited to lend to NIST software and hardware that implement message handling systems and file transfer, access, and management applications. Currently, GOSIP supports both applications. GOSIP was approved last fall as a Federal Information Processing Standard (FIPS), developed by NIST for use by the federal government. The standard defines a common set of data communication protocols that enables computer systems developed by different vendors to communicate and enables the users of different applications on these systems to exchange information. For information on the evaluation project, contact Steve Trus, NIST, B225 Technology Bldg., Gaithersburg, MD 20899, 301/975-3617.

N.Y. Firm Joins with NIST To Investigate Sensors

CID Technologies Inc. (CIDTEC), of Liverpool, N.Y., has begun a program with NIST that will investigate the effects of various forms of nuclear irradiation on charge injection device (CID) sensors and cameras. CID sensors are sophisticated imaging devices that offer numerous technical advantages over related techniques. For example, CID cameras allow excellent exposure control in low-light situations, but they also are more tolerant to intense light and produce accurate image detail even under extreme lighting conditions. This makes the devices ideal for purposes such as missile tracking, semiconductor pattern recognition, and factory inspection. For this cooperative project, CIDTEC and NIST researchers will use the NIST 20-megawatt reactor to expose sensors and associated CID components to x-ray, gamma, beta, neutron, and charged particle environments to determine "radiation hardness" of the materials. They will gauge the electronic characteristics of the devices before, during, and after radiation exposure. They also will explore the chemistry uses of CID's by developing spectroscopy applications to improve chemical analysis accuracy and detection limits.

Tiltmeter Studies in Colorado and Wyoming

Scientists at the NIST–University of Colorado Joint Institute for Laboratory Astrophysics (JILA) have completed field studies of specially designed tiltmeters in Erie, Colo., and Yellowstone National Park, Wyo. Tiltmeters are highly sensitive devices which are sunk deep into the Earth and which are designed to measure the slightest tilt in the Earth's surface. They might be used, among other things, as early-warning predictors for earthquakes. The JILA scientists found good agreement between their measurements and measurements of Earth tides on the Colorado plains but wide disagreements between these measurements in Yellowstone Park where the instruments were placed above a collapsed caldera. Only near a fault zone in Germany have comparably large tilt anomalies been observed, they report. For copies of two papers explaining their work, contact Jo Emery, NIST, Division 104, Boulder, CO 80303.

Computer Security: Protection Is the Name of the Game

Dr. Stuart Katzke has been talking a lot lately about viruses, bugs, and infections. But Katzke is not a medical doctor, and no human can catch these ailments. Katzke manages a team of computer scientists, mathematicians, and engineers at the National Institute of Standards and Technology. Their job is to find ways to help protect the federal government's unclassified computer systems against problems—including malicious software programs called viruses.

But, while computer viruses are nothing to sneeze at, Katzke and other experts agree there are more pressing computer security problems. Computerized information, says Katzke, must be protected from not only intentional acts such as sabotage or theft, but also natural disasters, hardware and equipment failure, and operator error.

Computer Security Act

Since the early 1970's, NIST has been developing cost-effective ways to help organizations—both in government and private industry—protect computerized data. These methods include sound management practices as well as technical solutions.

With the passage of the Computer Security Act of 1987 (P.L. 100-235) that role was broadened to give NIST the primary responsibility for protecting the security and privacy of unclassified information in federal computer systems. "We want . . . to be the government's leader in finding solutions to the problems related to the protection of unclassified information," said Ray Kammer, NIST acting director, last March before two congressional subcommittees. "I hope that, in the 1990's, we can say that the federal government leads the nation in developing and using cost-effective security controls," Kammer added.

To help NIST carry out its new role under the act, the Institute formed a 12-member board. Made up of industry and government experts, the board is to advise NIST and the Secretary of Commerce on security and privacy issues pertaining to unclassified federal computer systems.

What Is Computer Security?

According to Katzke, computer security means that data in a computer system are correct and confidential and that the system is available when needed. But, more than that . . . "computer

Before logging onto a network, Miles Smid uses a credit card-sized board, called a "smart" token, to perform a series of authentication checks for security.

security means never having to say you're sorry," says Katzke. He adds, "It means your organization from the top down is serious about computer security and the managers have evaluated what needs to be protected and have implemented cost-effective measures to protect it. It means that if something does happen, you're protected, or at the very least, you know what needs to be done to recover from the damage."

According to Doug Hunt, manager of computer security planning and assistance, an important step toward protecting data is for an organization to form a comprehensive computer security plan. Although this may seem obvious, Hunt says it is often overlooked. Such a plan should help make computer security an integral part of managing an organization's computerized information and keep everyone more aware of problems and solutions.

In fact, the recently passed computer security act mandates that federal agencies develop plans for systems containing sensitive but unclassified information and submit them to NIST for review. Since January, teams of computer security specialists from NIST and the National Security Agency (NSA) have been reviewing more than 1,500 plans. "We're not grading or judging the plans as good or bad. Our purpose is to provide constructive comments," says Hunt.

He and the teams have found wide disparities both among and within agencies in the quality and completeness of the plans. They also found that most agencies need to improve computer security training for all levels of staff. After reviewing the first round of plans this summer, Hunt's group will begin developing guidelines on both planning for computer security and training.

Weighing Cost vs. Risk

An important part of developing a computer security plan is to weigh the costs of controls against the risk of loss. " 'Absolute' security is achieved only at unlimited cost," says Dennis Steinauer, manager of the computer security management and evaluation group. "Since most organizations, including federal agencies, do not have unlimited funds, it's important to balance cost and risk. Controls that are more expensive than the value of the information they protect are not cost effective," he says.

To help achieve this balance, NIST is investigating techniques that can be used to identify risks and select cost-effective computer security measures. In collaboration with NSA, NIST has established a research laboratory to study methods that are currently available for assessing risk, to develop "standard scenarios" that can be used in comparing alternative methods, and to develop guidelines on selecting risk management procedures.

Locks and Keys

While good management practices and training are essential to protect computers and the data they handle, computer technology also can be part of the solution. In addition to developing standards and guidelines for management measures, NIST also works on the technical tools needed for an overall computer security program.

One of the best ways to ensure that someone cannot read or alter a data transmission is through cryptography. Cryptography is a mathematical process that encrypts—or scrambles—the information so only those with a secret "key" can unscramble it. Cryptography also can be used to generate codes that indicate whether unauthorized changes have been made to a message while it is in transit in a network or while it is stored in a computer.

In 1977, NIST issued the Data Encryption Standard (DES) that specifies an encryption algorithm. Although the DES was developed for use by the federal government, it is widely used by U.S. industry. For example, it has been adopted by the American National Standards Institute and the American Bankers Association for protecting transfers of funds and securities over communications lines. The Department of the Treasury also is using it to help protect the billions of dollars in federal funds that are transferred electronically each year.

The DES is reviewed by NIST and the Department of Commerce every 5 years to determine its adequacy to protect computerized data. After the most recent review in 1987, NIST approved its use for another 5 years, saying it continues to be a sound method for protecting computerized data.

To further encourage use of the DES, NIST validates commercial devices to assure that products properly implement the standard and are compatible with other equipment using the DES. "This benefits both buyers and sellers of data encryption devices," says Miles Smid, manager of the NIST security technology group. So far 33 products have been validated. NIST also has developed standards for managing the keys needed to use the DES algorithm.

Other technology can help control access to computer networks. While passwords often are used to authenticate the identity of those wanting access to a network, many times they are not used properly, providing little or no protection.

In 1985 NIST issued a standard with basic guidelines for designing and putting into place a password system. Now the Institute is working with the Defense Advanced Research Projects Agency and a Minneapolis company, Datakey, Inc., to develop a prototype system using a "smart" token that will make it tougher for hackers to gain access to a computer network. Essentially a microcomputer on a credit card-sized board, the token performs a series of authentication checks before allowing a user to log on to a network. The researchers are considering incorporating a physical characteristic of the user, such as fingerprints, into a future version of the system.

"It's similar to protecting your house," says Smid. "When you go out for the evening, you usually lock your door. If you lock your door and turn on your porch light,

For Your Information

NIST researchers have produced a number of publications dealing with computer security. Following is a partial list of the publications that are available from the Government Printing Office (GPO) or the National Technical Information Service (NTIS). See bottom of page 31 for ordering information.

- *Smart Card Technology: New Methods for Computer Access Control*, Martha E. Haykin and Robert B.J. Warnar, NBS Spec. Pub. 500-157 (September 1988). Order from GPO as stock no. 003-003-02887-8, $2.75 prepaid. Describes the basic components of a smart card and provides background information on the underlying integrated circuit technologies. The capabilities of a smart card are discussed, especially its applicability for computer security. The report describes research being conducted on smart card access control techniques; other major U.S. and international groups involved in the development of standards for smart cards and related devices are outlined in the appendix.
- *Data Encryption Standard*, FIPS PUB 46-1 (January 1988, Reaffirmed until 1992). Order from NTIS as FIPS PUB 46-1, $9.95 prepaid. Specifies an algorithm to be implemented in electronics hardware devices and used for the cryptographic protection of sensitive, but unclassified, computer data. The algorithm uniquely defines the mathematical steps required to transform computer data into a cryptographic cipher and the steps required to transform the cipher back to its original form. This standard has been adopted as a voluntary industry standard.
- *Guide to Auditing for Controls and Security: A System Development Life Cycle Approach*, Zella G. Ruthberg et al., NBS Spec. Pub. 500-153 (April 1988). Order from GPO as stock no. 003-003-02856-8, $13.00 prepaid. Describes a process for auditing the system development life cycle of an automated information system to ensure that controls and security are designed and built into the system. The guide was developed by the Electronic Data Processing Systems Review and Security Work Group of the Computer Security Project within the President's Council on Integrity and Efficiency and contains bibliographies and a description of pertinent laws and regulations.

For more information on the NIST computer security program or to get a complete list of NIST computer security publications, write or call the Computer Security Division, NIST, A216 Technology Bldg., Gaithersburg, MD 20899, 301/975-2934.

NIST computer scientists are working with researchers from private industry to develop security features for "open" computer networks.

you've made it a little tougher for an intruder. If you lock your door, turn on your porch light, and activate an alarm, you've made it even tougher. With each layer of security, you've decreased the odds that someone is going to get into your house—or your computer system."

Security for 'Open' Networks

Computer networks bring with them many advantages, such as quick access to lots of information. But, they also have opened up new opportunities for mischief and crime, so graphically demonstrated by a recent virus incident that wreaked havoc on a nationwide network of research computers. In addition to developing tools designed to make data transmissions safer and to restrict access to networks, NIST is helping to make networks secure as well as "open."

Since 1983, NIST has been working with manufacturers, users, and other government agencies to develop standards for "open" systems that will make it possible for different manufacturers' equipment to communicate. This research will make it easier not only for computers to talk to each other, but also for networks to talk to networks. But, until recently, little attention has been paid to incorporating security features into these standards.

In a project to do just that, NIST is working with NSA and several private companies, including IBM, Hughes Aircraft Corp., and Digital Equipment Corp., to develop and test specifications for security features that can be built into new networking products. "We are drawing upon technology being developed for the classified world and modifying it to use in the unclassified," says Rob Rosenthal, manager of the protocol security group at NIST.

Getting the Bugs Out

While incidents of virus infections in networks are relatively few, they have been increasing. Katzke and his staff are working with other experts in government and industry to develop ways to deal with these threats. As a first step, NIST is forming a response and information center. The center will act as the hub of a network of similar centers set up to respond quickly to attacks and as a resource center where people could get information and guidance on security problems at any time. During an emergency, such as a widespread virus attack, NIST would act as a focal point to coordinate other centers and collect and disseminate information.

'Our Big Story Tonight Is. . . .'

While NIST can provide guidance and some of the tools needed to protect computerized data, in the end, says Katzke, computer security is largely a matter of attitude. "Many people think about computer security only when they hear a story about a virus attack or break-in on the evening news," says Katzke. "But if your organization relies on computers to get its job done, and you are ignoring computer security, you do so at a risk. And tonight's news may be about a break-in to your computer system."

by Jan Kosko
NIST Public Affairs Specialist

'Standard Crack' Helps Detect Metal Fatigue in Aircraft

A "standard crack" recently developed at the National Institute of Standards and Technology can help the airline industry do a better job of testing for metal fatigue in aircraft. The importance of testing aircraft for metal fatigue has been underscored by recent events, such as the Aloha Airlines fuselage that partially ripped open in flight last year. Eddy current testing is the method most often used to detect the cracks, normally invisible to the naked eye, that lead to this kind of failure. This type of testing uses an energized coil of wire to induce electrical currents in metals. These currents, which are affected by fatigue cracks, are monitored, and an interpretation is made as to the absence or presence of a defect and its extent.

A difficulty of the eddy current technique is the lack of samples of well-defined "flaws" that accurately simulate fatigue cracks. These are necessary to calibrate accurately eddy current instruments and to provide base data for interpreting test results.

Now engineers at the NIST Boulder, Colo., laboratories have invented a technique for producing artificial flaws of known sizes which can be used to calibrate test equipment.

The NIST Office of Standard Reference Materials in Gaithersburg, Md., will sell 3-inch by 2-inch blocks of metal containing these standard defects. The initial offerings will be research prototypes which should be available this summer.

"There is the potential for enormously wide application of these blocks," says Frederick R. Fickett, leader of the research group that designed the "standard crack." Virtually every segment of the transportation industry is concerned about fatigue cracking of metal; nuclear reactor operators also are interested.

Thomas E. Capobianco, a NIST engineer, developed the technique. In simplest terms, Capobianco softens a ¾-inch-thick piece of metal (in this case aluminum alloy 7075-T6) by heating it, notches it to a known length and depth with an indenting tool, and compresses the metal in the direction perpendicular to the notch until the notch "disappears" at the surface. " The beauty of this technique," says Capobianco, "is that by using an indenting tool to make the notch, we can make the geometry of the cracks anything we want. We can make them look like fatigue cracks of any configuration and still know their dimensions."

Capobianco will oversee production of the research materials and ensure their quality control. "We may not manufacture them entirely ourselves but we will measure their properties and customers will be getting a carefully characterized product," he says.

Purchase inquiries should be made to the Office of Standard Reference Materials, NIST, B311 Chemistry Building, Gaithersburg, MD 20899, or call 301/975-2012.

by Fred McGehan
NIST Public Affairs Specialist

Building Quality into Advanced Materials during Processing

Materials scientists at the National Institute of Standards and Technology are seeking researchers in industry, universities, and other organizations who are interested in participating in collaborative programs on the intelligent processing of materials (IPM). The IPM concept is a new computer-based approach for producing advanced polymer, ceramic, and metal alloy materials that are far superior to those used today. The special properties of advanced materials are the results of microstructures designed and built into them during processing. An IPM facility with various on-line nondestructive evaluation (NDE) sensors and process models can monitor and control carefully the processing conditions required to give advanced materials many exceptional qualities, such as improved strength, unusual magnetic properties, and increased resistance to heat, friction, wear, and corrosion.

Tom Yolken, chief of the NIST Office of Nondestructive Evaluation, points out that the annual world market for advanced materials and for the products made from them is estimated to reach $300 billion by the year 2000. There also is a sizeable market for conventional materials that are improved by the use of intelligent processing technology.

"Our long-range goal is to develop the scientific and measurement base that is crucial to U.S. industry's success. . . ."

Lyle H. Schwartz, director of the NIST Institute for Materials Science and Engineering, says, "Our long-range goal is to develop the scientific and measurement base that is crucial to U.S. industry's success in capturing a significant share of the world market for advanced materials."

According to Yolken, advanced materials tend to be expensive because their production is labor intensive and rejection rates are high. The unpredictable variability of properties also prevents designers from exploiting the technological advantages of advanced materials. He points out that the intelligent processing of materials concept will allow for quality to be built into materials during processing rather than attempting to obtain it by inspection.

Intelligent processing technology involves four principal interconnected parts:

- the materials processor—various apparatuses to press, cast, or mold materials;
- a network of on-line NDE sensors to measure or monitor the microstructures of materials during processing;
- control devices, such as valves, pumps, and motors, that regulate pressure, temperature, and other processing requirements; and
- a computerized process controller that closes the loop be-

tween the sensors and the process controls.

The process controller incorporates various expert systems, process models, and data. This computerized "decision-maker" can quickly evaluate information and make rapid adjustments in production processes to achieve the desired microstructures in advanced materials.

The IPM concept uses on-line measurements in real time to control simultaneously a wide variety of processing parameters.

Yolken emphasizes that IPM technology differs greatly from conventional automated processing where variables, such as temperature and pressure, are automatically controlled to preselected values. This does not allow for variations in the incoming materials. The IPM concept uses on-line measurements in real time to control simultaneously a wide variety of processing parameters.

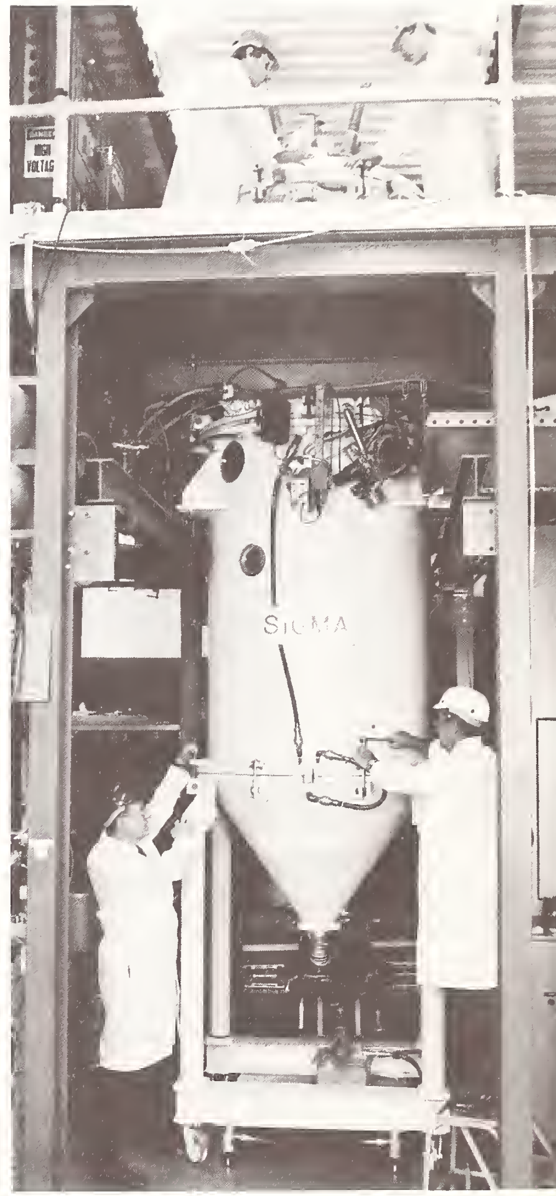
Now there are two IPM pilot demonstrations under development at NIST. An industrial consortium has been established to automate the production of rapidly solidified metal powders by high-pressure gas atomization. The total IPM package will consist of sensors, process models, and an "expert" computer system to control the atomization of liquid metals to produce powders with the desired microstructures for advanced metal alloys.

In another IPM project, NIST scientists are working with researchers from government, industry, and universities in a collaborative program on the hot isostatic pressing (HIPing) of titanium aluminide. The researchers are developing sensors, process models, and other measurement tools to automate the entire production cycle, from raw metal powders to finished parts at near-net, or close-to-final, shapes. (See article on page 12.)

In addition to the pilot demonstrations, NIST long-range plans call for collaborative IPM programs in polymers processing, ceramics processing, and the thermomechanical processing of metals. These programs will address industry needs that were identified by specialists at a national workshop on the intelligent processing of materials.

Collaborative IPM research opportunities are available where guest scientists from industry, government, and universities are able to work at NIST on projects of mutual interest with salaries paid by their employers. For information, contact the Office of Nondestructive Evaluation, NIST, B344 Materials Bldg., Gaithersburg, MD 20899, 301/975-5727. The NDE office also may be contacted for a copy of *Intelligent Processing of Materials, Report of an Industrial Workshop Conducted by the National Institute of Standards and Technology* (NISTIR 89-4024).

by Roger Rensberger
NIST Public Affairs Specialist



Researchers at NIST prepare for a test run using the supersonic inert gas metal atomizer (SIGMA). Clockwise from bottom left are John Manning, Frank Biancaniello, Stephen Ridder, and James Ingram, a research associate from Hoeganaes Corporation.

'HIPing': From Metal Powders to Reliable Materials

Consolidating rapidly solidified metal powders into close-to-final, or near-net, shapes through hot isostatic pressing (HIPing) may turn out to be a very reliable way to make parts out of advanced alloys, such as titanium aluminide. This high-performance material has great potential for airframe components and engine parts because it is lightweight and performs well at very high temperatures. But engineers need to overcome a variety of processing barriers before titanium-aluminide materials with the required internal properties can be produced cost effectively.

Materials scientists at the National Institute of Standards and Technology are working with a team of scientists and engineers from industry, universities, and government to develop the measurement and control tools needed to automate the HIPing process. The collaborative research effort is jointly supported by NIST and the Defense Advanced Research Projects Agency (DARPA).

To produce titanium-aluminide alloys using hot isostatic pressing, rapidly solidified metal powders are sealed in a canister or mold and placed inside a furnace. The material is then heated to approximately 1100 °C and compressed into solid shapes by hydrostatic pressures up to 200 megapascals, or 30,000 pounds per square inch.

Robert J. Schaefer, project leader in the NIST metallurgical processing group, says, "Our goal is to demonstrate that the required microstructural properties for titanium-aluminide alloys can be met by automated HIPing methods."

"The HIPing project offers us an opportunity to develop and test various measurement concepts for the automated control of materials processes. . . ."

Schaefer points out this will require new information for monitoring the overall HIPing process and measurement data for controlling the densification of metal powders to obtain the correct microstructures.

Concepts for the intelligent processing of materials (IPM) are being applied to the HIPing project. This is a new computer-based approach for producing advanced materials that are far superior to those used today. The special properties of advanced materials, such as exceptional strength and resistance to heat, result from microstructures designed and built into them during processing.

The researchers are developing sensors, process models, and an "expert" computer system to automate the entire production cycle of titanium-aluminide alloys and composites, from raw metal powders to finished parts. These measurement tools will ensure the production of reliable materials with the desired properties.

Neville Pugh, chief of the NIST Metallurgy Division, says, "The HIPing project offers us an opportunity to develop and test various measurement concepts for the automated control of materials processes in the same way robotics have been tested for discrete parts manufacturing."

Pugh says the HIPing of expensive metal alloys also provides a significant savings in materials. With near-net shapes, producers normally will lose no more than 10 to 20 percent of the bulk material in the final machining of a part. With conventional methods, manufacturers typically utilize only 10 to 30 percent of the material; the remainder becomes scrap.

NIST eddy current and ultrasonic sensors to measure the density and microstructures in the metal powders during consolidation will be incorporated in an IPM computerized control system being developed for DARPA by BDM International, Inc. The IPM controller will permit producers to take on-line measurements and evaluate the information with process models to control the properties of metal powders during HIPing.

NIST metallurgist Robert J. Schaefer monitors the compaction of rapidly solidified titanium-aluminide metal powders.

In a collaborative effort with NIST, University of Cambridge metallurgist Michael F. Ashby is

. . . HIPing of expensive metal alloys also provides a significant savings in materials.

developing the process models that will predict the density of metal powders based on pressure, temperature, and time. NIST metallurgist Roger B. Clough also is developing mathematical models of the mechanical deformation process during HIPing.

After the IPM controller system has been completed, plans call for various components to be installed in an industrial setting for tests under NIST supervision.

NIST also has established an advisory group for industry, university, and government collaboration in the HIPing program. Scientists and engineers may participate in the research effort through the NIST Research Associate Program, which provides them the opportunity to work at the Institute on projects of mutual interest with salaries paid by their employers.

For information on the cooperative program to automate the processing of titanium-aluminide alloys by HIPing, contact: Robert J. Schaefer, NIST, A153 Materials Bldg., Gaithersburg, MD 20899, 301/975-6162. *R.R.*

Exploring Earth's Formation

How did the Earth evolve from its beginnings billions of years ago to the present? Where do deposits of precious metals come from? How much of the Earth's makeup is from extraterrestrial sources? Researchers are helping to answer these questions with a custom-made chemical measurement system used to make unprecedented analyses of rocks and meteorites.

At the heart of the system, developed by NIST chemist Jack D. Fassett and Richard J. Walker, a geochemist for the United States Geological Survey (USGS), lies a powerful technique known as resonance ionization mass spectrometry (RIMS). Among other things, RIMS enables scientists to measure rhenium and osmium, two difficult-to-detect elements found in the Earth's rocks.

Based on the abundance of the two elements in Earth samples, scientists can accurately determine the age of rocks and learn much about the history of a rock sample.

Rhenium and Osmium's Role

Because rhenium and osmium are present only in minute quantities in rock samples—lower than parts per billion in most cases—and because these elements cannot be measured accurately by traditional methods, the researchers have tailored the RIMS technique to serve these geological purposes.

The key to much of the RIMS research is measurement of specific atoms—isotopes—of the two elements. The isotope rhenium-187 (Re-187) gradually decays over time and becomes the isotope osmium-187 (Os-187). As time progresses, Re-187 concentration decreases while Os-187 increases. In a given rock sample, the ratios of both isotopes to a stable (unchanging) reference isotope such as Os-186 corresponds to a specific period of time. By plotting isotopic ratios of the two elements on a graph, scientists can calculate the age of a rock sample.

There are other isotopic methods for studying and dating rocks. These are valuable, but they yield different information about samples than the Re/Os system. Ideally, scientists can glean the most information from rock studies by using several isotopic techniques in unison.

"It's another weapon in the arsenal," says Walker about the Re/Os method. "Because rhenium and osmium can date rocks that other systems can't, such as those with high concentrations of platinum group elements, they open up a whole range of new possibilities."

Practical Applications

Walker, along with colleagues from USGS and the Carnegie Institution of Washington, recently used the Re/Os technique in a study of rock samples from Montana's Stillwater Complex. This site contains a rich deposit of platinum concentrated in a thin layer. Scientists wanted to know why the metal had congregated in such a small band. The Re/Os method was called on because of its special abilities to provide information about platinum and related metals. Employing RIMS analyses of Re and Os isotopes, along with other independent methods, the study confirmed earlier work that a geological phenomenon known as "magma mixing" had occurred. That is, two geochemically distinct magmas—molten rock from within the Earth—blended together nearly 3 billion years ago, causing the platinum deposit to form.

Besides being important to geologists charting the Earth's history, the Stillwater study provides valuable information that can help locate similar platinum deposits.

Measuring Re and Os with RIMS has proven itself in other instances as well:

- A study in India showed that the movement of water mobilized certain components of very old crustal rocks, creating deposits of gold.
- In Ontario, Canada, Walker and collaborators affirmed other studies showing that a significant amount of noble metals in the Earth's mantle was added to the Earth from extraterrestrial sources following core formation 3.9 to 4.5 billion years ago.

How RIMS Works

The RIMS technique is actually a marriage of laser technology and the traditional chemical analysis method of mass spectrometry. By nature, RIMS is ideal for analyzing Re and Os. Conventional techniques cannot accurately determine Re and Os concentration. This is because these two elements are in such small amounts in most samples that they are hard to measure and because of "isobaric interference," a chemistry gremlin that throws off an analysis by making the concentration of one element appear to be part of a chemically similar element's concentration.

A RIMS analysis begins by illuminating a purified sample with laser light tuned to an element's "resonance" frequency, or the wavelength at which photons prompt a given element to ionize. This prepares the sample for analysis in the mass spectrometer. Since only one element has been ionized, the instrument can selectively analyze the concentration of this element with great sensitivity, allowing minute concentrations to be detected and eliminating the isobaric interferences of other techniques. To measure a second element, scientists need only to tune the laser to the resonance frequency of that element, then measure it in the mass spectrometer.

For some time, the RIMS instrument at NIST has been the only one of its kind used in this way, but the idea is catching on. For example, scientists at the Carnegie Institution of Washington are building their own RIMS instrument for their work in studying the Earth's geological history. Others will likely follow suit.

What Lies Ahead

NIST researchers are exploring other ways to use the instrument. One of the most promising is in semiconductor evaluation, where RIMS has been used to detect impurities that can cause degradation or even the costly scrapping of a semiconductor device. One element, vanadium, can fatally contaminate the thin films that coat semiconductors at levels as low as parts per trillion. The RIMS technique is especially sensitive to measuring vanadium at these levels, and NIST scientists have successfully used RIMS to analyze vanadium impurities in sample materials.

Another potential use is certifying the Standard Reference Materials (SRM's) NIST sells to laboratories to assist in calibrating instruments and evaluating analytical techniques. RIMS has been used to measure elements in these materials that other methods can't accurately gauge. RIMS was used effectively to certify the concentration of iodine and vanadium in an SRM for oyster tissue samples.

As scientists at NIST continue to produce data for Earth samples, semiconductors, and other specimens with RIMS, more ways to use the technique will likely surface. As Fassett says: "This method started as an experiment, now it is a workhorse—a day in, day out analytical tool that is very reliable and has many potential applications."

by John Henkel
NIST Public Affairs Specialist

Richard J. Walker prepares to analyze a rock sample.

NIST: Helping Industry To Compete

This past year has probably been one of the more eventful in our history as we made the transition from the National Bureau of Standards to the National Institute of Standards and Technology. Along with that name change, we saw the enhancement of our traditional measurement research and standards function to include a more general mandate to improve the competitiveness of U.S. industry. To my way of thinking, the NIST mission now has three major elements:

- measurement—providing the scientific data and standards that our economy needs to compete in the world market;
- technology—assisting U.S. industry to develop and apply emerging technologies to make world-class products; and
- technology transfer—accelerating the application and wide deployment of new technologies developed at NIST and elsewhere, to enhance the competitiveness of U.S. industry.

"Competitiveness" is becoming a cliche, but it has real meaning and real consequences. Competitiveness is the degree to which the United States can produce goods and services that satisfy customers in the international marketplace while *simultaneously* improving our real national income.

Another phrase that is getting a lot of use these days is "world-class products." If the U.S. economy does not succeed in producing world-class products, our future will be one of decline. World-class products have the following characteristics: highest quality, advantageous life-cycle cost, modern features, and prompt availability in the marketplace.

Processes involved in the manufacture of world-class products must share these attributes. I think the following examples illustrate the intersections between the expanded NIST mission and this definition of what U.S. industry desperately needs in order to market world-class products.

Quality

Motorola, a 1988 winner of the Malcolm Baldrige National Quality Award, recently did a survey of the quality of U.S.-produced goods and services. The result was disquieting. The usual defect rate, or failure, in U.S.-produced goods and services is about 6,000 per million actions. The level of performance that Motorola and a very few other U.S. companies achieve is more like three defects per million actions, 2,000 times better. This is the level of quality expected of world-class products.

Many companies now are recognizing that quality requires more than advertising—more time, more discipline, more measurements, and a more systematic approach. One encouraging sign to me is the number of U.S. companies that set out to apply for the Malcolm Baldrige National Quality Award, which is managed by NIST, and concluded while studying the application that they were not yet ready to submit to the examination.

Through our discussions with industry, I conclude that the Malcolm Baldrige National Quality Award is meeting its intended purpose, serving both as an incentive and, more impor-

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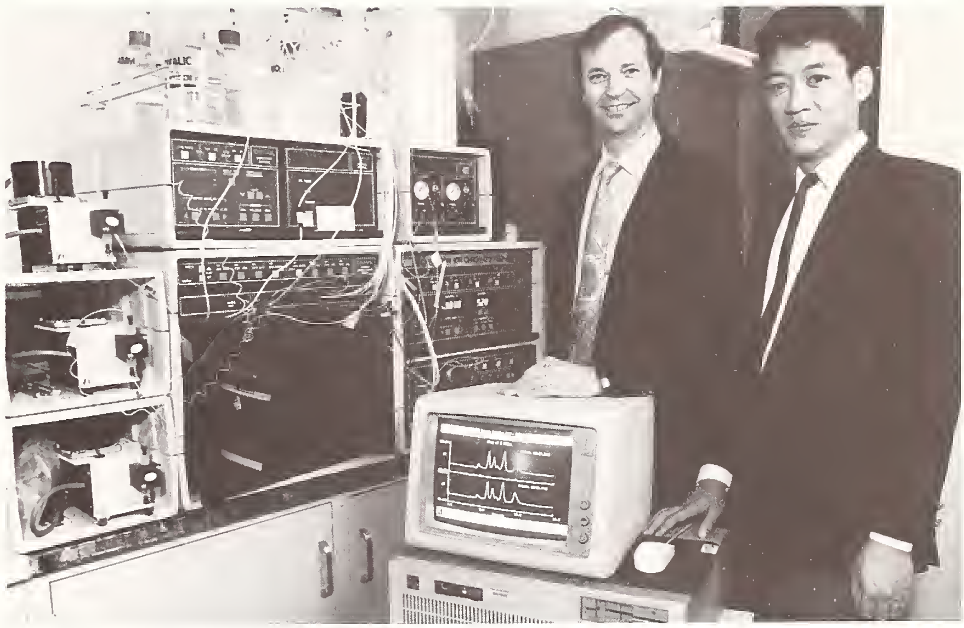
This article was excerpted from testimony given by NIST Acting Director Raymond G. Kammer before the Senate Committee on Commerce, Science, and Transportation on June 6, 1989.

tantly, a source of education on quality for U.S. business. Thousands of businesses are now actively *using* the examination document for self assessment, for initiating quality systems, for communications and comparisons, and as an adjunct to education and training, particularly at the management level.

Measurement

Modern instrumentation and applications have approached the limitations of supporting national standards in a number of technical areas. A timely example, which combines developments in electronics with basic standards and industrial advances, comes in the area of modern voltage standards. To keep the United States competitive with other industrialized countries, NIST is exploiting the technology required to develop superconducting electronics. This program has been so successful that it has produced the world's most accurate voltage standards for voltages up to 12 volts, a voltage range widely used in electronic instrumentation.

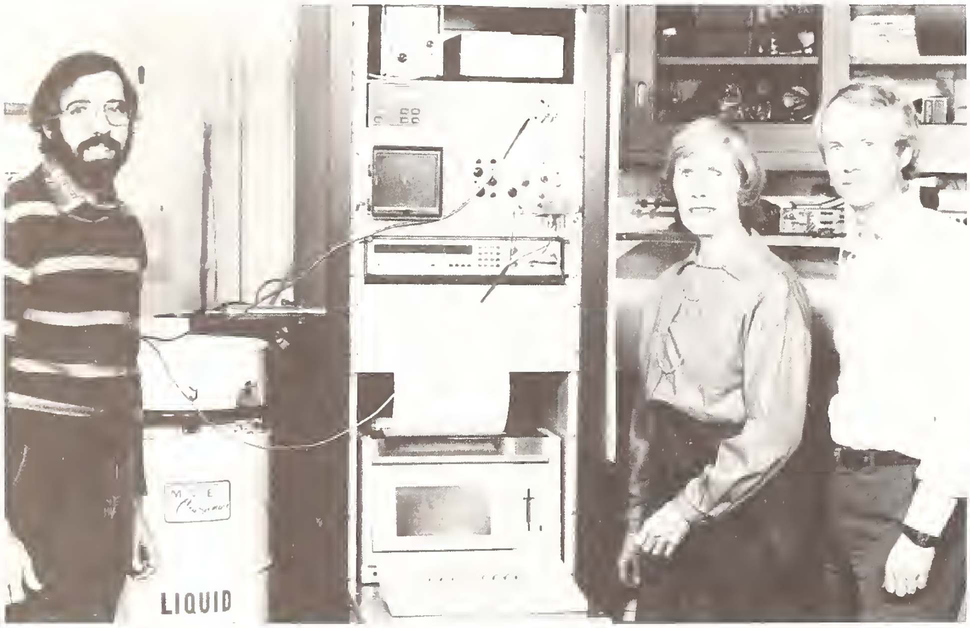
Measurement is also a key element in quality, and the opportunities and needs in measurement science have never been greater. Many of the critical technologies, such as high-temperature superconductivity and semiconductor electronics, can only be exploited through the most exacting applications of measurement science. Many of the required measurement technologies involve, however, industrial and public sector resources of enormous scope and size. This factor, the diversity and nature of the measurement technology, and the speed required to get new technologies to market, all work to ensure that no *single* firm or group of firms has sufficient incentive to produce, maintain, interrelate, and support the measurement methods, reference data, and reference materials underlying a critical industrial technology.



A collaborative effort between NIST and Dionex Corp. resulted in the development of a new generation of a widely used analytical chemistry instrument. H.M. (Skip) Kingston of NIST (left) and Archava Siriraks of Dionex are shown with the chelation ion chromatography system.

Measurement science is critical to the quality of products produced, for example, by the $40 billion per year magnetic recording industry. The density of data storage on magnetic memory devices doubles roughly every 2½ years, and now stands at over 10 million bits per square inch. Higher densities reduce both cost and space, and increase efficiency. To achieve further increases in data storage capacity and improvements in the performance of the read-write heads, and thus in the quality of products, industry must have the ability to visualize the actual size and shape of *individual* magnetic bits. A unique device that can do just that—resolve magnetic microstructures as small as 10 billionths of a meter—was developed at NIST 3 years ago. The device is called a SEMPA, for scanning electron microscope with polarization analysis. SEMPA makes it possible for the first time to map—at the atomic level—the magnetic characteristics of the surface of materials, for example an entire floppy disk. This ability is the key to storing more and more information in less and less space.

The NIST device is so good that industries like Honeywell, Control Data, Westinghouse, and Digital Equipment regularly send their scientists to use the $3,000/day SEMPA facility. In the past year, NIST researchers have assisted Perkin-Elmer to design a commercial version of the instrument; and its clones are now beginning to appear in other laboratories, Stanford and MIT to name but two. The key to advanced magnetic recording devices is the kind of quality in product development that the NIST SEMPA program has helped to ensure.



NIST researchers developed the world's most accurate voltage standard up to 12 volts. Left to right are Richard L. Kautz, Frances L. Lloyd, and Clark Hamilton with an early version of the system.

Technology

A Department of Commerce (DOC) report released in 1987 provided a status and futures assessment of seven of the most critical emerging technologies. These technologies will have an even greater impact on our economic well-being over the next several decades than they have in the past. It is interesting to consider the list of major emerging technologies given in that report: advanced materials, electronics, automation, biotechnology, computing, medical technology, and thin-layer technology. A report as recent as 1987 *did not* include high-temperature superconductors, although its potential emergence was noted in the report. An oversight? No, the report was in fact quite timely. This is just an example of how quickly new technologies can develop, and you may be assured that more surprises are out there waiting for us. This report is currently being reviewed and updated by the Department and NIST. The Secretary specifically charged us with proposing ways in which U.S. industry might be actively engaged to participate in the study.

About 40 to 45 percent of our directly funded research effort is devoted to the major emerging technologies identified in that DOC report. This didn't happen suddenly, of course; it has been a studied reaction to the increasing economic significance of these technologies. The NIST role in the service of emerging technologies is in the pre-competitive, laboratory proof-of-concept stage, when the technology is "generic." A generic technology is a non-product specific technology that is widely used by all firms in a particular industry.

A good example in the area of advanced materials is advanced metals. Conventional production of advanced materials is labor intensive and suffers from high rejection rates of finished products. Intelligent processing is a new computer-controlled approach to producing advanced polymer, ceramic, and metal alloy materials that are far superior to those in use today. The intelligent processing approach is based on the same concepts on which the NIST Advanced Manufacturing Research Facility is built. Continuous computerized monitoring during processing allows quality to be built in, rather than ensured by post-production testing. (See article on page 10.)

We have also been nurturing within the Institute a half-dozen small programs that are developing capabilities for finding, isolating, and manipulating individual atoms and groups of atoms on surfaces and in free space. We have seen "atomic wires" only a few atoms thick (a single human hair is a million atoms thick), a cluster of iron atoms that is perhaps no bigger than a *single* magnetic bit, and embryonic liquids and crystals formed from a handful of atoms. This is measurement science at the frontier—what NIST scientists do best—research that could ultimately have a major impact on several emerging technologies, including electronics and thin-layer technology.

Technology Transfer

The third element of our mission is an expanded effort in technology transfer. We have, for example, selected three organizations to become the first NIST Regional Manufacturing Technology Centers (RMTC's). The goal of these new RMTC's is to assist America's small- and mid-sized manufacturers in becoming more competitive by upgrading the technological skills of their workforce and by adopting modern automated manufacturing technology. This will include, where appropriate, the transfer of technology from NIST's Automated Manufacturing Research Facility.

Technology transfer often means taking measurement techniques off the bench, out of the laboratory, and into the real world. To us at NIST it also means serving as a conduit, convener, and often stimulus to voluntary private-sector standards-setting bodies, helping them to employ the latest technical advances with minimal impediments to manufacture and trade. NIST brings to the table not only technical expertise, but the "third party" objectivity and lack of proprietary interest essential to rapid deployment and acceptance of new advances in science and technology.

Some of the keys to promptness to market, particularly for expensive and intricate components that must work well with other products, are product standards, interface standards, and other agreements and sets of requirements that aggregate a market. The simpler the requirements for a new product, the easier it is to connect with something already out there, the faster it can be designed and produced, and the greater the potential market for it.

PDES, which stands for Product Description Exchange Specification, is an example of how technology, in this case information technology related to the design, maintenance, and use of databases, is transferred to industry. PDES is intended to provide a standard *format* for a repository of measurement data about a product—in digital form—that will govern its entire production cycle. The data will describe such things as geometries (no more blueprints), fit, finish, tolerances, and complete instructions for automated manufacture. PDES is not the data itself, but the specification of the format for the database. A buyer can then, for example, directly communicate his needs electronically to a supplier's manufacturing system. Quality is improved since product fit and tolerances are encoded into computerized specifications. Cost is reduced because process engineering is performed during the design phase, not after, and machine setup is automated. Build time and inventory costs can also be reduced because small lots can be more easily fabricated.

At a much more fundamental level, PDES is an emerging technology that deals with how to represent *all* the required knowledge about the product or process as data that can be stored, manipulated, and interpreted by machines without human manipulation. PDES is a very sophisticated technological enterprise that deals, *in parallel*, with the development of an emerging technology (knowledge representation) and an emerging standard (a data format). The very unusual parallel development of both a generic technology and a standard gives NIST a particularly unique role to play. I am proud to say that the NIST Automated Manufacturing Research Facility is being used as the national testbed for PDES, and that as a result NIST has led the effort to establish the PDES standard.

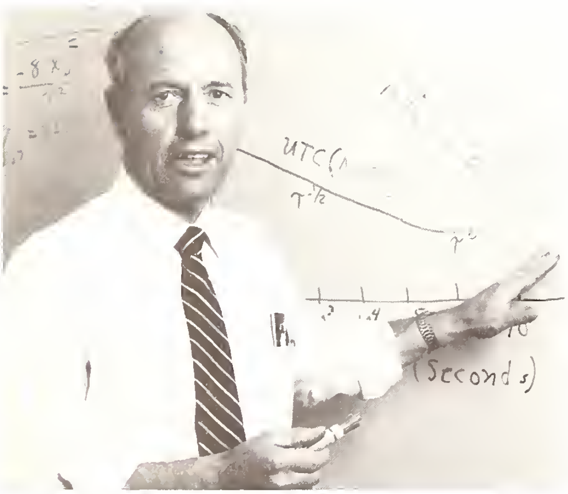
With our new mandate, we can aggressively respond to opportunities presented both by the needs of our society and by the constant flux of exciting developments in science and technology.

Tracking Time

Donald B. Sullivan, chief of NIST's Time and Frequency Division, is fond of leading visitors behind the scenes of his division's operations. One place he takes them is a dimly lighted, musty, underground suite of two rooms. In one room sit two oil-fired generators, and in the other are row upon row of lead-acid storage batteries of the kind used to propel golf carts. These are the backup power systems for the NIST timescale.

"You can let a laser-power or a microwave standard go down for several days and everything is ok. But you can't do that with the clock; it has to operate continuously. That's why I like to take visitors to the battery room, to emphasize this point," says Sullivan.

And just what is it that operates continuously—a round wall clock with well-calibrated ticks? A snazzy digital display that reads out in microseconds?



David W. Allan explains the methods used to measure performance of different clocks and to transfer time worldwide.

Guess again. The "clock" that keeps most of the United States running on time is a piece of paper. A piece of paper??!! That's right, a piece of paper that spits out of a printer in a room chock full of computer equipment. There's not even an old-fashioned wall clock adorning that sterile room.

But, you argue knowingly, doesn't NIST have one of the world's most accurate atomic clocks? Isn't that what is used to set the nation's civilian time?

Well, yes and no. NIST does have one of the world's most accurate clocks (dubbed NBS-6, so named when NIST was the National Bureau of Standards), and it does serve as the basis for the timescale. But here's where we let you in on a little secret. NBS-6 is a 20-foot-long stainless steel tube resting on a huge table. The metallic element cesium is cooked at one end of the tube until it is vaporized and sent rushing down the tube. The vibrations of the cesium atoms are counted electronically and, after more than 9 billion vibrations, 1 second of time has elapsed. Its accuracy is 1 second in 300,000 years. That's how NBS-6 works . . . but NBS-6 hardly works at all.

Because NBS-6 was not designed to operate continuously, it is turned on only about once a year. For most of the time NIST relies on a series—in timekeeping jargon an ensemble—of commercial atomic clocks. There are 12 clocks in all, encased in environmentally controlled metal chambers in a lab room across the hall from NBS-6 and next door to the sterile computers. And that's where the paper comes in. All 12 of the clocks are wired to the computer which every 2 hours asks each clock its time with respect to all the others. The result of this interrogation is a number—or more accurately 12 numbers. These numbers are mathematically and statistically averaged and the result, which can be shown to be more uniform than the best clock in the ensemble, is the official atomic time of NIST. Or is it?

Here's where we let you in on secret number two. There are several timescales. First there is the timescale that is traceable directly to calibrations using

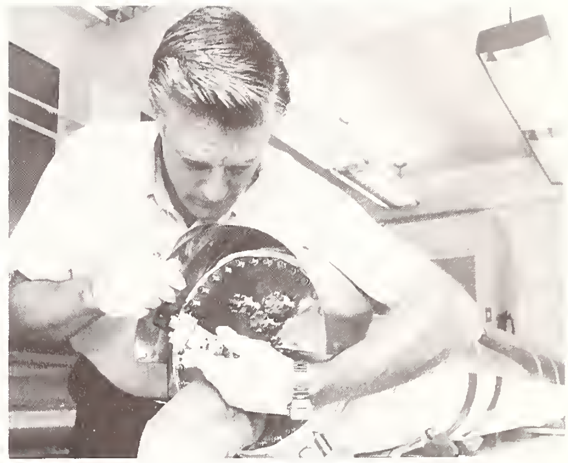
NBS-6—this is termed atomic time, TA(NIST). Then there is the raw time generated by the ensemble of commercial cesium clocks—this is atomic time 1, AT1(NIST). Finally atomic time 1 has added to it or subtracted from it enough time to make it synchronous with the international timescale—this is called universal coordinated time, UTC(NIST).

But wait, there's more. NIST feeds to the International Bureau of Weights and Measures (BIPM) in Paris the readings of its three timescales. BIPM takes the feed from NIST and 39 other contributing countries, averages them, and issues the official universal coordinated time. It is all a paper process; there is no official, physical clock at the BIPM. NIST takes the data from Paris and once a month uses it to correct—or steer—its own UTC(NIST) timescale to conform to the international one. But, strangely enough, by the time NIST receives the Paris data and makes the adjustments for UTC(NIST), as many as 2 months have elapsed. Since most customers don't want to wait 2 months for the official world time, they take the best they can get from NIST, which is usually within one-fourth to one-half of a microsecond of world time.

Who are the people that provide the nation with such accurate time? Before the advent of atomic timekeeping, it was astronomers who had charge of the world's clocks. Today it is mathematicians, physicists, electrical engineers, and computer experts. At NIST, two of the key players are David W. Allan, a physicist and statistician, who has perfected the mathematical formula—or algorithm—that is the basis of the paper clock, and Judah Levine, another physicist who is an expert in computer hardware and software.

According to Levine, the different timescales are driven by the needs of different users. The telecommunications industry, for instance, wants a timescale that is linked to the Earth's rotation or, in Levine's words, a timescale where, at noon, "the sun is overhead." These users receive the NIST version of UTC. A radio astronomy observatory or a frequency counter manufacturer, for example, is interested in atomic time, AT(NIST), because their real requirement is frequency stability. Since AT(NIST), is derived from NBS-6, it provides the best frequency count currently obtainable. "What you want to know is that after 9 billion oscillations of the cesium atom exactly 1 second has elapsed. You're not interested in the time of day," Levine notes, adding that this scale "is most useful for calibrating secondary frequency standards."

It is Levine's job to keep the computer up to the job of maintaining the various timescales. "A monster computer program runs all of these processes. It continually looks at the algorithm and monitors the clocks for their 'health.' It may automatically take one clock off-line if it misbehaves," Levine says. The computer has been known to fail but



Physicist David J. Glaze adjusts NIST's newest atomic clock—NIST-7.

not the clocks. "The software crashes about twice a year and we lose our real time capabilities. We've lost our ability to tell you what time it is but the clocks haven't stopped," Levine adds. When the computer comes back on-line it picks up the count from the continuously operating clocks.

Additionally, one of the cesium clocks has a steered output which is kept within one-half a nanosecond (billionth of a second) of the computed scale. If the computer goes down, this steered clock wanders away from computed time very slowly—on the order of 1 nanosecond per day. NIST's primary time dissemination services are not affected by such computer glitches. Radio stations WWV (Fort Collins, Colo.) and WWVH (Kauai, Hawaii), where most users get their time information, have their own cesium clocks which are coordinated with the time scale but are not disturbed by computer failures; the satellite time service is not affected either.

Levine is currently overseeing a switch of computer systems. The old computer does not have enough data analysis capability and has become costly to maintain. The new computer system is being installed, and both systems will run in parallel for 3 or 4 months until all the bugs are worked out.

Just as important as the computer system is the algorithm that combines the data, makes allowances for errors and biases, and comes up with a paper time. "If you design the algorithm right, you can have a time output that's better than any one clock individually," says Allan, adding, "each time I add information to the system, I know more . . . the sum is better than any one of its parts."

Allan says it almost doesn't matter whether he adds a "good" or a "bad" clock to the system, so long as the performance of the new clock is well known before it is added to the ensemble. The algorithm he has developed assigns weights to each clock in the system, so a clock that is inherently less stable will be assigned a much lower weight. Once part of the ensemble, the clock's performance is carefully monitored for changes over time, and these changes are factored into the formula. Because the paper time output is better than any one of the clocks in the ensemble, a physical clock is adjusted periodically so that it is kept within

NIST Time and Frequency Services

How does NIST disseminate its time and frequency information?

The oldest and most popular service is radio station WWV, near Fort Collins, Colo., which has been broadcasting since 1923. It covers the continental United States and broadcasts at 2.5, 5, 10, 15, and 20 MHz on the short-wave band. A sister station, WWVH, broadcasts to the Pacific basin from Kauai, Hawaii, on all but the 20-MHz frequency. The broadcasts include standard frequencies and time intervals, the time (both voice and digital code), astronomical time corrections, and public service announcements, such as marine weather, geophysical alerts, and radio propagation information. The accuracy of these broadcasts, as received, is between 1 and 10 milliseconds. A telephone time service, which carries the WWV broadcast, is available by dialing 303/499-7111 (a toll call).

Another NIST radio station, WWVB, broadcasts a digital time code at the standard frequency of 60 kHz. Also located near Fort Collins, this low-frequency station, which covers the continental United States, has an accuracy for time comparisons of between 0.1 and 1 millisecond. Its 60-kHz carrier frequency can be used for frequency calibrations with an accuracy of better than 1 part in 100 billion.

NIST also disseminates time code information via satellite, utilizing two National Oceanic and Atmospheric Administration GOES weather satellites. The coverage includes North and South America plus portions of the Atlantic and Pacific oceans. This digital time code is accurate to within 100 microseconds, depending on knowledge of the position of the satellite.

The newest dissemination service, the Automated Computer Time Service (ACTS), which just completed its first year of operation, provides millisecond accuracy for computer clocks and other digital systems using telephone lines. This service includes automatic compensation for telephone-line delay and advanced notices for changes to and from daylight savings time as well as leap seconds.

Who uses these services and why?

One major user is the communications industry. Radio and television stations use WWV and WWVB to maintain accurately their allocated frequencies to comply with Federal Communications Commission regulations. Networks and stations time their broadcasts via WWV, WWVB, or GOES. Telephone companies use the radio stations to set their time-of-day services and to time one-half of a nanosecond of the paper clock. In Allan's terms, the steered clock "chases" the paper clock. "We are virtually unique in that respect," he says, noting that many other countries prefer to have a physical—versus paper—clock as their final timekeeping output. Two nations that have elected to go the paper route and have adopted variant versions of Allan's mathematical formula for their timekeeping systems are Israel and Switzerland. A similar algorithm is being developed by the U.S. Air Force for its own timing purposes.

Can the NIST timescale system be improved? The answer is a resounding "yes!" In the next 2 years, NIST hopes to bring on-line its newest atomic clock—NIST-7—which will replace NBS-6 as the nation's primary standard. NIST-7, which is now in the final stages of construction and testing, will improve long-term stability and frequency uncertainty by tenfold; it will be accurate to 1 second in 3 million years. A cesium clock, it will use laser light instead of magnetic fields for atom state selection. "NIST-7 will run more continuously because it can estimate errors more easily," says Sullivan. This more frequent operation will add more data points to the algorithm for averaging the NIST timescale, making it more accurate and reliable than ever. *F.M.*

long-distance calls. In still another application, the New York City Fire Department uses a commercial WWVB receiver to insert a time code on all of its 911 emergency calls. NIST time and frequency dissemination services are also used to synchronize data transmissions.

The electric power industry is another major user of NIST services obtaining a master time reference for its transmission grid, a frequency reference to maintain accurately the power frequency at 60 hertz, power flow monitoring, fault analysis, and precise characterization of power networks for stability analysis. One power company uses WWVB to synchronize data transmissions from 15 substations that feed data into a central data bank.

The transportation industry depends on NIST to provide a time reference for scheduling railroad operations, as a time base for Federal Aviation Administration voice recorders in airport control towers, for air traffic control operations and analysis, for cockpit flight recorder timing, and for automatic synchronization of traffic light operations. In the latter application, the County of Los Angeles recently purchased 1,000 commercial traffic-light controllers, all of which derive their time from WWV, to regulate traffic flow along busy commuter corridors.

WWV receivers are common on larger ships as part of a timing reference for electronic navigation systems; pleasure boaters also use WWV receivers as a time reference for celestial navigation. The United States Coast Guard uses WWVB receivers on all of its ocean-going ships for frequency and time control.

Other users of NIST time services include oil exploration and drilling companies for position location, private and government calibration laboratories for calibration of various pieces of high-tech equipment, the national space agency for timing of various deep space missions, the music industry for standard musical tones, and law enforcement agencies for the calibration of tuning forks used with radar speed guns. One interesting user of the WWVB service is Walt Disney World in Orlando, Fla., which uses one WWVB receiver to set time for its primary computer system and another to time all of the various shows and animation sequences in the sprawling theme park.

How can I get more information about these NIST services?

For general information about NIST time dissemination services, contact Roger E. Beehler, NIST, Time and Frequency Division, Boulder, CO 80303, 303/497-3281. For software to access the Automated Computer Time Service, contact the Office of Standard Reference Materials, NIST, B311 Chemistry Building, Gaithersburg, MD 20899, 301/975-6776; ask for product RM8101.

Movies Reveal Secrets of Materials

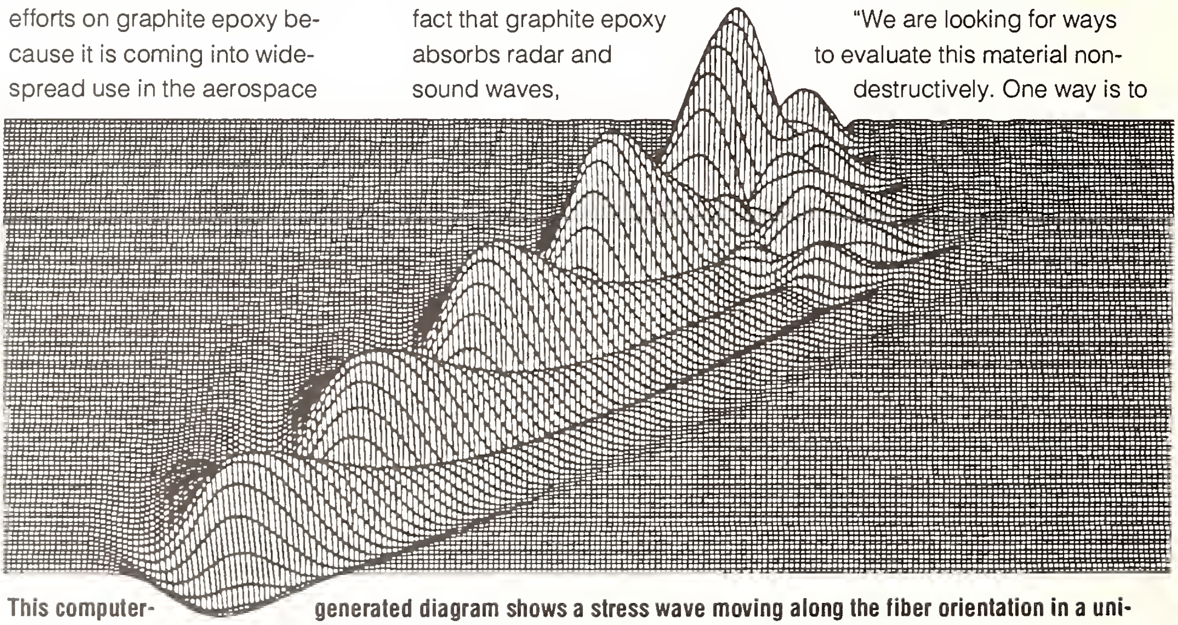
Engineers at the National Institute of Standards and Technology in Boulder, Colo., are in the movie business—but their objective is not to pack in theaters. Using supercomputers and fancy computer-generated graphics that would impress Hollywood, they are trying to understand better how new composite materials—particularly graphite epoxy—stand up under stress and strain.

With sophisticated mathematical modeling techniques, they are able to simulate a stress wave moving through a piece of graphite epoxy and—for the first time—view the progression of this wave in three dimensions from different planes and perspectives.

They are focusing their initial efforts on graphite epoxy because it is coming into widespread use in the aerospace and defense industries. An extremely lightweight but stiff and durable new material, it is used extensively on the Air Force's new stealth bomber, and the Navy is considering using 20-inch-thick layers of graphite epoxy for the hulls of submarines. Of particular interest to the military is the fact that graphite epoxy absorbs radar and sound waves, making the material "invisible" to detection.

Oil companies are also interested in using graphite epoxy for tethers on deep-sea oil-drilling platforms. The tethers need to be stiff to keep the platform stable and strong enough not to break under the tremendous pressure.

"We are looking for ways to evaluate this material nondestructively. One way is to



This computer-generated diagram shows a stress wave moving along the fiber orientation in a unidirectional graphite/epoxy composite. Each of the five humps represents one of the periods of the wave and the ripples coming off of these periods.

put transducers on the material to show how the stress waves propagate through the material," says Ronald D. Kriz, a mechanical engineer in NIST's Fracture and Deformation Division. If graphite epoxy were a clear material, it would be possible physically to see the waves moving through. But because it is opaque, Kriz has had to resort to computer simulation of the stress waves.

Working with John M. Gary of the Scientific Computing Division, Kriz developed a simulated block of graphite epoxy containing 80,100 elements. A sound wave was "passed through" the block, taking almost 3 hours to propagate and using up virtually all the memory of NIST's supercomputer. When the results of the computer simulation were compared with theoretical models, there was a difference of less than 2 percent, giving Kriz and Gary confidence that their method was valid.

More recently, Gary has come up with new numerical techniques that have reduced the time to propagate a wave through the simulated material to 40 seconds and to use much less computer memory.

Using advanced computer graphics, they are able to convert their data into moving representations of the wave passing through the material. "By converting to a movie, we are able to confirm what has been assumed about wave propagation but never visualized before," says Kriz. One pulse sent through the material breaks into two waves—one shear and one longitudinal. Once they reach the edge of the block, they bulge slightly and are reflected back along the same path. One small wave, apparently a reflection, goes off in another direction. "This was not predicted," says Kriz.

Movies give the researchers perspectives that were never available before. The more movies they make and the closer they inspect them, the clearer things become. "The simulation is starting to make sense concerning what we measure in the laboratory," Kriz notes. A little blip in a wave pattern that showed up on a static diagram now can be traced as a break-off wave and followed dynamically through its cycle.

"By converting to a movie, we are able to confirm what has been assumed about wave propagation but never visualized before."

"I never saw the connection between the Rayleigh surface waves and the wakes of the propagating bulk waves before," Kriz says, adding, "I never realized these two phenomena were connected. This simulation clearly shows the connection between these two phenomena."

"The purpose of the simulation is to aid in the design of new nondestructive evaluation (NDE) techniques for these composite materials," Kriz notes. Working with NDE design engineers, Kriz will be able to predict where the sound wave will go, the shape of the wave, and the time it will take to propagate and reflect back. "Before, this was done by trial and error techniques," Kriz says.

In many ways, the NIST researchers are blazing new trails in the way that scientific data are presented. For many portions of their work, videocassette tapes are more important than written reports with static diagrams. They are sharing these tapes with colleagues in the same field of research and have been asked to present their movie results at two conferences: The International Union of Theoretical and Applied Mechanics conference on elastic wave propagation and ultrasonic nondestructive evaluation at the University of Colorado and the Review of Progress in Quantitative Nondestructive Evaluation in Brunswick, Maine.

The next step is to go to a more advanced computer, called a connection machine, which may reduce the processing time to less than a second and enable the block of graphite epoxy to be projected in a three-dimensional, cube perspective. Kriz and Gary also have been working with two Boulder computer graphics companies, Precision Visuals, Inc., and G.W. Hannaway and Associates, to improve the quality of their movies. *F.M.*

Technique Sterilizes Clinical Instruments in Seconds

The time needed to sterilize dental and medical instruments now can be reduced from hours to seconds by an innovative process developed by scientists at the National Institute of Standards and Technology. The new sterilization method completely disinfects instruments in 30 seconds when they are treated by a microwave-generated gas plasma. The gas plasma is produced in a container that holds the contaminated instruments inside a conventional microwave oven.

The technique should help health-care professionals improve patient care, and it may reduce the damage to expensive instruments caused by repeated exposure to time-consuming, traditional sterilization methods.

Two NIST scientists, Waldemar de Rijk, dentist and physicist, and John A. Tesk, leader of the dental and medical materials group, collaborated on the microwave sterilization project.

The scientists have filed a patent application, and de Rijk is working with other researchers to measure how the treating process affects various materials and microorganisms. He also hopes to work with industry to develop a practical sterilizing appliance in which a gas plasma can be used routinely in health-care facilities.

De Rijk says, "We are interested in producing a simple sterilization method that will be as easy to use as a household microwave oven." He emphasizes that the new process offers an

Waldemar de Rijk, front, and John A. Tesk sterilize clinical instruments with their new microwave-generated gas plasma method.

inexpensive and rapid way to sterilize instruments. This is important because some tools are reused more than 10 times each day.

It is estimated there are approximately 80,000 sterilizing apparatuses in dental offices, clinics, hospitals, and other health-care facilities throughout the United States. Most sterilizers are either dry heat or steam autoclave, with the latter being the most common. Both processes take 1½ to 2 hours to complete a sterilization cycle.

Continued heat sterilization can take its toll on equipment. The rubber seals and gaskets in most dental handpieces fail when exposed to dry heat at temperatures of 160 to 170 °C. Repeated steam-autoclave exposure at temperatures of 120 °C or more can dull the cutting edges of dental metal burs used for cavity preparation. These high temperatures also can anneal metal instruments, changing their strength and hardness.

Despite these shortcomings, De Rijk says the detrimental effects from high-temperature processes are preferred over alternative cold chemical treatments which may not destroy all of the microbial spores and viruses on instruments.

In addition to conventional sterilization methods, gas plasmas generated by radio-frequency electromagnetic waves also have been used to destroy organic matter on mirror-smooth surfaces. Tesk and de Rijk decided to investigate microwave technology because it could be more effective and easier to adapt for health-care use.

But first the scientists had to find a way to treat metal instruments in a microwave unit without the severe arcing that can damage the magnetron energy source in the appliance. The problem was solved by placing metal instruments in a glass container inside a microwave oven and then evacuating the air in the container to create a low vacuum or a rarified atmosphere. When microwaves are applied, the atmosphere is ignited and becomes a low-pressure ionized gas that destroys the microorganisms. The gas plasma prevents the electric arcing of metal objects.

Initial trials show it is the gas plasma that kills all of the organisms on artificially contaminated instruments.

The scientists found that both metal and nonmetallic instruments can be sterilized by the new microwave process. De Rijk points out that even after 1 minute of exposure, the surfaces of the instruments are heated to no more than 60 °C, a temperature much lower than conventional heat processes. "We are speculating that the microorganisms are being killed by ion bombardment in the plasma which 'denatures' or destroys their protein," says de Rijk. Other explanations are being investigated.

Initial trials show it is the gas plasma that kills all of the organisms on artificially contaminated instruments. Previous experiments with test strips with microbial spores and contaminated instruments revealed that organisms can survive microwave radiation alone or in a vacuum without the radiation. Both are required to produce the gas plasma. Biological studies on test spore strips and contaminated instruments are being conducted for NIST by Lance L. Forsythe and Mark D. Gilberts of the U.S. Naval Dental School in Bethesda, Md.

Tesk says, "The new microwave radiation sterilization method for dental and medical instruments is an example of how our research can improve the safe, efficient, and economical use of dental and medical materials and instruments to benefit consumers and health-care professionals."

The NIST microwave radiation research project is supported in part by the National Institute of Dental Research (NIDR), one of the National Institutes of Health, a primary sponsor of dental research and related training in the United States.

For information on the microwave-generated gas plasma sterilization process, contact: John A. Tesk, NIST, A143 Polymer Bldg., Gaithersburg, MD 20899, 301/975-6801. *R.R.*

Can Smoke Control Systems Save Lives and Property?

Smoke is a killer. Just minutes after most fires start, it can be moving steadily through a building, clogging stairwells and hallways, cutting off escape routes, and inhibiting fire fighting. Each year, fires in the United States take nearly 6,000 lives. Yet, contrary to what people might think, these deaths are not all caused by fire and flame. Data compiled by the National Center for Health Statistics indicate that smoke inhalation deaths exceed burn deaths by a margin of roughly two to one.

In theory, smoke control systems can protect life and property by producing pressure differences across barriers, such as walls, floors, ceilings, and interior partitions of the building, to restrict smoke movement and direct it away from the inhabitants. However, the technology is relatively young and is based primarily on engineering principles and judgment. To be sure the systems really protect building occupants from deadly fumes, NIST researchers conducted the first known full-scale tests in the United States of these systems. "The theory is they will work," says mechanical engineer John Klote, head of the research project at the NIST Center for Fire Research. "But the reality is they've never been tested under full-scale conditions either in a simulated situation, such as we've done, or during a real-life fire," he said.

The NIST tests were conducted in the former Plaza Hotel, a seven-story building in Washington, D.C., which is scheduled for demolition. The researchers burned stacks of wood placed in a second-floor room to simulate a fully involved fire in a furnished room. Using large fans and ducts, the floors above and below the fire floor and the stairwell were pressurized. This helped confine the smoke to the fire floor from which it was exhausted to the outside. Much of the air-handling equipment used for this project was loaned to NIST by the Air Movement and Control Association, Inc. Other groups sponsoring this research were the Architect of the Capitol; American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.; Bell Atlantic Telephone Company; New Jersey Bell Telephone Company; U.S. Fire Administration; U.S. Veterans Administration; and US West, Inc.

. . . NIST researchers conducted the first known full-scale tests in the United States of these systems.

For the course of the NIST experiments, the building was fitted with instruments—video cameras, thermocouples, and smoke meters—to trace the flow of smoke and measure its composition, density, and temperature. Natural ventilation flows in the building, which can cause smoke to move up or down stairwells and elevator shafts, were examined. The fire itself was monitored to determine its heat output and rate of fuel consumption. In addition, in one experiment, the NIST researchers examined the effect of a sprinkler on the fire and smoke spread when the smoke control system was in operation. All of these measurements were recorded on a data acquisition computer, and video recordings documented events at key locations.

NIST's research results will be used to evaluate current guidelines for smoke control systems, including those developed in 1983 by NIST in conjunction with

Located on the first floor of the hotel was the data acquisition computer where John Klote (standing), Richard Zile (seated left), and Darren Lowe monitored events during the fire.

the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. The information also will be used to develop and validate computer models and to determine whether small-scale physical models can predict accurately the behavior of a full-scale system in a building.

The computer models are being developed by the NIST Center for Fire Research to predict fire and smoke movement through a building and the vulnerability of occupants to fire. These models make it possible to duplicate, within a limited budget, real fire situations. It is far less costly and far more practical to "burn" a room or building using a computer. Several models are available and can be used on personal computers. The NIST Fire Simulation Laboratory gives the fire protection community, as well as architects, codes officials, and others, the opportunity to learn about these models and obtain "hands-on" experience.

The NIST Center for Fire Research investigates the scientific principles that govern the phenomena of fire, providing knowledge for fire safety; develops the underlying technical support for new safety standards; and generates the engineering methods needed to support the practice of fire protection engineering.

NIST's research results will be used to evaluate current guidelines for smoke control systems. . . .

NIST scientists and engineers conduct research on how fires start and spread and how they can be detected and suppressed. This research leads to realistic material test methods, cost-effective fire safety design concepts, and new methods of fire control and extinguishment. Some of the research being conducted at NIST includes studies on the physics and chemistry of fire, flame spread, sprinkler systems, the lethal effects of smoke, and the heat given off by furniture and wall coverings.

NIST does not promulgate or enforce standards or regulations. It provides technical support to voluntary standards and model codes groups, the engineering and design community, the building industry, fire services, and fire protection organizations. It also provides scientifically based recommendations to other government agencies that have fire safety or regulatory responsibility. *J.K.*

New Publications

1989 Directory of NVLAP Accredited Laboratories

Donaldson, J.L. and Horlick, J., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4056, 56 pages (April 1989). Order by stock no. PB 89-189278 from NTIS, $15.95 prepaid.

About 200 labs nationwide and abroad are listed here that are accredited by NIST for specific test methods in various fields of testing as of April 1, 1989. The current fields are acoustics; carpet; commercial products—paint, paper, plastic, and seals and sealants; computer protocols; construction testing services—concrete, cement, aggregates, soil and rock, admixtures, geotextiles, road and paving; personnel radiation dosimetry; electromagnetic compatibility and telecommunications; solid fuel room heaters; and thermal insulation. The labs are listed alphabetically by name, field of testing, and state. For information on NVLAP programs, including the new bulk asbestos analysis program, contact: National Voluntary Laboratory Accreditation, NIST, A124 Bldg. 411, Gaithersburg, MD 20899, 301/975-4016.

The Effect of Chinese Standardization on U.S. Export Opportunities

Lin, Y., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 88-4000, 15 pages (December 1988). Order by stock no. PB 89-166128/AS from NTIS, $6.95 prepaid.

Technical information exchange programs between the U.S. and the People's Republic of China (PRC) and more U.S. trade missions to China will encourage the adoption of U.S. standards as well as increase trade between the two countries," says Yan Lin, NIST guest scientist, in this publication. Lin, from the China Electronics Standardization Institute, describes for U.S. electronics manufacturers and exporters the standardization system as it exists in the PRC and reports on the role of the China State Bureau of Standards in the standards coordination process. "U.S. trade missions can expect great success if the Chinese government agencies concerned with major joint venture projects are shown that solutions to their major problems and expertise suiting their interests are available from U.S. companies," says Lin. Information on the impact of China's quality program on U.S. export opportunities also is included.

Theory and Measurements of Radiated Emissions Using a TEM Cell

Koepke, G.H., Ma, M.T., and Bensema, W.D., Natl. Inst. Stand. & Tech. (U.S.), NIST Tech. Note 1326, 40 pages (January 1989). Order by stock no. 003-003-02932-7 from GPO, $2.25 prepaid.

Transverse electromagnetic (TEM) cells are used widely for establishing a known electromagnetic field for susceptibility testing and antenna calibrations. This publication offers theoretical information and some practical tips for using TEM cells. The report addresses mechanical requirements for positioning the test equipment inside the cell, problems associated with cables, single- and multi-frequency measurements, and use of a computer system for automated measurements.

Stable Implementation Agreements for Open Systems Interconnection Protocols

Boland, T., editor, Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 500-162, 508 pages (December 1988). Order by stock no. 003-003-02921-1 from GPO, $26 prepaid.

The second version of stable implementation specifications for OSI (Open Systems Interconnection) protocols has been agreed to and is available. These agreements are based on recognized international OSI standards and were reached by vendors and users participating in the NIST Workshop for Implementors of OSI. They support the second version of the Federal Information Processing Standard for GOSIP (Government Open Systems Interconnection Profile), which is expected to be proposed later this year. The agreements are considered advanced enough for use in product and test suite development.

NBS Reactor: Summary of Activities—July 1987 through June 1988

O'Connor, C., editor, Natl. Inst. Stand. & Tech. (U.S.), NIST Tech. Note 1257, 227 pages (January 1989). Order by stock no. 003-003-02920-3 from GPO.

The National Institute of Standards and Technology (formerly National Bureau of Standards) reactor serves the needs of NIST, other government agencies, and outside organizations as a national center for the application of neutron methods to problems of national interest. Operating at 20 MW, the Institute's reactor supports 25 experimental facilities, ranging from intense neutron beams to extensive irradiation facilities. A major expansion of the experimental facilities is currently under way. A cold neutron source has been installed, and construction of a large neutron guide hall is completed. The guide hall will accommodate 15 new instruments. This will be a national facility providing state-of-the-art instruments that are currently unavailable in the United States.

This report summarizes work accomplished in the period July 1987 through June 1988. The programs cited 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, neutron radiography, and nondestructive evaluation.

GATT Standards Code Activities of the National Institute of Standards and Technology 1988

Overman, J.R., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4074, 38 pages (March 1989). Order by sending a self-addressed mailing label to the Office of Standards Code and Information, NIST, A629 Administration Bldg., Gaithersburg, MD 20899, 301/975-4037.

The NIST Office of Standards Code and Information (SCI) serves as the U.S. GATT (General Agreement on Tariffs and Trade) inquiry point for information on standards and certification activities that might significantly affect U.S. trade. This publication describes SCI's activities over the past year. These include coordination of comments on foreign regulations, translations of foreign texts, and the operation of the GATT "hotline" (301/975-4041, not toll free) that provides the latest information on notifications of proposed foreign regulations issued by the GATT Secretariat in Geneva, Switzerland. SCI also provides technical assistance to the Office of the U.S. Trade Representative in developing proposals to enhance the Standards Code. Special reports include the recent summary of European Community plans to achieve an internal market by 1992 and the standards-related implications of such a program on U.S. exports.

Description of the SRM 1965 Microsphere Slide

Hartman, A.W. and McKenzie, R.L., Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 260-107, 67 pages (November 1988). Order by stock no. 003-003-02911-4 from GPO, $3.75 prepaid.

A series of microscope experiments for students is described in this report on the construction, preparation, and recommended uses of Standard Reference Material (SRM) 1965, Microsphere Slide, 10-Micrometer Polystyrene Spheres. The SRM is a microscope slide with the first commercial product made in space—the 10-micrometer polystyrene spheres—deposited on it. The SRM is an education tool as well as a standard to calibrate microscopes for small particle measurements. The spheres are arranged in two types of groupings. One is an "unordered" arrangement, resembling strings of beads. The other grouping is an "ordered" two-dimensional hexagonal array for use as a microlength standard and to act as a "stage" micrometer.

Center for Radiation Research—1988 Technical Activities

Kuyatt, C.E., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 88-3869, 261 pages (November 1988). Order from the Center for Radiation Research, NIST, C229 Radiation Research Bldg., Gaithersburg, MD 20899, 301/975-6090.

Interaction of radiation with matter cuts a broad swath across science and technology, with applications—or implications—in the development of advanced materials, electronic components and technology, biotechnology, thin-layer technology, and medical technology. A report from NIST details the agency's 1988 research activities in all these areas, as well as in the more fundamental task of making and providing accurate measurements across the optical and ionizing radiation spectrum. The report summarizes the technical activities of the five major divisions in the NIST Center for Radiation Research as well as consultation services, participation on technical and professional committees, invited talks, and technical publications.

An Electrochemical Technique for Rapidly Evaluating Protective Coatings on Metals

Lin, C. and Nguyen T., Natl. Inst. Stand. & Tech. (U.S.), NIST Tech. Note 1253, 23 pages (October 1988). Order by stock no. 003-003-02910-6 from GPO, $1.50 prepaid.

NIST researchers have developed a fast, reliable technique for evaluating the performance of organic coatings used for controlling metallic corrosion. In addition to being a threat to the safety and reliability of structures and products, metallic corrosion annually costs the United States an estimated $160 billion. About one-fourth of this cost is for paints, platings, or other surface coatings used to combat corrosion. While other evaluation methods are available, they often are time consuming, sometimes taking months, or may require expensive equipment. The new NIST electrochemical technique is quick (15 minutes to several hours depending on the coating), reproducible, and causes very little perturbation to the coating. In addition, the testing procedure is simple and uses commonly available instrumentation.

Ordering Information

To order publications from NTIS, send request with payment to: National Technical Information Service, Springfield, VA 22161. Publications can be ordered from GPO by mailing the order with payment to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Conference Calendar

September 19–21, 1989

12th International Symposium on Polynuclear Aromatic Hydrocarbons

NIST, Gaithersburg, MD

The major focal point for multidisciplinary research on this important class of chemical species, this symposium encourages open discussions among scientists representing government, academic institutions, industry, and research facilities investigating the chemical properties and biological effects of these compounds. The 1989 meeting will include presentations on parent hydrocarbon PAH's as well as heteroatomic species and PAH derivatives including amino, nitro, and halogen substituted compounds. Topics include adducts, bioactivity, carcinogenesis, mutagenicity, cell transformation, detoxification, epidemiology, pollution modeling, occupational exposure, organic synthesis, and environmental studies. Sponsored by NIST, the National Institutes of Health, and Battelle Memorial Institute. Contact: Willie E. May, NIST, A113 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-3108.

October 2–6, 1989

Atomic Processes in Plasmas

NIST, Gaithersburg, MD

Among the subjects to be discussed at this biennial meeting of international experts are atomic processes relevant to plasma applications, such as material processing by plasmas, x-ray lasers, fusion, and astrophysics. This conference combines the series previously known as the APS Topical Conference on Atomic Processes in High-Temperature Plasmas with the International Conference/Workshop on the Radiative Properties of Hot Dense Matter. Sponsored by the American Physical Society, the Department of Energy, and NIST. Contact: Yong-Ki Kim, NIST, A267 Physics Bldg., Gaithersburg, MD 20899, 301/975-3203.

October 10–13, 1989

12th Computer Security Conference—Information Systems Security: Solutions for Today, Concepts for Tomorrow

Baltimore Convention Center, Baltimore, MD

This conference provides a forum for the government and private sector to share information technologies, present and future, that are designed to meet the ever-growing challenge of telecommunications and automated information systems security. The conference will offer multiple tracks for the needs of users, vendors, and the research and development communities. Topics will include: systems application guidance, security education and training, evaluation and certification, innovations and new products, management and administration, and disaster prevention and recovery. Sponsored by NIST and the National Computer Security Center. Contact: Irene Gilbert, NIST, A254 Technology Bldg., Gaithersburg, MD 20899, 301/975-3360.

November 20–22, 1989

Reducing the Cost of Space Infrastructure and Operations

NIST, Gaithersburg, MD

Entrepreneurs at this conference will discuss methods of reducing the cost of commercial enterprise in low-Earth orbit. The great cost of space infrastructure and operations is presently limiting the extent of commercial participation in space activities. Meanwhile, the private sector is being urged to make major investments in space activities while working to reduce launch fabrication and operations costs. In order to develop recommendations on future industrial activity in low-Earth orbit, this conference will consist of keynote presentations on major topical areas and a follow-up workshop in each area. A draft report on each workshop will be presented at the end of the conference. Sponsored by NIST and the Office of Space Commerce of the Department of Commerce. Contact: William Stone, NIST, B168 Building Research Bldg., Gaithersburg, MD 20899, 301/975-6075.

February 5–8, 1990

Fourth International Symposium on Biological and Environmental Reference Materials—BERM-4

Sonesta Village Hotel, Orlando, FL

The major aim of these symposia, held approximately every 2 years, is to bring together efforts in the production, study, and use of reference materials in the analytical, biological, biomedical, clinical, environmental, and nutritional communities. The third symposium, held in May 1988 in Bayreuth, Bavaria, FRG, provided an opportunity for attendees to exchange ideas and views on a variety of topics. This fourth symposium is expected to broaden these discussions as well as focus on more specific aspects of future research on problems and projects discussed at the previous symposia. Sponsored by the Department of Agriculture, the Department of Commerce, NIST, and the Food and Drug Administration. Contact: Wayne R. Wolf, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-2030.

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