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NIOSH

REPORT ON OCCUPATIONAL SAFETY AND HEALTH FOR FISCAL YEAR 1990

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

REPORT ON

Occupational Safety and Health for fiscal year 1990

Prepared by the
National Institute for Occupational Safety and Health

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EXECUTIVE SUMMARY

Fiscal Year 1990 marked the twentieth year of the signing of the Occupational Safety and Health Act of 1970. With this law, the Nation launched a new era in federal leadership in prevention of occupational illnesses and injuries. The old proverb, an ounce of prevention is worth a pound of cure, is most appropriate when describing sound and effective public health practice. Americans are still dying from diseases and injuries which are completely preventable, such as heart disease, lung cancer, and injuries. In the twenty years of developing leadership in the field of occupational safety and health, NIOSH has focused on the prevention of diseases and injuries that result from exposures to hazards found in the workplace. In 1985 and 1986, NIOSH identified the ten leading occupational illnesses and injuries, and developed strategies for preventing them. Since then, NIOSH has directed efforts in surveillance, research, and intervention to carry out these prevention strategies. In the 1980's, NIOSH along with the rest of the Nation, faced the new challenges that arose from potential exposures to the human immunodeficiency virus. Most recently, NIOSH has expanded its scope to target illnesses and injuries that are present in two high-risk occupations: agriculture and construction. The following activities were some of the most significant in the Institute s effort in FY 1990 toward prevention in the field of occupational safety and health.

Agriculture Program - During FY 1990, NIOSH initiated work on surveillance, research, and intervention in agriculture, one of the most dangerous occupations in terms of risk of traumatic injury and to certain cancers. NIOSH cooperative agreements were begun in Farm Family Health and Hazard Surveillance; Occupational Health and Safety Surveillance through Health Departments and Nurses in Agricultural Communities; Demonstration Cancer Control Projects for Farmers; Agricultural Health Promotion Systems; and Centers for Agricultural Research, Education, and Disease and Injury Prevention. NIOSH agriculture research will be conducted by agricultural land grant universities, state health departments, and agricultural extension services. Agricultural programs are discussed on page 33 of this Report.

Construction Program - NIOSH provided assistance for the identification and evaluation of occupational health risks to construction workers. Researchers analyzed the 1984-86 NIOSH occupational mortality surveillance data for the proportionate mortality patterns of construction workers in special trades. Results show that several site-specific cancers and other chronic disease statistics were significantly elevated for 61,682 white male construction workers. Men younger than age 65 had significantly elevated proportionate mortality ratios for cancer, asbestos-related diseases, mental disorders, alcoholism, digestive diseases, falls, poisonings, industrial fatalities, and homicides. NIOSH published a report describing findings from an assessment of interventions for safeguarding construction workers from potentially hazardous exposures and health problems in the *Scandinavian Journal of Work and Environmental Health*. The Construction Program is discussed on page 35 of this Report.

Methods for Evaluating Reproductive Risks from Workplace Toxicants - Workplace exposures to chemical and physical agents have significant potential for harming reproductive functions of both men and women. NIOSH has developed methods for studying hazards to male reproductive systems, including longitudinal studies of men for sperm profiling, and methods for adapting fertility indicators for assessing health effects for workplace exposures in women. These methods are described on page 26 of the Report.

Toluene Diisocyanate and Toluenediamine - NIOSH published a Current Intelligence Bulletin (CIB) that describes recent studies demonstrating the carcinogenic effects of toluene diisocyanate (TDI) and toluenediamine (TDA). Occupational exposure to TDI and TDA occurs in the manufacture of flexible polyurethane foams, sealants, and adhesives. Because of the carcinogenic effects, NIOSH produced guidelines for minimizing occupational exposures to these chemicals during manufacturing processes. This CIB is discussed on page 51 of this Report.

Bladder Cancer in Workers - *ortho*-toluidine and aniline are aromatic amines used as intermediates in the manufacture of dyes and other products. NIOSH studied bladder cancer incidence among 1,749 workers at a chemical plant that used *o*-toluidine and aniline in one department, and found that among 708 workers assigned to that department, there were 7 cases of bladder cancer, a risk six times greater than would be found in an unexposed population. Maintenance and janitorial workers at the plant were 3.7 times more likely to develop bladder cancer than individuals in an unexposed population. NIOSH notified the company and union of these results, and sent notification letters to individual workers. NIOSH also provided the company with recommendations for reducing potential exposure to *o*-toluidine and aniline. This study is discussed on page 17 of this Report.

Preventing Electrocutions and Electrical-related Injuries - Electrocution is one of the leading causes of traumatic occupational fatalities. NIOSH data show that overhead powerlines are a frequent source of electrical energy that causes worker fatalities. In investigating deaths caused by electrocution, NIOSH traveled to Puerto Rico where more than five workers were killed while restoring power after Hurricane Hugo. After conducting these investigations, NIOSH prepared an Alert on the cause of these electrocutions which was disseminated in both English and Spanish. This investigation is described on page 22 of the Report.

Manual of Analytical Methods - NIOSH published a new supplement to the *NIOSH Manual of Analytical Methods*, and has prepared a new supplement for publication that brings the total number of methods to 262, covering 476 toxic substances. Over 7,000 national and international requests have been received for the Manual, which is used in NIOSH studies as well as control technology assessments and epidemiologic investigations. The Manual is discussed on page 50 of this report.

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INTRODUCTION

The history of the National Institute for Occupational Safety and Health began in 1798, when the fifth Congress of the United States established the Marine Hospital Service for merchant seamen, the first government service intended to protect the health of workers. This agency was later to become what is today the U.S. Public Health Service. In 1914, the Office of Industrial Hygiene and Sanitation was established for preventing injury and illness among workers. This Office underwent several changes throughout the decades that followed, and in 1970, was transformed by the Occupational Safety and Health Act of 1970 (PL 91-596) to become the National Institute for Occupational Safety and Health (NIOSH), and placed in the Department of Health, Education, and Welfare (now Health and Human Services). In 1973, NIOSH became part of the Centers for Disease Control (CDC), the nation s agency for the prevention of injury and disease, and for the promotion of healthy lifestyles.

The OSHAct Public Law 91-596 was passed December 29, 1970, to assure safe and healthful working conditions for working men and women...by providing for research, information, education, and training in the field of occupational safety and health. NIOSH conducts numerous activities pursuant to this Act. Foremost among these is NIOSH research and development of methods for dealing with occupational safety and health problems. NIOSH also produces criteria for toxic substances and physical agents, and develops ways to discover latent disease and establish casual relationships between work conditions and diseases and injuries. Upon written request NIOSH determines whether a given substance has potentially toxic effects in the concentrations normally found in the workplace, and conducts and publishes industry-wide studies on the potential health effects resulting from exposures to industrial materials, processes, and stresses. To prepare people for service in occupational safety and health, NIOSH serves as a principal focus for training programs. To aid in the recognition of potentially hazardous substances, NIOSH publishes an annual list of all known toxic substances and the concentrations at which such toxicity is known to occur. NIOSH also develops and coordinates appropriate reporting procedures to describe the nature of national occupational safety and health problems. NIOSH consults with and provides recommendations to the Department of Labor, as well as other Federal, state, and local government agencies; industry and employee organizations; and other appropriate individuals and organizations to promote occupational safety and health.

In addition to the Occupational Safety and Health Act, NIOSH has legislative mandates under the Federal Mine Safety and Health Act and the Public Health Service Act. To protect the safety and health of miners, NIOSH surveys toxic substances and hazardous physical agents in mines and recommends worker exposure limits to the Mine Safety and Health Administration (MSHA), in the Department of Labor; administers the x-ray surveillance program for coal miners; and tests and certifies respirators and coal mine dust measuring devices.

NIOSH also carries out responsibilities under the Toxic Substances Control Act, the Superfund Amendments and Reauthorization Act (SARA), and has been charged with various tasks under other legislation.

OSHA and NIOSH The Occupational Safety and Health Act also mandated that the Occupational Safety and Health Administration be established as a regulatory agency within the Department of Labor (DOL) to promulgate and enforce standards for occupational safety and health, investigate suspected violation of standards, and provide consultation and training services for employers and employees. Whereas NIOSH's responsibility lies in conducting research and forwarding occupational safety and health standards to the Secretary of Labor, OSHA prescribes regulations for safety in workplaces and carries out inspections and investigations to determine whether these standards are upheld.

Prevention Strategies To help establish research priorities, NIOSH developed a list of ten leading work-related diseases and injuries

and proposed strategies to prevent each of them. NIOSH invited leading experts to improve and elaborate on these strategies at two national symposia held in 1985 and 1986.

The ten leading Work-Related Diseases and Injuries in the United States are:

- Occupational Lung Diseases
- Musculoskeletal Injuries
- Occupational Cancers
- Severe Occupational Traumatic Injuries
- Occupational Cardiovascular Diseases
- Disorders of Reproduction
- Neurotoxic Disorders
- Noise-Induced Hearing Loss
- Dermatological Conditions
- Psychological Disorders

These strategies define the nature of each problem, describe preventive measures that can be taken now, and identify needs for additional knowledge. Common themes in the strategies include: surveillance of hazards and health effects; identification of research needs; definitions and diagnoses of certain conditions; and developing control measures.

Organization of the Institute To address health and safety problems for America's workers, NIOSH coordinates the efforts of a variety of trained scientists: physicians, nurses, industrial hygienists, epidemiologists, toxicologists, chemists, physicists, engineers with various specialties, behavioral scientists, ergonomists, psychologists, and sociologists, as well as statisticians, educational specialists, and writers.

The Office of the Director for the Institute is supported by an Office of Program Planning and Evaluation; an Office of Administrative and Management Services; and a Grants Program Activity, all located in the CDC facility in Atlanta, Georgia; and by a liaison office in Washington, D.C.

The Institute also has seven divisions, two in Morgantown, West Virginia, and five in Cincinnati, Ohio. NIOSH industrial hygienists are assigned to regional offices that serve the U.S. Public Health Service in Atlanta, Boston, and Denver.

Division of Biomedical and Behavioral Science (DBBS)

DBBS conducts research via both laboratory and worksite investigations focused on toxicology, stress, ergonomics, and the effects of physical agents.

The Division's toxicology program emphasizes the development and evaluation of sensitive methods for assessing adverse effects of workplace exposures to reproductive and neurotoxic hazards; development of methods for biological monitoring to evaluate exposures to workplace chemicals; and studies of factors that affect toxicity in the workplace such as combination exposures, percutaneous absorption, and physical activity. Additional research is directed at cardiotoxic hazards and animal studies of early developmental disorders in offspring of exposed parents.

Stress research involves investigations of job demands and workplace conditions that produce emotional and mental strains and related psychological disorders. Current studies are directed at the impact of new technology, the development of methods to rate job stress and strain, and the evaluation of worksite stress reduction efforts.

Ergonomics research in DBBS is concerned with techniques for limiting overexertion hazards in lifting jobs and injuries of the upper and lower limbs due to poor tool design, work station layout, or tasks that call for repetitive, forceful movements. Recent studies in several industries have provided NIOSH with much information about ways to prevent cumulative trauma disorders.

Research on physical agents evaluates occupational hazards posed by noise, heat, vibration, and nonionizing radiation. Improved instrumentation and methodologies for the evaluation of occupational hazards resulting from worker exposures to physical agents are being developed.

Division of Physical Sciences and Engineering (DPSE)

DPSE conducts worksite and laboratory research to develop procedures and equipment for the control and measurement of occupational health hazards. It also provides analytical support for the Institute's research efforts and operates a quality control reference program for industrial hygiene laboratories.

The control technology program is designed to arrest occupational disease and injury by assisting employers, especially smaller businesses, in better design and operation of the workplace. This work involves identification and evaluation of effective engineering controls used in a variety of processes and industries. The division promotes the transfer and wide-spread application of these preventive engineering control measures.

DPSE also conducts research to develop and improve methods for analysis of toxic substances and to establish performance requirements for direct reading, area, and personal instrumentation used in the evaluation of exposures to hazardous levels of chemical and physical agents.

The quality of the nation's analytical data on workplace environments is assessed through the NIOSH Proficiency Analytical Testing (PAT) program. DPSE and the American Industrial Hygiene Association determine the analytical competence of participating laboratories, and assist those laboratories in improving analytical performance.

DPSE also encourages and supports development and promulgation of national guidelines for accreditation of industrial hygiene laboratory facilities; selects and develops standard reference materials for use in the measurement of industrial hygiene hazards; and provides quality assurance in the analysis of the Institute's laboratory and field programs and contract laboratories.

DPSE provides analytical chemistry support to the Institute s laboratory research and field investigation programs, including routine measurement of samples by established methods, special measurement of complex samples, and short-term development of methods by using state-of-the-art analytical instrumentation.

Division of Respiratory Diseases Studies (DRDS)

DRDS is the Institute's focal point for epidemiological research on occupational respiratory diseases. The division designs, conducts, and interprets cross-sectional and prospective morbidity and mortality studies of occupational respiratory disease. Field studies, including a health hazard evaluations program for mines, with industrial hygiene, epidemiology and medical components, are conducted at mines, mills, and other industrial plants where respiratory diseases may occur.

Research is conducted on immunological mechanisms and cell biology and physiology, including the role of microbiological organisms, the effects of environmental exposure associated with occupational respiratory diseases, and to identify factors associated with early detection of disease.

DRDS plans, coordinates, records results, and prepares notifications of medical examinations mandated under the Federal Mine Safety and Health Amendments Act of 1977, and operates a certification program for medical facilities and physicians who participate in the examination program. DRDS evaluates and approves employer programs for the examination of employees in accordance with published regulations and arranges for the examination of employees who work at locations not having an approved examination program. The division also conducts the National Coal Workers Autopsy Program and performs research into the post-mortem identification and quantification of occupational respiratory exposures.

Division of Safety Research (DSR)

DSR is responsible for the safety research program aimed at preventing traumatic injury and death. DSR conducts laboratory and worksite studies to establish methods for minimizing workers risk to injury and disease. These methods include the use of personal protective equipment, work practices, managerial approaches, and engineering controls.

The division maintains various national surveillance data bases for detecting and monitoring the frequency of injuries in occupational settings, for risk assessment, for establishing research priori-

ties, and for identifying problems for the occupational safety and health community. The division conducts general occupational injury surveillance, including the collection, analysis, and interpretation of injury statistics. DSR works with state agencies to upgrade injury surveillance and to conduct epidemiologic studies of occupational injuries and their etiology.

To identify and document effective methods for reducing musculoskeletal and acute traumatic injuries, DSR studies the effects of workplace environment factors on safety and provides technical assistance on problems requiring expertise in ergonomics, engineering, and related disciplines. Using safety techniques that account for all elements of an operating system, the division analyzes operations to identify hazards and develop strategies that will prevent injuries.

The division evaluates, certifies, and maintains records of respirators and of instruments for measuring dust in coal mines. To ensure that respirators continue to meet regulatory requirements, DSR audits, develops and reviews performance requirements, standards, and guidelines for certification. The division conducts field evaluations and laboratory research on the performance of personal protective equipment including respirators and protective clothing.

Division of Standards Development and Technology Transfer (DSDTT)

DSDTT serves as the focal point for the development and review of scientific policy in the institute. DSDTT develops and maintains a system of current information profiles that identify the number of potentially exposed workers, manufacturing production volumes, toxicity, and severity of the hazard, and the status of research studies in Federal agencies and the private sector. Using these profiles, the division identifies those substances, industries, and occupations that pose an unacceptable safety and health risk and sets priorities for which recommendations should be developed or revised and which research should be conducted.

DSDTT compiles, analyzes, and critiques existing detailed scientific and technical information in preparing recommendations for the prevention of selected occupational safety and health hazards. The most complex of these recommendations are Criteria Documents, which include environmental limits, requirements for medical examinations, personal protective equipment, employee notification of hazards, work practices, engineering controls, worker training, monitoring, and recordkeeping. The second form of recommendation, the Current Intelligence Bulletin (CIB), disseminates new scientific information about occupational hazards. A CIB may focus on a previously unrecognized hazard or may report new data on a known hazard. It gives background information about the hazard and outlines recommended action for controlling exposures. A third form of recommendation is the Alert, which is a short narrative of new findings or case histories published with the intent to reduce injuries, disease, or fatalities through prevention strategies. Alerts are targeted to persons in a position to intervene directly in the workplace to quickly eliminate the problem or reduce the risk. The division also prepares special occupational hazard reviews and risk assessments of potential workplace hazards.

In cooperation with DOL, the division develops and coordinates the Institute's testimony for hearings on proposed standards to support scientific and technical considerations. As appropriate, DSDTT prepares recommendations for emergency temporary standards in support of DOL.

DSDTT annually revises the legislatively mandated toxic substances list, the Registry of Toxic Effects of Chemical Substances (RTECS®). The division also develops and maintains the NIOSH computer-based technical abstract information system (NIOSHTIC) and other computer-oriented information resources such as the Document Information Directory System (DIDS) which catalogs NIOSH documents (e.g. Hazard Evaluation and Technical Assistance, Control Technology, Industrywide Study, contract and grant, Fatal Accident Circumstances and Epidemiology, and miscellaneous reports; numbered publications; training documents; testimonies; and scientific journal articles resulting from NIOSH research).

DSDTT manages a clearinghouse for NIOSH technical information on occupational safety and health. The division establishes liaison with government and nongovernment sources, including

international organizations, to obtain and disseminate technical data.

Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS)

DSHEFS conducts surveillance of the nation's work force and its environs to make an early detection and continuous assessment of the magnitude and extent of job-related illnesses, exposures, and hazardous agents.

DSHEFS conducts legislatively mandated industrywide epidemiological research. The objective of the industrywide studies program is to conduct occupational health studies, the results of which are used to help make industry-wide recommendations regarding safe levels of exposure in the workplace. These studies are designed to answer specific research questions important to occupational health and are accomplished by conducting various types of epidemiological mortality and morbidity and exposure assessment studies to a) identify the occupationally-related causes of disease in the working population and their offspring, b) determine the incidence and prevalence of acute and chronic effects from work-related exposures to toxic and hazardous substances and determine at what level of exposure or dose these effects occur, and c) provide information needed to develop recommended standards for the control of occupational health hazards.

On request, DSHEFS investigates the causes of workplace illnesses and accidents and determines through on-site HHE s whether a substance, practice or condition is a present or potential hazard. Depending on the problem, the division may send industrial hygienists or dispatch a team of specialists that may include physicians, nurses, chemists, toxicologists and engineers. After the field investigation, DSHEFS completes a final report that is sent to OSHA and to both the employer and the employee representative in the plant involved.

Using new and existing data sources from Federal State, and local agencies, labor, industry, registries, physicians, and medical centers, DSHEFS conducts surveillance to detect occupational health and exposure problems early and to assess their on-going magnitude and extent. DSHEFS also evaluates and validates studies on the reporting systems for occupational illness to help develop methods that will measure the magnitude of the occupational health problem nationally.

DSHEFS also provides, on request and on a self-initiated basis, technical assistance, demonstrations, and consultation on technical matters pertaining to occupational safety and health to other Federal, State and local agencies, and other technical groups, unions, employers, and employees.

Division of Training and Manpower Development (DTMD)

DTMD implements Section 21 of the Occupational Safety and Health Act, which mandates the training and education functions. The division develops continuing education programs to maintain and improve the competence of the occupational health and safety professional and paraprofessional work force.

DTMD provides short-term technical training courses, including seminars, independent study packages, and specialized workshops to Federal, State, and local governments; private industry; labor unions; and other organizations. The curriculum development program designs and produces course packages and other training materials for Institute-sponsored training programs, including presentations by in-house faculty and those conducted by universities and other outside training organizations.

The educational resource development program continually assesses manpower needs for occupational health and safety practitioners and researchers on a nationwide basis. To help meet the demand for such personnel, DTMD administers a major training grant program, through training project grants and the 14 Educational Resource Centers (ERC's), to foster the development of academically-based training programs for occupational health nurses and physicians, industrial hygienists, toxicologists, epidemiologists, and safety professionals. In addition, two intramurally supported programs, Project Shape and Project Minerva, influence the basic educational processes for practicing engineers and managers,

respectively, by helping incorporate occupational safety and health principles and concepts into existing curricula at schools of engineering and business administration.

Grants Program Activity

This office advises the Institute on the development and progress of NIOSH-sponsored extramural research; cooperates with the Institute's divisions and offices to stimulate grant applications for research and demonstration projects in relevant priority areas; monitors in-depth reviews from consultant experts of grant proposals; conducts secondary reviews of grant proposals; receives and evaluates reports of grant-supported projects; and coordinates the grants program with the Institute's intramural and contract research and with related programs in other HHS units, U.S. Department of Labor, U.S. Department of the Interior, and other agencies.

NIOSH publications are available from:

Publications Dissemination, DSDTT
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Cincinnati, Ohio 45226
(513) 533-8287

A toll free number is provided in the continental United States for requesting Health Hazard Evaluations and technical information. **1-800-35-NIOSH.**

FY 1990 Administrative Summary

NIOSH operated in FY 1989 with 851 allocated full-time equivalents, and a total budget of $84,665,000 of which $10,461,000 was allocated for training grants, and $6,149,000 for research grants. In all, 115 research grants were active during this fiscal year, and 70 awards were made. Currently 16 Epidemic Intelligence Service Officers are assigned to NIOSH.

This report presents a summary of highlights from the FY 1990 activities of NIOSH and meets the reporting requirements of sections 22(f) and 26 of the Occupational Safety and Health Act of 1970 (P.L. 91-596) (29 U.S.C. 671(f) and 675).

IDENTIFICATION

Before action can be taken to reduce or eliminate occupational health and safety hazards, the hazards must first be identified. NIOSH identifies problems through the analysis of data from the Bureau of Labor Statistics, the Social Security Administration, the National Center for Health Statistics, the National Institute of Environmental Health Sciences, the National Cancer Institute, the National Safety Council, state workers compensation files, state vital statistics and other state files, hospital discharge data, and the National Electronic Injury Surveillance System.

In addition, NIOSH conducts its own surveillance activities, including the National Occupational Exposure Survey (NOES), the National Occupational Health Survey (NOHS), the National Occupational Health Survey of Mining (NOHSM), the National Study of Coal Workers Pneumoconiosis, and the National Traumatic Occupational Fatality project. NIOSH also responds to requests from employers or employees and their representatives for investigations of health and safety hazards in the workplace. Results of these investigations, called Health Hazard Evaluations (HHE's), are made available to all involved and interested parties and to the Department of Labor.

SENSOR

NIOSH established the Sentinel Event Notification System for Occupational Risks (SENSOR) to promote reporting and intervention of occupationally-related traumatic injuries and illnesses at the state level. SENSOR is a network of health care providers who operate through cooperative agreements between NIOSH and participating state health departments. The health care providers report cases of specified illnesses and injuries to their state health departments, and if the case is determined to have resulted from exposures in the workplace, the health department notifies the worker and whenever possible, evaluates workplace conditions and the health of coworkers. Recommendations for eliminating or reducing these exposures are the responsibility of the state health department. In FY 1990, NIOSH continued to fund cooperative agreements for SENSOR in ten states: California, Colorado, Massachusetts, Michigan, New Jersey, New York, Ohio, Oregon, Texas, and Wisconsin. Sentinel providers collected data on incidences of carpal tunnel syndrome and other repetitive motion disorders, hypersensitivity pneumonitis, pneumoconioses, occupational asthma and other acute respiratory disorders, occupational burns, lead poisoning, pesticide poisoning, silicosis and silica exposure. For Colorado, New Jersey, New York, Ohio, Oregon, and Wisconsin, providers also report on exposures to the human immunodeficiency virus (HIV) for health care and emergency response workers.

The National Traumatic Occupational Fatalities (NTOF) Database

Through the National Traumatic Occupational Fatalities (NTOF) database, NIOSH compiles a comprehensive count of deaths resulting from traumatic injuries for workers in the United States who are 16 years of age and older. NTOF is created from state data sources, and provides a mechanism for monitoring trends in occupational fatalities, identifying occupations at highest risk for fatal injuries, and for targeting prevention efforts. Analyses of NTOF data have enabled NIOSH to address the most compelling causes of traumatic occupational death: motor-vehicle crashes, falls from elevations, electrocutions, deaths caused by machines, and homicides. NTOF data have also been used to identify industries at highest risk for occupational fatalities: mining, agriculture, and construction. Based on these data, NIOSH is developing in-depth, epidemiologic investigations of problems in the populations identified as being at risk. NIOSH is also focusing on an approach to the study of traditional and innovative safety controls and worker protection systems by combining engineering and industrial hygiene programs.

Fatal Accident Circumstances and Epidemiology (FACE)

Under the Fatal Accident Circumstances and Epidemiology (FACE) project, NIOSH investigates selected work-related traumatic deaths and responds to requests for technical assistance. Investigators use epidemiologic methodology to identify factors that contributed to the fatal incidents, and recommend methods for preventing similar deaths, then develop and distribute summary reports for each FACE investigation. Dur-

ing FY 1990, NIOSH conducted 40 FACE investigations in 9 states, the District of Columbia and the Commonwealth of Puerto Rico. Of the 40 incidents, 22 resulted from contact with electrical conductors, 15 resulted from falls from elevations, and three workers were asphyxiated in confined spaces. Forty-two investigations were conducted by states during FY 1990; six investigations involved deaths resulting from contact with electrical conductors, 24 resulted from falls from elevations, three resulted from workers collapsing in confined spaces, six resulted from farm-related injuries, and 3 occurred in combination categories.

Development of Surveillance Methods for Occupational Motor Vehicle Injuries

In FY 1990, NIOSH began collaborating with CDC's Center for Environmental Health and Injury Control (CEHIC), and the National Highway Transportation Safety Administration (NHTSA) to improve the quality of data on motor-vehicle injuries. The group analyzed current surveillance data on occupational motor vehicle injuries and drafted one article on available databases for surveillance of occupational motor vehicle injuries, and a second one addressing underreporting of this type of fatality in the United States. The articles will be published in FY 1991. NIOSH, CEHIC, and NHTSA also shared information with officials at the Occupational Safety and Health Administration (OSHA) to develop a formal definition of an occupational motor vehicle injury.

Surveillance of Health Care Workers

During FY 1990, NIOSH conducted several Hazard Evaluation and Technical Assistance (HETA) projects in FY 1990 that focused on potential hazards present in the health care setting:

Aerosolized Pharmaceuticals

NIOSH continued to assess potential health risks and control measures associated with the administration of two aerosolized pharmaceuticals, Ribavirin and pentarnidine. Ribavirin is used to treat children with respiratory syncytial virus, and is known to be teratogenic (causes severe birth defects) in animals, although the effects on humans is not well understood. NIOSH assessed several sites where Ribavirin was being used, and made recommendations for controlling exposures to the drug. Pentamidine is used in the treatment of AIDS patients with pneumocystis pneumonia, some of whom also test positive for tuberculosis. Health care workers administering pentamidine therapy are potentially exposed to both pentamidine (which causes respiratory effects) and the tuberculosis bacillus. NIOSH is developing a sampling and analytic method for pentamidine that will permit quantification of airborne exposure levels.

Ultraviolet Lamps

Ultraviolet (germicidal) lamps are being installed with increasing frequency as a means of disinfecting the air in clinical settings where the patients being treated are suspected of carrying infectious diseases such as tuberculosis and the human immunodeficiency virus. NIOSH has provided assistance in evaluating exposures to ultraviolet (UV) radiation in clinical settings where patients are being treated for these respiratory diseases, and found that maximum irradiance levels of direct, reflected, and tabletop UV radiation exceeded recommended evaluation criteria. NIOSH recommended control measures for reducing occupational exposures to UV radiation that included moving lamps so that workers were not receiving direct exposure to them, replacing worn or damaged lamp bulbs, and having workers wear caps and long-sleeved shirts for protection from harmful rays. The recommendations have been incorporated by reference into a CDC Morbidity and Mortality Weekly Report (MMWR) supplement on guidelines for protecting health care workers involved in treating HIV/AIDS patients.

Smoke from Laser Surgery

NIOSH received a request to evaluate the potential hazards of exposure to smoke generated by medical lasers during laser surgery. Researchers detected a wide variety of compounds in the smoke plume generated during laser surgery techniques, including hydrocarbons, polynuclear aromatic compounds, formaldehyde, and cyanide. Solvent extracts of airborne particles from the smoke plume were found to be mutagenic to bacteria (Ames test). NIOSH investigators concluded that a potential health hazard existed, and recommended the use of smoke evacu-

ators as a control measure. These findings were published in a peer-reviewed journal, *Clinical Laser Monthly.*

State-Based Surveillance for Occupational Lead Exposure

Occupational lead exposure has persisted as a serious public health problem in the United States. In 1988, 4,804 adults with blood lead levels (BLLs) of 25 micrograms per deciliter (μg/dl) of blood were reported to NIOSH by seven state health departments. Of these 4,804 adults, 519 (11 percent) had a BLL of 50, μg/dl or greater, the level at which medical removal protection is required by OSHA. Workers at risk of exposure to lead are employed in industries such as battery manufacturing, secondary smelting and founding of nonferrous metals, vehicle radiator repair, indoor firing ranges, and various construction activities such as residential lead abatement and renovation of bridges and other outdoor steel structures. Lead is toxic to the central and peripheral nervous systems; the hematologic (blood-forming) system; the reproductive systems of both men and women; and the kidneys.

In FY 1990, the network of state health departments conducting blood lead surveillance in adults doubled from seven to fourteen states. Approximately 47.2 percent of the U.S. work force is employed in these fourteen states. Surveillance activities serve several important functions: 1) the identification of occupations, industries, and workplaces in which exposure to lead has occurred; 2) the evaluation of the effectiveness of current health and safety regulations; 3) the control of lead exposures in certain high-risk industries, such as radiator repair and bridge reconstruction; and 4) the dissemination of information by means of educational efforts, by the publication of reports and articles, and by presentations at meetings. Articles on state-based surveillance were published in the *Journal of the American Medical Association;* the *American Journal of Industrial Medicine.* Authors are preparing articles for future publication in the *American Journal of Public Health* and the *Journal of Health Policy.*

Lead Abatement Workers

NIOSH has received several requests for health hazard evaluations and technical assistance in assessing potential hazards associated with removing lead-based paint from structures such as bridges, storage tanks, and housing units. Because of concerns about environmental contamination, many lead-based paint abatement projects are now being conducted under varying degrees of containment, which can increase the risk of lead exposure to employees involved in removing lead-based paint. The potential size of the affected workforce is expected to be large, as the Nation moves toward removing lead-based paint from public housing units and rehabilitating aging bridges and other structures.

NIOSH provided recommendations to the Department of Housing and Urban Development for its use in developing requirements for contractors who will be removing lead-based paint from public housing units. NIOSH is also developing a hazard alert on the subject of lead exposures during bridge rehabilitation.

Coal Worker's Pneumoconiosis (CWP)

In the National Study of Coal Workers Pneumoconiosis NIOSH is evaluating the effectiveness of the Federal Coal Mine Dust Standard in preventing both pneumoconiosis and nonpneumoconiotic lung disease caused by inhalation of coal mine dust. Results from FY 1990 data continue to show a reduction in new cases of pneumoconiosis, although the number of deaths per year with pneumoconiosis has remained the same since 1970, (approximately 2,000). Data from this study show that severe CWP still occurs even in miners who started work after the standard was established, indicating that the current standard does not entirely protect miners from either CWP or accelerated decline of pulmonary function in the absence of CWP. NIOSH is continuing to evaluate longitudinal declines in pulmonary function in relation to coal mine dust exposure. In the CWP chest x-ray screening program, which was begun in 1970, all miners are eligible to receive an x-ray examination at least once every five years at NIOSH-certified facilities. Findings from each evaluation are confidential, however, under the Mine Safety and Health Act, miners found to have CWP may be transferred to other work without reduction in pay. In FY 1990, NIOSH reviewed a total of 2,900 coal miners' chest x-rays, and issued dust transfer options to 64 miners. In the National Coal Workers Autopsy Study NIOSH received and processed autopsies for 190 miners.

NOHSM

The National Occupational Health Survey of Mining (NOHSM) is developing information regarding toxic chemicals and harmful physical agents present at mining sites. NIOSH began field data collection for this

project in May 1984. In FY 1990, 28 commodity reports were completed, and 491 site reports were sent to sampled mines. Over 10,000 tradenames were identified as chemical products, and tradename verification was initiated. NOHSM inventories of chemicals and potential exposures projections are currently used by Mine Safety and Health Administration (MSHA) inspectors to focus their on-site toxic substance sampling efforts. By 1991, the NOHSM data base will be accessible to the regulatory agencies, management, labor, and the public. The development of this resource will permit NIOSH and other public health officials to identify the most significant hazards in the mining industry and to put priorities on research for improving mine safety and health.

EVALUATION

NIOSH evaluates work-related health problems to help understand their cause and severity. This is done primarily through targeted laboratory and field research. The Institute developed its suggested list of ten leading work-related diseases and injuries as an aid to setting priorities and focusing its activities and resources on the most important problems. NIOSH has also expanded its evaluation activities to other illnesses and injuries, such as those found in agriculture and construction industries.

OCCUPATIONAL LUNG DISEASES

Cotton Dust

NIOSH is continuing efforts on a pilot system for measuring the distribution of endotoxin in the U.S. cotton crop. Endotoxin is present in the cell walls of gram negative bacteria found in various organic dusts including cotton dust. NIOSH has associated endotoxin with the acute respiratory response that may be experienced upon exposure to cotton dusts. These respiratory effects are being studied through analysis of data collected from cotton gins in U.S. cotton growing areas, and analysis of respiratory morbidity (e.g., asthma and byssinosis) data with respect to airborne endotoxin concentrations. In FY 1990, researchers conducted several walkthrough industrial hygiene surveys at cotton gins. So far, the researchers have found significant geographic differences in the degree to which airborne cotton dust in cotton gins is contaminated with endotoxin. NIOSH also designed, built, and field tested samplers for measuring the aerodynamic size distribution of endotoxin-containing dusts, and prepared an article about this research for publication. This work will be continued in FY 1991.

Agricultural Bronchitis

Agricultural workers may be exposed to many types of dust from animals and crops, and as a result may suffer from asthma, allergies, chronic bronchitis, organic dust toxic syndrome (ODTS), and other respiratory problems. In FY 1990, NIOSH completed its investigation of several agricultural environments including poultry and swine confinement units, chicken-raising operations, mushroom farms, grain storage bins, and silos. For the first time, histamine was quantified in environmental samples of barn hay. Total bacteria, gram negative bacteria, thermophilic bacteria fungi, and endotoxins were quantified in dust from composted wood chips. Studies of human serum showed biomarkers of exposure to the biohazards isolated from the wood chips. Results from this study will yield new information about the characterization of airborne biohazards in agriculture, and will help explain the potential for adverse respiratory responses in workers exposed to these dusts. Work on this research will be continued in FY 1991. NIOSH published articles on occupational bronchitis in the *Proceedings of the VII International Pneumoconioses Conference, Applied Occupational Environmental Hygiene, FASEB Journal, the Scandinavian Journal of Work and Environmental Health, the American Journal of Industrial Medicine, Biodeterioration Research* and *Annals of Biochemistry.*

Occupational Asthma

Occupational asthma may be caused in industrial and agricultural workers after breathing dusts, vapors and gases from plants, animals, and chemicals. More than 200 agents are potential risks for causing occupational asthma. NIOSH is conducting an initiative in occupational asthma research that includes surveillance (to define disease prevalence), hazard evaluation (to identify work place agents, their levels, and the symptoms they cause), and clinical studies (to diagnose the disease entity). Laboratory studies are being used to model the human disease and to define its mechanisms. NIOSH is also continuing research on developing procedures for assessing the effects of agriculture dust on cell cultures. Abstracts and articles about NIOSH research on occupational asthma were published in the *Journal of Toxicology and Applied Pharmacology FASEB Journal the American Review of Respiratory Disease;* the *British Journal of Pharmacology,* the *European*

Journal of Pharmacology, and Applied Occupational and Environmental Hygiene.

Silicosis

The U.S. Department of Labor estimates that 1.25 million people are exposed to silicosis through contact with crystalline silica or coal dust at work. Workers at risk of exposures include miners, stone quarry workers, sand and gravel workers, sandblasters, foundry workers, and glass workers. Acute silicosis is characterized by the rapid development of respiratory disability. In contrast, chronic silicosis develops 20-40 years after initial exposure and is characterized by the progressive development of dyspnea (shortness of breath). Several theories concerning the etiology of silicosis involve silica-induced inflammation, which is associated with increased membrane damage and lung injury. Another theory is that surface properties of silica play an important role in the biological activity and cytotoxicity of silica dust. In researching these theories, NIOSH found that fracturing silica particles results in the generation of radicals, which are highly reactive molecules that can potentially damage cell tissues. NIOSH is comparing the effects of fresh (immediately after fracturing) versus aged (several weeks after fracturing) silica; results indicate that the fresh silica is more bioactive than aged silica. These data may help explain why some occupations with silica exposure show higher rates of the disease than others. For example, sandblasters, rock drillers, and granite cutters who work with fresh silica may be at higher risk than workers who use aged silica, such as glass workers. In another silica-related project, NIOSH found that insufficient numbers of silica samples are being collected under MSHA's current sampling scheme to adequately characterize silica exposure in mines. These results will be published in FY 1991.

Dusty Trades

In collaboration with the University of North Carolina School of Public Health and the National Cancer Institute, NIOSH has completed a cohort mortality follow-up of 760 workers identified as having silicosis by the North Carolina Health Department's Dusty Trades Program. Analyses of the data effectively controlled for confounding by age, cigarette smoking, and exposure to known occupational carcinogens. Findings from this study are consistent with the hypothesis that an association exists between silicosis and lung cancer, and will be published in the American Journal *of Industrial Medicine* and presented at the 1991 annual meeting of the American Thoracic Society. This analysis is currently being prepared for publication.

Improvements in Occupational Exposure Data

To improve the quality of occupational exposure data, NIOSH conducted the Proficiency Analytical Testing (PAT) program in cooperation with the American Industrial Hygiene Association. Since the beginning of the PAT program, approximately 15 National Bureau of Standards Standard reference materials (SRM) applicable to occupational health laboratories have been developed. Other reference materials have been distributed in PAT, most notably, asbestos on filters. Currently, over 1,400 occupational health laboratories are enrolled in the PAT program. NIOSH prepared a technical report to explain the new laboratory reports and rating criteria for the PAT program and will disseminate it during FY 1991. A paper on the quality of fiber count data was published *in Applied Industrial Hygiene.*

Expansion of Direct Reading Instrumentation Capabilities

NIOSH evaluated available monitoring instruments and techniques for conducting on-site environmental monitoring, and developed an instrument for use in indoor air quality studies to monitor respirable particulate, carbon dioxide, temperature, and humidity on a continuous basis. Researchers also evaluated a method for methylene chloride analysis by portable gas chromatography, which will be published as part of the *NIOSH Manual of Analytical Methods.*

Halogen Gases Sampling and Analytical Methods

According to National Occupational

Exposure Survey data from 1987, approximately 166,000 workers are potentially exposed to chlorine, and 18,000 are potentially exposed to bromine in the manufacture of chlorine and other chemicals in the pulp and paper industry, and in disinfecting processes. NIOSH is conducting research to improve the methods for monitoring workers' exposure to these gases. Existing monitoring methods use liquid-containing cylinders for sampling workplace air, however, these monitors are inconvenient for the workers to wear while measurements are being obtained, and impractical for use in some workplaces. Also, these methods are insufficiently specific for chlorine and bromine. To address these problems, NIOSH developed a new approach to sampling halogen gases, based on the use of commercially available silver membrane filters as a reactive solid sorbent. The newly-developed method for chlorine and bromine (NIOSH Method 6011) is more sensitive and can be used at sites where liquid-containing samplers may not be used. A report on the development of the solid sorbent monitoring method for chlorine and bromine in air has been submitted to the *Applied Occupational and Environmental Hygiene Journal.*

Quick-Response Methodologies and Sampling Media For Field Industrial Hygiene Investigations

In addition to providing routine methods to support research at NIOSH, it is often necessary to develop quick-response methodologies and sampling media for immediate use in field industrial hygiene investigations. Short-term method development or method modification efforts are almost always required when a request for analytical support involves a compound not found in the NIOSH *Manual of Analytical Methods*. The requirements for these efforts vary depending upon the nature of the measurement problem. NIOSH methods were developed or modified during FY 1990 in the course of providing support to the Health Hazard Evaluation Program, the Industrywide Studies Program and toxicological research. Methods were developed for:

- *Super absorbent polymer:* A super absorbent polymer (Sanwet IM-3500), which is a sodium polyacrylate cross-lined with starch, is used in the manufacture of disposable infant diapers because it has a high degree of absorbency (one gram of polymer can absorb about 400 grams of water). This polymer is suspected of causing breathing difficulties in workers who inhale dust containing it. NIOSH developed a sampling and analytical method for this polymer in air. The method also applies to other super absorbent polymers.

- *Pentamidine:* NIOSH developed a sampling and analytical method in response to several requests to provide assessments of exposures of health care workers to Pentamidine. Pentamidine is a drug used to prophylactically treat *pneumocystis carinii* pneumonia (PCP), an opportunistic infection frequently found in AIDS patients. The drug is administered as an aerosol. Health care personnel have two concerns relative to this procedure: passive exposure to the drug itself, and exposure to pathogens from the patient during therapy. This latter issue required the development of a safety protocol designed to protect both industrial hygiene and laboratory personnel from accidental exposure to tuberculosis bacilli.

- *Portable Dioxin Sampler:* Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are highly toxic chemicals frequently found as combustion products of chlorinated materials, especially transformer fluids. The sampling device currently used for collection of area air samples is heavy and bulky, so NIOSH is working to develop an improved portable sampler for PCDDs and PCDFs that can also be used for personal sampling. A prototype sampling device (a glass fiber filter in series with polyurethane foam — both contained in a lightweight aluminum housing) has been fabricated. Work is currently underway to assess the limit of detection and the precision of this method.

Process Containment for Bioaerosols

Bioaerosols are used in industries that use enzymes and fermentation processes that manufacture vitamins, birth control pills, and

other drugs. In these processes, workers are exposed to potentially hazardous microorganisms, biologically active products or intermediates, and processing chemicals. Any of these exposures may cause asthma, allergic reactions, or infection. NIOSH had previously conducted a control technology assessment of enzyme fermentation processes to identify effective controls for these hazards. Current research involves methods development for bioaerosol sampling. NIOSH is evaluating the relative sampling efficiencies of eight bioaerosol samplers. This evaluation will allow the differentiation between sampler variation caused by sampler collection efficiency variation and those caused by microorganism viability variation. Each sampler was individually challenged with a bioaerosol of either *Bacillus subtilis* or *Escherichia coli* at a concentration of approximately 2,000 colony forming units (CFU) per cubic meter. Each sampler was evaluated under controlled conditions in a horizontal bioaerosol chamber. The results of this research indicate a wide variation from sampler to sampler for free bacteria. Current research and literature indicate a need to repeat the experiments with larger particles or microorganisms such as fungi or the same bacteria in a larger droplet. An automated method for cell enumeration of the broth or buffer suspensions of bacteria is being investigated using a microscopy imaging system.

Analytical Methods For Inorganic Substances

In FY 1990, NIOSH completed work on evaluating problems identified with sampling and analytical methods for fluorides, aerosol and gas, (NIOSH Method 7902). Results from this evaluation were summarized in a report recommending revisions to the method that included sample analysis by ion chromatography and modifications to the sampler design. These revisions have been incorporated into Method 7902 in the Fourth Supplement to the *NIOSH Manual of Analytical Methods.*

MUSCULOSKELETAL INJURIES

Health Care Industry Low Back Study

Among the occupational groups facing high risk of low-back injury are workers in the health care industry who must lift and move patients. Within the health care workforce, nursing aides working in nursing homes are particularly vulnerable to back injury. This population includes over 500,000 workers. NIOSH has attempted to identify patient-handling tasks that are most stressful to the lower back and develop methods of eliminating that stress. Using these methods, NIOSH conducted an ergonomic intervention trial in a county nursing home. Before and after data showed improvements in several criterion measures including: 1) perceived level of physical stress experienced by nursing assistants; 2) biomechanical demands of patient transfer tasks; 3) back injury rate; and 4) lost-workday rate.

Cumulative Trauma Disorders

Cumulative trauma disorders (CTD's) are injuries that occur after repeated trauma without sufficient time to recover. The result can be debilitating diseases, such as carpal tunnel syndrome, in which tendons in the wrist become swollen and press against the median nerve causing pain and loss of motor ability in the hand. In FY 1990, NIOSH continued to investigate CTD's among workers in poultry processing industries, workers using keyboards in the news and telecommunications industries, and workers in grocery stores using laser scanning devices. The studies in the poultry processing industry have identified many of the specific work practices that result in CTD's, which has led to the development of recommendations for changes in work practices to help alleviate the problem. NIOSH has supported Federal and state OSHA enforcement actions in this area. Because of the growing trend toward keyboard-based data entry and word processing in a wide variety of industries, and indications that upper extremity CTD's may result among workers engaged in such tasks, NIOSH has undertaken several efforts to evaluate stressors, disease, medical management practices, and control techniques among this group of workers. It is expected that this work will appreciably advance the understanding of CTD's and ways to prevent them among workers in repetitive jobs.

Revised/Updated Methods for Assessing Overexertion Risks in Manual Lifting

Workers' compensation claims and other indicators report that low back problems are one of the most common and costly types of work-related injuries. The main cause of these injuries is believed to be overexertion in manual lifting tasks. In 1981, NIOSH published a work practices guide for assessing the hazard of overexertion in lifting jobs, and over 30,000 copies of this guide were disseminated by the American Industrial Hygiene Association and the National Technical Information Service. Because low back injuries in industry continue to be a major problem, NIOSH updated and revised the 1981 guide. As in the original formulation, a panel of leading scientists in the areas of biomechanics, industrial engineering, work physiology, and human factors psychology contributed to the revised guidelines. The new guidelines include an updated formula for rating lifting loads and expand the original version by including adjustments for more frequent lifts, twisting type lifts, and the presence of handles or cut-outs on the load to ease the task. The document also includes a users guide with examples illustrating application of the formula and accents ergonomic (i.e., task redesign) approaches to reducing apparent overexertion risks. NIOSH anticipates that worksite trials will be conducted to demonstrate the effectiveness of the guide in reducing lifting hazards at work.

Shoulder and Neck Muscle Tension from Repetitive Work

A report from the Bureau of Labor indicates that repetitive motion injuries now show the fastest rate of increase in the U.S. workforce. There has been increased publicity about hand and wrist disorders such as carpal tunnel syndrome and the risk factors (forceful grips and repeated wrist deflections) that con-

tribute to their occurrence. Other tasks involving overhead work can also lead to repetitive motion injuries caused by strain on the upper arm, shoulder and neck. To study causes of these strains, NIOSH observed simulated assembly tasks under conditions in which the repetition rate, vertical reach distance, tool weight, and required force output were each varied. Work duration limits and tremor measures were used to determine the extent to which these factors could accelerate the onset of fatigue or pain as precursors of cumulative trauma. The results indicated that increases in any of the above factors caused increased strain in the upper body and thus shortened the durations of acceptable work periods. NIOSH will conduct further laboratory work to compare work-rest durations for these tasks during day and night shift hours as well as for extended workshifts. The results of this research will be used for recommending limits on time schedules for repetitive overhead work and to establish ergonomic guidelines for workstation layout. An article about this research was published in *Behavior Research Methods, Instruments, and Computers.*

OCCUPATIONAL CANCERS

O-Toluidine and Aniline

ortho-Toluidine and aniline are aromatic amines used as intermediates in the manufacture of dyes and other products. NIOSH estimates that during the period 1981-83, 28,483 workers were potentially exposed to o-toluidine and 35,781 workers were potentially exposed to aniline. NIOSH studied bladder cancer incidence among 1,749 workers at a chemical plant that used o-toluidine and aniline in one department. Among 708 workers assigned to that department, there were 7 cases of bladder cancer, a risk that is six times greater than would be found in an unexposed population. Maintenance and janitorial workers at the plant were 3.7 times more likely to develop bladder cancer than individuals in an unexposed population. The risk among the remaining workers, where there was little or no exposure, was not significantly above that would be expected for the normal population. The highest risk of developing bladder cancer was among workers with over 10 years assignment to the department where o-toluidine and aniline were used.

NIOSH notified the company and union of these results, and sent notification letters to individual workers. NIOSH also conducted a walk-through survey at the plant and made specific suggestions to reduce potential exposure to o-toluidine and aniline. An in-depth survey of exposures was then conducted, including collection of urine and blood to evaluate exposure through the skin. The results of this part of the study will be completed in FY 1991. NIOSH also prepared a Hazard Alert regarding o-toluidine and aniline, which should be released in early FY 1991, and submitted a paper describing the bladder cancer incidence study for publication. Findings were also reported in a NIOSH Hazard Evaluation and Technical Assistance Interim Report.

Gas and Vapor Measurement Techniques

NIOSH continued research to develop a versatile system for surveillance of airborne pollutants in the workplace by producing a real-time map (measurements of exposures at the time they are occurring, as opposed to accrued over a period of time) of pollutants. The major portion of this work centered around the construction of a laboratory test system to evaluate the feasibility of constructing a workable indoor light detection and ranging (LIDAR) system for workplace pollutant monitoring. This benchmark test system required the design and construction of a special carbon dioxide laser producing the necessary short, rapidly reattuned output pulses. Researchers modified the benchmark test system to make it transportable, and made changes to the software for filtering noise from return LIDAR signals. A paper was presented at the 1990 Conference on Lasers and Electro-Optics, and a second paper is being prepared for publication.

Sensor Development (Polymer Film Characterization by SAW Monitoring)

NIOSH continued studies to develop and evaluate various sensors for measuring various workplace exposures. In FY 1990. NIOSH tested the surface acoustic wave (SAW) device, a sensor that has recently been receiving attention because of its potential for measuring gases and vapors in the air. The SAW device is a piezoelectric device (one that creates electricity when struck) with a resonant frequency in the acoustic range. A thin coating of polymer on the crystal can adsorb vapors from the air, and the resulting change of mass or elasticity causes a change in the resonant frequency. NIOSH experimentation focused on the deposition of thin, reproducible, polymer films onto SAW devices, SAW effects on SAW response during sorption, and desorption of vapor into the polymer. Researchers determined that mass loading, not elastic tightening, produces the dominant SAW response to vapor exposure. A detailed mathematical description of SAW polymer film stress effects due to temperature changes or vapor-induced swelling was developed, and a journal article describing this work was published in *Analytical Chemistry*.

Sampling And Analytical Method For Airborne Diesel-Exhaust Particles

In its Current Intelligence Bulletin 50, *"Carcinogenic Effects of Exposure to Diesel Exhaust,"* NIOSH recommended that whole diesel exhaust be regarded as a potential occupational carcinogen. As a result, NIOSH researchers have been investigating various approaches for monitoring worker exposure to diesel-engine exhaust emissions. This research has been conducted both independently and in cooperation with the Mine Safety and Health Administration (MSHA) and the Bureau of Mines (BOM). Because diesel exhaust contains thousands of compounds, a surrogate measure of exposure must be selected, and NIOSH has proposed the use of elemental carbon as an exposure index. Elemental carbon constitutes a large fraction of the particulate mass and serves as a carrier of polycyclic aromatic hydrocarbons. Its only significant source in many workplaces is the diesel engine.

Researchers completed preliminary field and laboratory studies to determine the potential suitability of a thermal-optical method (TOM), which speciates organic, carbonate, and elemental carbon, for analysis of carbon in particulate diesel-exhaust samples. Various aerosol size fractions were collected in two diesel-equipped and two electric-powered underground coal mines, a coal-dust chamber, and a diesel-equipped limestone mine. Because interference by coal dust is expected in the determination of diesel-source elemental carbon in samples from underground coal mines, this environment was the focus of these studies. Results of preliminary work indicate that only low levels of elemental carbon were found in sub-micrometer dust samples collected in electric-powered underground coal mines.

Chemical Characterization of Roofing Asphalt Fume

In conjunction with the National Cancer Institute, NIOSH is evaluating the carcinogenic effects of petroleum asphalt fume. The first phase of the research included development of the asphalt fume fractionation scheme used to prepare materials for the study. Gas chromatography/mass spectrometry characterizations provided the researchers with guidance for optimizing the separation of the asphalt fume, to the extent possible, by chemical classes, e.g., hydrocarbons and ketones. In the second phase of the research, investigators identified a more detailed characterization of the five asphalt fume fractions generated in the study.

Determination of Formaldehyde Content of Airborne Dust

NIOSH is conducting research on exposures to formaldehyde received from airborne dust. Airborne dust was identified as a possible source of exposure to formaldehyde after two separate epidemiologic studies conducted by NIOSH and the National Cancer Institute showed excesses of upper respiratory tract cancers even when exposures to formaldehyde vapor were low. Researchers in both studies noted that a significant dust exposure potential existed. Now NIOSH researchers are investigating ways to estimate the dose of formaldehyde from airborne dust, and have submitted a report describing their method development research and field studies to *Applied Occupational and Environmental Hygiene* for publication.

Dioxin Morbidity and Mortality Studies

In 1978, NIOSH constructed a registry of all U.S. chemical workers employed in the production of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) contaminated chemicals between 1942 and 1984. TCDD is generated as a contaminant in the production of 2,4,5-trichlorophenol, and is widely dispersed in low levels in the environment. The general public has exposure to TCDD in the food chain, incinerator emissions and bleached paper products. Data from the registry are used as the basis of epidemiologic studies to evaluate health effects related to occupational exposure to TCDD. To evaluate health effects previously associated with exposure to TCDD by several epidemiologic and toxicologic studies, NIOSH conducted a cross-sectional medical study of 281 workers from two plants. The

prevalence of health effects in the workers was compared to health effects in an unexposed group of 260 individuals who were matched for age, race, gender, and community. Health effects studied were chloracne and other dermatologic disorders and adverse health effects involving the liver, nervous system, and respiratory system. Serum TCDD levels in the exposed workers were found to be approximately 30 times higher than the levels in the unexposed referent group, indicating very high occupational exposure to TCDD-contaminated chemicals. Despite the high serum TCDD levels, no increases in the prevalence of respiratory disease or disorders of the peripheral nervous system were found among the workers compared to the unexposed group. Reports on disorders of other systems will be completed in 1992.

To evaluate mortality from cancer, from previous exposure to TCDD, NIOSH conducted a cohort mortality study of 5,172 workers from 12 plants. The death rate in the workers exposed to TCDD was compared to that of the U.S. general population for soft tissue sarcoma, Hodgkin's disease, non-Hodgkin's lymphoma, and stomach, liver, and nasal cancers. The full report of the study will be published in FY 1991. Articles on this research were published in *Chemosphere*, and the *American Journal of Industrial Medicine*.

Welding Fumes

Numerous studies have demonstrated that welders have a 40 percent excess in lung cancer than is expected in the normal population. There are an estimated 185,000 full-time welders in the United States (approximately 700,000 when part-time welders are included). The cause of the observed lung cancer excess could be carcinogenic agents in welding fumes, excess smoking or asbestos exposure. One possible explanation for the excess risk is welding of stainless steel resulting in a welding fume with nickel and chromium, which are known lung carcinogens. To investigate further, NIOSH studied 4,459 male mild-steel welders at heavy equipment plants in the Midwest who had been exposed to welding fumes from the 1950's to the 1980's. These men all had at least two years of welding experience (average 8.5), averaged 20 years since first exposure, and had no known exposure to either asbestos or stainless steel welding fumes. Results show that welders, compared to the U.S. population or to other nonwelders in the same plants, had no excess risk for lung cancer. There were no significant positive trends in lung cancer with duration of exposure or time-since-first-exposure.

Testicular Cancer Among Tannery Workers

NIOSH performed a health hazard evaluation at a finishing department of a tannery where three cases of testicular cancer were reported among workers on the same shift and during the same time period. After conducting a standardized incidence ratio study of finishing workers at the tannery, NIOSH observed a 40-fold elevated risk for testicular cancer among these workers The expected rate of testicular cancer for this group (white males) is 2 cases per 100,000 per year. To follow up on this finding, NIOSH conducted a testicular cancer screening program and an industrial hygiene survey at the plant. Testicular cancer was not found in any of the other workers screened, and all industrial hygiene measurements were below the OSHA permissible exposure limits.

During this investigation, researchers were especially concerned with identifying exposures to dimethylformamide (DMF) because it had been suspected of causing clusters of testicular cancer in a previously published study of workers at two aircraft maintenance sites. The cluster of cases at the tannery added to concerns about the carcinogenicity of DMF, however, because of a lack of detailed information about exposures to DMF at the plant, and because workers may have suffered effects from co-existent exposures to other chemicals, researchers were unable to draw definite conclusions about the causes of these cancer cases. Information about this study was published in CDC's Morbidity and Mortality Weekly Report (MMWR).

Diesel Exhaust and Lung Cancer

Researchers have noted that truck drivers have shown a fairly consistent elevation of lung cancer risk approximately 50 percent

higher than what is expected in the rest of the population. Suspected causes of this excess include smoking and exposure to diesel exhaust, which is known to cause cancer in laboratory studies. To investigate this excess risk, NIOSH conducted a case-control study of lung cancer in the Teamsters Union. Approximately 1,000 decedents with lung cancer and 1,000 other decedents were selected from Teamster files of pensioners who died in 1982-1983. Researchers interviewed next-of-kin to determine smoking habits and work history, and obtained additional work history information on Teamster records. Researchers then assigned workers to the job category in which they had worked the longest. These categories included long-haul driver (diesel truck), short-haul driver (gasoline truck), mechanic, dockworker, and those outside the trucking industry with presumably no diesel exposure. All job categories in the trucking industry were compared for lung cancer risk to those outside the trucking industry. The results suggested that an excess risk existed for mechanics and truck drivers with many years employment, after controlling for smoking. These findings were published in the *American Journal of Public Health.*

In a concurrent NIOSH industrial hygiene survey, researchers measured the levels of diesel exhaust exposure among mechanics, truck drivers, railroad workers, dockworkers, and miners. NIOSH found that levels of exposures to diesel exhaust are highest for mechanics and for miners who work where diesel engines are used in confined spaces. Truck drivers and railroad workers have exposures that are approximately twice the levels experienced by the general population, and dockworkers' exposures are similar to the levels to which the general population is exposed. An article on this study was published in the *American Journal of Public Health.*

DNA Adduct Study

NIOSH has developed specific methods to determine the induction of DNA-adducts in the lungs by industrial chemicals. These DNA adducts are expected to be used as biomarkers for determining the chemical exposure actually received by lung tissue (as opposed to the exposures to the upper respiratory system). In addition, NIOSH has developed a biological assay system for the detection and monitoring of genotoxic agents and potential carcinogens in occupational settings, and for the detection and assessment of potential health hazards to workers. Selection of occupational settings for field studies to utilize this system were completed in FY 1990. Results from this research will provide information upon which exposure standards for industrial chemicals can be set and control technology developed.

The Role of Mineral Dusts and Fibers in Carcinogenesis

NIOSH is exploring new approaches for analyzing the roles of fibers and dusts in causing cancer. These approaches will include laboratory and epidemiology studies, and methods for analyzing cells for alteration or damage to DNA and chromosomes. Basic research in carcinogenesis must still be performed to determine whether cellular damage can be induced by mineral fibers and whether any synergistic effect exists between fibers, chemicals, and complex mixtures, since exposures to all of these may occur simultaneously in the workplace. NIOSH will initiate studies FY 1991 to try to overcome some of the inherent problems (e.g., the continual introduction of new chemicals and mixtures into the workplace, the long latency period for cancer, and the small number of workers exposed to specific chemical mixtures) in determining causes of occupational cancers. One of these studies will determine whether silica, talc, and glass fibers can induce cell transformation. The information generated from this help to determine the potential carcinogenic hazards of these fibers to exposed workers, and the characterization of cell transformation in relation to oncogene expression and activation may provide insight into the occupational carcinogenesis of dusts and fibers.

Asbestos Substitutes and Asbestos-Related Disease

In FY 1990, NIOSH prepared tables on deaths with asbestosis from 1968-1986 by year and on deaths with asbestosis from

1980-1987 by state. The annual number of deaths with asbestosis has increased ten-fold over this time period. Asbestos fibers cause an increase in the incidence of mesothelioma, lung cancer, and possibly other types of neoplasia in exposed workers. However, the mechanism of asbestos fiber carcinogenesis is not known, and the potential health risks of asbestos substitutes and synthetic fibers is inadequate. One of the difficulties in predicting these risks is lack of knowledge as to whether fiber chemistry or fiber dimension is the critical factor in initiation of disease. Therefore, NIOSH is attempting to identify the health risks of asbestos substitutes by analyzing the physical properties and developing testable dose ranges. Researchers have developed tissue culture conditions, defined effective dose ranges, and are in the progress of conducting laboratory exposures of lung tissue to specific particles. Thus far, when dose is quantitated on a weight basis, fibrous crocidolite, for example, is substantially more toxic than its non-fibrous form, riebeckite. NIOSH is also studying the surface properties of selected fibers and correlating those data with the surface toxicity of native and surfactant-treated minerals fibers to determine the surface physics and chemistry of selected fibers; correlating their biological activity with surface properties; and devising strategies for altering their surface so as to eliminate their disease potential.

SEVERE OCCUPATIONAL TRAUMATIC INJURIES

Occupational Motor Vehicle Injuries

NIOSH studies have shown that motor vehicle crashes are the leading cause of occupational deaths due to traumatic injuries. Based on its National Traumatic Occupational Fatality (NTOF) data base, NIOSH identified an average of approximately 1310 work-related traffic deaths per year for the six-year period from 1980 through 1985. This figure represents 20.1 percent of the total number of identified work-related deaths caused by traumatic injuries. These numbers may be underreported because NTOF data are collected from death certificates, and must be marked as "injury at work" to be included. There is no quality control mechanism in states that makes sure that occupation is recorded on the certificate, therefore if the occupation is not recorded, the fatality will not be identified for NTOF. Factors that may contribute to motor vehicle crashes are failure to use seatbelts; lack of driver training; driver fatigue and loss of alertness during monotonous or repetitious tasks, especially over a long period of time; driving during night or early morning hours, especially between 2:00 a.m. and 6:00 a.m.; and the amount of sleep obtained or lost by the driver. Drug or alcohol usage also may be a factor, although this has not been formally studied as a cause in occupational fatalities. NIOSH prepared comments for an OSHA proposed rule, and will publish this research in FY 1991.

Occupational Falls

Analysis of NIOSH National Traumatic Occupational Fatality (NTOF) data indicates that 3,491 fatal occupational falls occurred during the six-year period from 1980 through 1985. Most of these falls (77.5 percent) were from elevations, and nearly half involved construction workers, predominantly skilled craftsmen and laborers. Of these, 41 percent were falls from buildings, 17 percent were from scaffolds, 15 percent were from ladders, and seven percent were falls through openings in work surfaces including skylights and roof openings. The analyses of NTOF data and FACE data were presented at the Industrial Ergonomics and Safety Conference and published in the Conference Proceedings. The FACE analysis was based on 40 cases investigated from 1987 through September 1989. Research projects are underway to address falls from scaffolds, falls through skylights and roof openings, and falls from heavy offroad construction equipment, a source of a large number of nonfatal workplace injuries.

Electrocutions and Electrical-Related Injuries

Electrocution is one of the leading causes of traumatic occupational fatalities. According to NTOF data for the years 1980 through 1985, at least 700 occupational electrocutions occur each year, about 10 percent of all traumatic occupational deaths. Electrocution is also one of the focus areas for fatality investigations under the FACE program. Based on patterns emerging from FACE investigations, overhead powerlines have emerged as a common source of contact with electrical energy that results in death. Crane booms, ladders, long-handled tools, dump trucks, large sections of conductive materials, etc., are some of the many types of equipment, tools, and materials that are inadvertently brought into contact with overhead powerlines. To solve this problem, NIOSH asked a senior engineering design class to develop a nonconductive remote controller that could eliminate electrocutions caused when truck drivers and crane operators inadvertently move truck-mounted cranes with remote pendant controllers into powerlines. The class designed a fiber-optic remote controller that may have application on boomed vehicles, such as truck-mounted cranes.

As part of the FACE program, NIOSH traveled to Puerto Rico to investigate five electrocutions during efforts to restore power to the island in the aftermath of Hurricane Hugo. Three of these deaths were caused by feedback currents. Although the main generator supplying power to the island had been shut down, many shops and residences had back-up generators that were in use after the hurricane. Unaware that these backup generators were supplying energy to the lines, the workers picked up or brushed against the

wires and were electrocuted. NIOSH prepared an Alert on these electrocutions, which was translated into Spanish for dissemination in Puerto Rico.

Occupational Machine-Related Fatalities and Injuries

Occupational fatality data from the National Traumatic Occupational Fatality (NTOF) database indicate that approximately 840 traumatic workplace deaths every year can be attributed to machinery. This represents about 14 percent of all traumatic occupational fatalities. In the past, NIOSH has studied ways to improve safety for working with industrial machinery such as mechanical power presses, metalworking lathes, forklifts, and robots. Analysis of NTOF data reveals that agricultural machinery, particularly tractors, may be associated with more occupational deaths each year (over 200 per year) than any other single type of machine with the exception of motor vehicles. Tractor rollovers are the principal cause of traumatic fatalities among agricultural workers. The most effective way to prevent rollovers is the use of Rollover Protective Structures (ROPS). Although many manufacturers are including ROPS on new tractors, estimates indicate that perhaps 75 to 80 percent of all tractors in use are not equipped with these devices. During FY 1990, NIOSH submitted a manuscript on Agricultural Machine Fatalities to the American Journal of Public Health and conducted a workshop for developing a national strategy on farm tractor fatality prevention, where participants drafted a strategy document on fatality prevention.

Occupational Homicides

Work-related homicide has emerged as a public health problem of significant proportion. In U.S. workplaces, homicide is the leading manner of traumatic death among women and the third leading manner of traumatic death among men. During 1980 through 1985, 13 percent of all fatal injuries that occurred at work were homicides. Nearly half of all women (42 percent) and 12 percent of all men who die from injuries in U.S. workplaces are murdered. The average workplace homicide rates for men and women during 1980 through 1985 was 1.2 and 0.4 deaths per 100,000 employees, respectively, or 8.3 deaths per 1,000,000 employees annually. While over one-quarter of those murdered in the workplace are in the age group 25-34 years, workplace homicide rates are highest among those 65 years of age and older (2.7 deaths per 100,000 employees). During 1980 through 1985, in the broadest industry classifications, at least 33 percent of the workplace homicide victims had been employed in retail trade, 19 percent were employed in service industries, and 11 percent in public administration. At 2.1 deaths per 100,000 employees, workplace homicide rates were highest in public administration. In more precisely defined industries, local passenger transportation, Standard Industrial Classification (SIC) code 41, was one of the most hazardous forms of employment: 47 percent of the victims were taxi drivers with a homicide rate of 3.5 deaths per 100,000 employees per year. Eleven percent of the homicide victims were employed in retail food sales (SIC 54) where the homicide rate was 2.2 deaths per 100,000 employees.

Almost three quarters (73 percent) of the workplace homicide victims die from gunshot wounds. Available evidence suggests that the United States is the only developed country where homicide is a significant risk in the workplace. Based on the need for further action, NIOSH is currently developing a national strategy to prevent workplace homicide. The goal of this strategy is to outline the role that NIOSH and others can play in the prevention of work-related homicide. In July 1990, experts on U.S. violence dynamics collaborated in a NIOSH-sponsored multidisciplinary workshop to interpret information on workplace homicide, recommend long-range program goals, and outline strategies to achieve those goals. Examples of proposed strategies include:

- Bullet-proof vests for law enforcement officers
- Barriers around workers as in banks, self-service gas stations, and some taxis
- Increased store lighting and visibility
- Reduced incentives for robbery-associated violence through locked drop safes and improved cash management and
- Worker training in behavioral approaches, such as conflict management, non-resistance, and compliance with perpetrator demands.

Alaska Activities for Occupational Trauma Prevention Research Of all the 52 reporting units in the United States included in the National Traumatic Occupational Fatalities (NTOF) database, Alaska consistently exhibits the highest rate of traumatic occupational death (34.2 deaths per 100,000 workers). This high rate is principally due to a disproportionate number of deaths occurring in a few occupational groups — commercial fishermen, loggers, airplane pilots, sailors, and truck drivers. In fact, transport-related incidents caused over 60 percent of Alaska s traumatic occupational deaths during 1983 through 1987. NIOSH is developing a group of Alaska-oriented program activities with emphasis on the Institute's mission in the area of occupational trauma prevention research. NIOSH recognizes that state-specific environmental, geographic, political, and social factors influence the occurrence of occupational injury, as well as how, and to what extent, cases are reported; injury data are classified, coded, and stored; state and local services are provided; industries are organized and regulated; etc. Studying occupational traumatic injuries in a single high-risk state provides special opportunities to reduce risk in those areas unique to the state, and to identify similarities with other states that will facilitate technology transfer when successful prevention strategies are demonstrated. The program will be operational in Alaska beginning in FY 1991. NIOSH-assigned field station epidemiology staff, working closely with Alaska agencies, industry and labor, will collect and analyze data for the purposes of occupational injury surveillance and risk factor identification. NIOSH field station engineering staff will work with state and federal interests to observe and analyze high-risk operations first-hand, and to investigate deaths of loggers and fishermen as cases are identified. Findings from epidemiologic risk factor analyses and worksite engineering analyses of processes, equipment, tasks, and management will result in the development of prevention strategies. As information about risk and risk reduction options is developed, NIOSH and field station staff will plan and conduct efforts to communicate such information within Alaska and to other states with comparable occupational risk.

OCCUPATIONAL CARDIOVASCULAR DISEASES

Cellular Scanning for Cardiac Toxicants

To study the effects of industrial solvents on heart tissue, NIOSH researchers observed the rhythmic contractions of cells from cardiac muscle tissue in a culture medium before and after the introduction of chemicals known to induce various cardiac disorders. The chemical agents studied included halogenated hydrocarbons, which comprise a large group of industrial solvents that can cause cardiac arrhythmia and sudden death. The researchers found that these chemicals depress the contractility of the heart cells, suggesting that halocarbons can act directly on the heart and are not dependent on other vascular, respiratory, or central nervous system responses to induce arrhythmia. By injecting a fluorescent dye into a cell and observing its spread across gap junctions to adjacent cells before and after the introduction of the hydrocarbon agent, researchers found that this class of chemicals inhibits intercellular communication, which may be the mechanism underlying the arrhythmic reaction. These types of tests suggest ways for screening workplace chemicals for any cardiac toxic properties. Publications on this research appeared in Cytotechnology, Toxicology in Vitro, the Journal of Molecular and Cellular Cardiology, and Toxicology.

DISORDERS OF REPRODUCTION

Video Display Terminals and Adverse Reproductive Outcomes

Approximately 20 million women in the United States currently use video display terminals (VDT's) in their jobs. Concern about the potential reproductive effects of VDT use began in 1981 when several clusters of birth defects and miscarriages were reported among women who used VDT's at work. To determine whether electromagnetic fields produced by VDT's cause adverse pregnancy outcomes, NIOSH conducted a study among 2,430 female telephone operators, some of whom used VDT's and others who did not. VDT use was determined through company payroll and employment records, and exposure to electromagnetic fields was assessed through a field survey of some telephone operator offices. Researchers interviewed all of the participants about their pregnancy outcomes. Findings from this study are to be published in FY 1991. FY 1990 publications about the study design appeared in *Reproductive Toxicology.*

Analysis of Exhaled Breath

NIOSH has been working on the development of a solid sorbent sampling device that permits collection and concentration of solvents present in exhaled breath. So far, researchers have successfully used this device during a study of adverse reproductive effects from exposure to methylene chloride. NIOSH will develop a commercial prototype of this sampler after the final design plans are completed. This device was initially developed to support biological exposure indices of worker uptake of toxic chemicals. However, the sampler should also permit researchers to estimate the solvent dosage throughout the workday via the development of solvent uptake curves for individual workers. The sampler may be configured to permit quantitation of extremely low concentrations of solvents in breath and, therefore, should be useful in occupational health clinics as an aid in the diagnoses of illnesses related to solvent exposures occurring prior to medical intervention.

A paper on the comparison of sampling and analytical methods for measuring *m*-xylene in breath was published in the *American Industrial Hygiene Association Journal.* NIOSH filed an application to patent the breath sampler with the US Patent and Trademark Office in January 1988, and filed a continuation-in-part for this patent as well as an application for an international patent in January 1990. Two companies have expressed interest in manufacturing the sampler.

Methods for Evaluating Reproductive Risks from Workplace Toxicants

The potential for workplace exposures to chemical and physical agents to affect reproductive functions of both male and female workers has prompted NIOSH to develop sensitive indicators for detecting decrements in the reproductive potential of workers. NIOSH has recently been involved in methods development for studies of hazards to male reproductive function. This research has led to the establishment of computerized assessments of sperm count, motility, and shape, with newer assays directed to sperm penetrability and DNA damage to the sperm cell. Longitudinal testing of human males has yielded reference values that will aid in designing occupational exposure studies. In FY 1990 this study, titled Longitudinal Semen Quality in Unexposed Workers was awarded the Alice Hamilton Science Award for Occupational Safety and Health for the second consecutive year. The sperm profiling methods developed in the study are currently being used in evaluating artillerymen exposed to lead in firing heavy weapons.

NIOSH is also studying reproductive effects in women workers. Research thus far has focused female methods study on adapting fertility indicators for workplace assessments of reproductive risk. In the researchers first evaluation, they found women willing to participate in field studies that incorporate a variety of clinical procedures used in determining the normalcy of the menstrual cycle and the period surrounding implantation.

Hormonal and other tests offered indications of the sensitivity of these procedures for eventual use in field studies, and for possible use in projects involving large populations of women workers.

Combined Chemical/RF Radiation Teratogenesis

Most standards for occupational exposure limits are set without considering the interactions between chemical and physical agents in the workplace even though concurrent exposures are common in a number of industries. For example, combination exposures to glycol ethers and radiofrequency (RF) radiation can occur in the microelectronics and plastic processing industries. Since each of these agents has been separately shown to produce birth defects in animal studies, NIOSH conducted research on whether the two together would interact in ways that could increase their potency for causing birth defects. A first study indicated that joint exposures to a glycol ether (2-methoxyethanol) and to RF radiation more than doubled the frequency of malformed fetuses produced by the RF exposure alone and exceeded the frequency shown for the glycol ether treatment by more than five times. This result has led to an effort to determine dose-response relationships for each agent when presented in single fashion and also when combined. NIOSH will continue research on uncovering mechanisms underlying any interactive effects on the reproductive measures. If significant interactions are demonstrated, they will emphasize the need to assess the hazard potential of other combination exposures. An article on this research will be published in *Teratology* in FY 1991.

NEUROTOXIC DISORDERS

Consultations to the Office of Technology Assessment

NIOSH participated in an Office of Technology Assessment (OTA) review of major public concerns and policy issues in the neurosciences. The Institute's contributions in this area were reported by OTA in 1990 in a publication titled "*Neurotoxicity - Identifying and Controlling Poisons of the Nervous System.*" Much of this report was summarized from earlier work published by NIOSH on the neurotoxic properties of over 800 chemicals found in the work environment and the worker populations at risk of health effects from exposure to them; methods development for screening and diagnosing neurotoxic effects; and determinations of the efficacy of current regulatory limits in controlling for neurobehavioral effects from acute exposures to known neurotoxic agents.

One of the recommendations from OTA's assessment was that Federal agencies should form a cooperative working group to discuss needs and accomplishments in neurotoxicological research and regulations. As a result, the Interagency Committee on Neurotoxicology (ICON) was formed and is comprised of NIOSH, the Environmental Protection Agency, the National Institute for Environmental Health Statistics, the Food and Drug Administration, the Consumer Product Safety Commission (CPSC), the Agency for Toxic Substances and Disease Registry, the National Center for Toxicological Research, the National Institute on Aging, the National Institute on Drug Abuse, and the Health Effects Research Laboratory. Since its first meeting at the beginning of FY 1990, the Committee has formed standard definitions of neurotoxic effects and established a neurotoxicity data base of chemicals shown to affect the nervous system. The Committee plans to compile an annual report on human neurotoxicants, and in FY 1990 published articles in *Neurotoxicology* and *Teratology.*

NOISE-INDUCED LOSS OF HEARING

Occupational Impact Noise

Current noise regulations specify limits for continuous noise, however, no minimal threshold limits have been established for impact noise. To study the relative hazard of conditions where workers are subjected to impact noise versus conditions where the noise is continuous, NIOSH examined groups of workers in an automobile manufacturing plant who had documented histories of exposure to both types of noise. Researchers gave each worker an audiometric examination and tested for indications of whether ear protectors had been used. The results indicated that after accounting for differences in the energy levels of the impact and continuous noise, workers exposed to impact noise showed greater hearing loss than the workers exposed to continuous noise. These findings will be further evaluated to define particular factors in impact sounds (e.g., peak level rise-time, repetition rate) that may induce hearing loss. This research is intended to determine whether impact noise should be treated differently from other industrial noise exposures when developing criteria for safe occupational noise exposures. Two articles were published in *Ear and Hearing* and *Hearing Instruments*.

DERMATOLOGIC CONDITIONS

Chemical Protective Clothing (CPC) Research

An estimated 42 percent of the U.S. workforce is at risk of dermal exposure to hazardous chemicals. The U.S. Bureau of Labor Statistics Annual Survey data show that dermatologic diseases account for approximately 30 percent of all cases of chronic occupational disease. Additionally, acute dermatologic disorders (e.g., chemical burns, acute contact dermatitis, etc.) account for an estimated three percent of all work-related hospital emergency room cases reported nationally (National Electronic Injury Surveillance System data).

As with respiratory hazards, the preferred approach to eliminating dermal exposures is by substitution of nontoxic chemicals, and where this is not possible, by putting engineering controls in place. Personal dermal protection, such as chemical protective clothing (CPC) should be used only when no other means of controlling exposures is possible, since it is not always completely effective in eliminating exposures. FY 1990 research on dermatologic conditions focused on developing methods of examining the penetration of chemical agents through holes in gloves and on evaluation of chemical permeation of CPC materials. During FY 1990, NIOSH assessed CPC requirements for furniture stripping operations, particularly by workers in sheltered workshops, and for public transit workers handling methanol fuels.

NIOSH also published A Guide for Evaluating the Performance of Chemical Protective Clothing. This guide describes a method for an industrial hygienist or equivalent safety professional to select appropriate CPC for workers, based on evaluating worksite conditions, obtaining samples of CPC candidates, and testing the samples under the conditions in which they will be used as a basis for selection. Because of growing concern over the transmission of infectious biologic agents including the human immunodeficiency virus, NIOSH has also begun research on garments used in health care and emergency response work, which will be continued in FY 1990.

Physiological Responses to the Wearing of Protective Equipment

Workers who must wear protective equipment and ensembles (respirators and chemical protective suits) encounter specific physiological stressors, including those that affect the respiratory system. NIOSH is conducting research to protect workers from such harmful effects. The research includes evaluations of the respiratory and thermal stresses encountered by workers using closed circuit self-contained breathing apparata (SCBA), such as those used in firefighting, hazardous waste operations, and other strenuous jobs. Researchers examined the effects of hot, humid inspired air on SCBA users to compare the effects of cool/dry, cool/humid, hot/dry, and hot/humid inspired air on lung mechanics, including dynamic compliance during rest, low, and moderate exercise. The results of this study demonstrated several positive effects of hot air breathing on lung mechanics. Dynamic lung compliance was increased with both hot/dry and hot/humid air breathing during rest and exercise. These increases in compliance imply a decrease in the inspiratory work of breathing, although no statistically significant decreases were demonstrated. Frequency of breathing was decreased and tidal volume increased with hot air, allowing a more efficient breathing pattern. These results support the current inspired air temperature criteria for SCBA certification, as set forth in 30 CFR Part 11 and the proposed revision (42 CFR Part 84).

PSYCHOLOGICAL DISORDERS

Consultations to the Office of Technology Assessment on Issues of Shiftwork, Health, and Well-being

NIOSH participated in an Office of Technology Assessment (OTA) review of existing research information on biological rhythms and their implications for shiftwork and extended workday schedules. OTA conducted the review to identify knowledge gaps and programmatic needs for determining whether disruption in biological rhythms due to irregular work schedules or excessive hours of work contribute to health and safety problems. The review included the Institute's published studies of worksite evaluations showing fatigue buildup over the course of 10-12 hour workdays, problems of sleep loss among shiftworkers, and NIOSH analyses of strategies for overcoming these kinds of problems. Other high priority topics identified in the review were developing guidelines for designing work schedules and setting limits for overtime hours. An article about this research was published in *Shiftwork*.

Occupational Incidence of Stress Related Disorders

Workers' compensation claims and questionnaire surveys indicate a sharp rise in health problems resulting from stress experienced on the job. NIOSH identified occupations and job factors associated with an increased risk of emotional and cardiovascular problems by merging a data base of job-specific activities with Social Security Administration disability files and questionnaire survey data reporting various types of stress-related morbidity and health complaints. Correlational analyses and odds ratios found both mental and cardiovascular problems to be excessive for service workers and laborers. Transport workers and farmers showed increased risk for mental problems while household employees, craftsmen, and foremen evidenced increased cardiovascular problems. Job factors reflecting lack of job control or decision-making, variable shift work, and responsibility for the safety of others were correlated with increased reports of psychological distress and chest pain in some comparisons, and increased cardiovascular problems in others. These results suggest target worker groups and job design factors requiring further study in clarifying health effects of stress and needs for their alleviation. An article is currently in press for publication in the Journal *of Clinical Epidemiology* and another article appeared in the *Journal of Occupational Medicine*.

OTHER DISEASES OF OCCUPATIONAL ORIGIN

Renal Disease

More than 125,000 Americans suffer from end stage renal disease (ESRD). Treatment of this disease is paid for by the Federal government and costs over $2 billion per year. Little is known about the causes of most ESRD, although review of the scientific literature shows that heavy acute exposures to metals (e.g., lead), solvents (e.g., carbon tetrachloride), and silica can cause acute renal failure. There have also been a number of case-control studies of chronic renal disease implicating solvent and metal exposure. To further investigate this problem, NIOSH conducted a case-control study of 325 male ESRD cases in Michigan, and 325 age, race, and sex-matched controls. Cases occurred from 1976-1984 in four urban areas of Michigan and were selected from an ESRD state registry. Con-genital, obstructive, heroin, and diabetic nephropathy cases were excluded from the study. Results showed that exposure to silica and solvents was significantly associated with ESRD, with solvents used as degreasers and silica exposure in foundries and sandblasting having the highest odds ratios. Exposure to lead also appeared to increase the risk associated with ESRD. Nonoccupational variables significantly associated with ESRD included family history (close relatives only), regular use of acetaminophen/phenacetin, and regular use of moonshine whisky (presumably contaminated by lead). Results of this study have been published in the *American Journal of Public Health.*

AGRICULTURAL DISEASES AND INJURIES

According to the U.S. Department of Agriculture, 13.1 million persons in the United States have some farm income; 6 million are farm family members; and 3.2 million are full-time workers in agriculture. Agricultural workers and their families experience a disproportionate share of injuries and disease associated with numerous chemical, biological, and physical hazards. Workers in the agriculture industry have the fourth highest occupational fatality rate. While it constitutes only about 2 percent of U.S. workers, agriculture ranks fourth highest in numbers of work-related traumatic fatalities, accounting for 724 deaths annually. Of the estimated 1,500 machinery-related deaths annually among all occupations, more than half involve farm equipment, particularly tractors. NIOSH information from a nationwide sample of hospital emergency room visits suggests farm workers have excess risks for fractures, amputations, and dislocation injuries associated with their occupation. Farm workers also show increased rates of mortality and disease for cancers of the stomach, lung, pancreas, kidney, hematopoietic system, and urinary system and increased rates of cirrhosis and other liver disease; respiratory illnesses, such as chronic obstructive pulmonary disease, asthma, pneumonitis, and bronchitis; cerebrovascular disease, cardiovascular disease, and chronic musculoskeletal disorders.

During FY 1990, NIOSH initiated work on surveillance, research, and intervention in agriculture. Research in this area will utilize existing agricultural information networks, such as the state and county cooperative extension service, the agricultural land grant university system, state health departments, and other organizations. The following projects have been funded under the Institute's agricultural initiative:

Farm Family Health and Hazard Surveillance

NIOSH is funding this surveillance program to document the health status of agricultural workers and their families and the work-related risk factors and conditions of exposure to potentially hazardous agents. States will develop surveillance strategies and collect data on farm-related health status and health hazards. These data will be used to develop disease and injury prevention, health promotion, and hazard reduction strategies.

Occupational Health and Safety Surveillance through Health Departments and Nurses in Agricultural Communities

This program was designed to develop intervention strategies for reducing injury and disease rates among agricultural workers and to develop more complete information on the types of injuries and diseases that occur in this population. The surveillance programs will link state health departments to agricultural areas and, in some instances, to local hospitals. Nurses in agricultural communities will collaborate with state and local health departments and other community resources to identify and report health events related to agricultural hazards; provide targeted educational interventions; and conduct community evaluations of potential risks to agricultural workers.

Demonstration Cancer Control Projects for Farmers

NIOSH is funding demonstration projects on effective cancer control for farm populations to demonstrate the effectiveness of a strategy to reduce cancer morbidity and mortality among farm populations by utilizing existing networks of rural nonprofit hospitals. Surveillance data have suggested that some groups of farmers may be at increased risk of cancers of the hematopoietic system, skin, lip, prostate, and stomach. These projects are to provide a strategy for the prevention, screening and early detection, and timely treatment of cancer. This type of cancer control was developed by the National Cancer Institute as part of its strategy to reduce cancer mortality by 50 percent by 2000. The projects will demonstrate that morbidity and mortality from cancer can be reduced by more effective use of information on prevention, detection, and treatment, especially by groups at high risk of either developing cancer or not surviving from it.

Agricultural Health Promotion Systems

NIOSH is helping to establish an agricultural health promotion system through occupational safety and health programs at existing cooperative extension services (CES) and land grant universities. NIOSH funds will be used to provide agricultural workers with information, education, and referral services through these programs. The programs will be responsible for disseminating information and conducting programs on injury and illness prevention among agricultural workers and their families.

Centers for Agricultural Research, Education, and Disease and Injury Prevention

This program was designed to: develop and conduct applied preventive research relative to the occupational health and safety of agricultural workers and their families; develop model educational programs on agricultural workers and their families; and develop model programs for the prevention of illness and injury among agricultural workers and their families; evaluate agricultural injury and disease prevention programs implemented by agricultural extension programs, state health departments, Federal agencies, and others; conduct applied research and evaluation of engineering and ergonomic control technology and procedures developed by Federal, state and private agencies; and provide consultation and training to researchers, health and safety professionals, graduate professional students, and agricultural extension agents.

In addition to the cooperative agreements, NIOSH is conducting the following research:

Agricultural Lung Diseases

NIOSH is conducting 12 research projects on respiratory diseases associated with exposures to agents present in agricultural work. In some of these projects, researchers are assessing the roles of microbes, fungal spores, organic dusts, and endotoxin, and the lung's response to these irritants. Agricultural projects also include lung disease program peer review, respiratory disease surveillance in agriculture, and respiratory disease technical support for nurses in rural hospitals. All of these projects will be continued in FY 1991.

Surveillance of Farmers and Farm Families

NIOSH is developing a uniform agricultural traumatic injury surveillance system for implementation through agricultural extension safety specialists at the state level. This surveillance system will provide injury and work exposure information needed to estimate the numbers and rates of agricultural injuries at the state, regional, and national level. Data from the system will be used to develop a national agricultural injury survey. In a related project, NIOSH is developing a model injury questionnaire and assisting states will be collecting data under the Farm Family Health and Hazard Survey.

Ammonia Releases in Agriculture Applications

Although there is no national systematic reporting of agricultural anhydrous ammonia incidents, reports reveal that there have been fatalities and numerous injuries due to anhydrous ammonia releases in Ohio. The seriousness of the health effects caused by anhydrous ammonia exposure, coupled with the widespread use of anhydrous ammonia, prompted NIOSH researchers to propose a hazard and operability (HAZOP) study in an attempt to identify factors to reduce the likelihood of injury. This technique will be used to identify potential problems with design or work practice and to make suggestions for elimination or reduction of these problems. NIOSH plans to conduct a systematic review of all types of equipment used in ammonia application operations. In FY 1990, NIOSH conducted a walk-through survey to observe anhydrous ammonia equipment and application and to gather background information. Site visits were conducted at two retail ammonia outlets and at a farm. Review of records from the Ohio Department of Agriculture of ammonia-related incidents were examined, and although they were incomplete, researchers were able to identify possible problem areas. Work in this area will be continued in FY 1991.

CONSTRUCTION INDUSTRY DISEASES AND INJURIES

Construction work presents unique problems in occupational safety and health. About 7 million people are employed in construction, and this population is mobile, widely dispersed, and often lacking in job training and skills. The average turnover rate in construction is approximately 178 percent per year. The majority of construction companies are small businesses: 96 percent employ less than 50 workers, and many of these do not have formal safety and health programs. Conditions at construction sites change from day to day throughout the course of the project and several activities, each requiring its own crew, materials, and tools may be ongoing concurrently. Not only are the types of activities constantly changing, but locations of construction sites frequently move as well. NIOSH estimates that construction operations are ongoing at approximately 5 million sites at any given time. Many of these sites exist for only a few days, although some may last for more than a year. Construction workers die as a result of work-related trauma at a rate that is over three times the annual rate for workers in all industry sectors (24.1 deaths per 100,000 workers in all industry sectors). They are also at higher risk for nonfatal injuries, lost time from work, or restricted work activity. Additionally, construction workers are at risk for occupational lung diseases, musculoskeletal disorders, hearing loss, and dermatologic conditions from workplace exposures.

The FY 1990 NIOSH construction program has been initiated to target the variables and problems associated with construction work. Most of the NIOSH research is related to on-site management of safety and health programs, with particular emphasis on small employers. NIOSH is funding several projects including 1) the Model Construction Safety and Health Program, whose purpose is to reduce the toll of occupational injuries and illnesses in the construction industry within the awardee's state; 2) a study of equipment design by evaluating falls from construction vehicles and failure modes of a specific type of suspended scaffold; 3) work practices and procedures through the Model program, as well as a project to provide technical assistance during construction of the new NIOSH facilities at Morgantown, WV. This initiative also includes surveillance activities focusing on 1) falls from elevations and contact with electrical energy; 2) evaluation of available databases containing information on falls from elevations in construction; 3) establishing an injury reporting system for employers involved with the erection of structural steel; and 4) activities associated with the FACE and NTOF projects.

Construction Worker's Health

In response to a request from the Building and Construction Trade Unions, AFL-CIO, NIOSH provided assistance for the identification and evaluation of occupational health risks to construction workers. Researchers analyzed the 1984-86 NIOSH occupational mortality surveillance data for the proportionate mortality patterns of construction workers in special trades. These data were obtained from 19 states that, along with the National Cancer Institute and the National Center for Health Statistics (NCHS), have shared the added costs of coding occupation and industry on their death certificates. Results show that several site-specific cancers and other chronic disease statistics were significantly elevated for 61,682 white male construction workers. Men younger than age 65, who were probably still employed at death, had significantly elevated proportionate mortality ratios for cancer, asbestos-related diseases, mental disorders, alcoholism, digestive diseases, falls, poisonings, industrial fatalities, and homicides.

As part of the evaluation, NIOSH researchers also assessed membership records of 14 national building and construction trade unions for potential use in surveillance and research of construction workers health risks. As a result of these findings, NIOSH has begun follow-up evaluations of the health and safety of construction workers. NIOSH submitted an article about this assessment to the *American Journal of Public Health* and published an article in the *Scandinavian Journal of Work and Environmental Health.*

Control of Lead in the Construction Industry

Until banned for use on residences, lead-based paints were used as a protective coating for houses, as well as buildings, bridges, storage tanks, and other structures. Maintenance of structures or rehabilitation of homes often require the removal of paints that have deteriorated so that new protective

coatings may be properly applied. In recent years, many Federal and state regulations have been passed restricting the contamination of the atmosphere, water, or soil by hazardous substances, including various forms of lead. As a result, it is necessary for work to be performed in enclosures that prevent the emission of banned substances. However, working in these enclosures may increase the potential for hazardous exposures to workers who perform these operations. This practice has resulted in several workers requiring hospitalization or outpatient treatment for lead poisoning. In FY 1991, NIOSH began investigating and documenting current engineering controls, or those under development for reducing lead exposures during the rehabilitation and maintenance of buildings and bridges.

HUMAN IMMUNODEFICIENCY VIRUS

Battelle Project

NIOSH is conducting a project to assess the dissemination and use of CDC guidelines for prevention of occupational transmission of Human Immunodeficiency Virus (HIV) to health-care workers. Specifically, this project will address two issues: 1) an assessment of the extent of compliance with CDC guidelines by health-care workers and 2) an assessment of factors that influence the compliance with CDC guidelines by health-care workers. This information will be used in formulating regulatory policy (by OSHA) and developing priorities for efforts to increase compliance. Information the survey provides about factors influencing compliance can help labor, management, and the medical community develop strategies to better protect the safety of health-care workers.

Aerosolization Project

Under an interagency agreement with the Department of Energy, NIOSH is conducting research to measure the physical, chemical, and biological nature of aerosols to determine whether operating room personnel are at risk of infection from aerosols generated during surgical procedures in which high energy surgical tools are used. Researchers will evaluate the simulation of surgical procedures employed in medical practice and sampling positions relative to these surgical procedures will be determined to assess exposures of both the surgeon and other operating room personnel. Both videotaping and aerosol measurements will be used to provide for documentation of the production of aerosols during the use of various types of tools.

Glove Project

Under an interagency agreement with the Department of Energy, NIOSH is attempting to find methods to evaluate the penetrability of latex surgical gloves by viruses, particularly HIV, after being subjected to stress levels and body fluids. An electro-conductivity test will be validated in which a gloved hand is placed inside a tub with an electrically charged salt solution. Any electrical current passing between the solution and the glove wearer (surgeon and operating room personnel) will be measured on a micrometer.

Sensor Project

NIOSH is conducting a project among SENSOR states to determine the number, type, and frequency of emergency first-responders exposures to potentially infectious blood during the normal course of their work. These data will be used to create or modify existing guidelines addressing workplace exposure to blood.

Educational Resource Center, Inc. Project

Through ERC, Inc., NIOSH is providing funds for research of emergency first-responder and laboratory worker safety during exposure to and handling of infective material. In FY 1990, six Educational Resource Centers were provided funds: four to perform compliance studies of health-care workers to Universal Precautions Guidelines; one to develop an innovative control technology course for health-care workers; and one to look at aerosolization of blood during surgical procedures. Final results from this research will be reported at the end of FY 1991.

CONTROL

The goal of the Institute's prevention program is to control work-related diseases and injuries by discovering, assessing, and improving measures that can reduce occupational hazards. This, too, is accomplished through targeted research in the areas of control technology and personal protective equipment. In the latter category, NIOSH, in conjunction with MSHA, tests and certifies respirators based on their compliance with requirements in 30 CFR 11 and 30 CFR 74.

NIOSH maintains analytical chemistry and biological expertise to support its laboratory research and field studies. Air and biological samples are analyzed and new methods are developed for sampling and measuring toxic materials.

OCCUPATIONAL LUNG DISEASES

Respiratory Protective Devices

Engineering solutions (such as designing systems to enclose, ventilate, or otherwise contain or separate the harmful substances from workers) are often sought in the attempt to eliminate exposures to the human respiratory system from inhalation of hazardous atmospheres. However, not all substances used in workplaces have viable substitutes and, in some cases, some means of respiratory protection is needed when engineering controls are installed. Respirators are mechanical devices used in high-hazard environments to prevent immediate, adverse health effects and deaths in environments where airborne contaminants are produced and when it is impossible to substitute non-toxic substances. Respirators provide protection either by removing contaminants from the air before it is inhaled (air-purifying), or by supplying an independent source of respirable air (atmosphere-supplying). Up to 6.6 million American workers use NIOSH-certified respirators, either full or part time. By the mid 1990's, this number could be as high as 10 million.

NIOSH conducts respirator research in support of the Federal respirator testing and certification program. To do so, researchers examine fundamental questions regarding the performance of respirators. New performance standards based on research findings are developed. Test methods are drafted, validated through interlaboratory testing, and evaluated for technical feasibility and efficacy. Recommended standards are developed and introduced into the rulemaking process.

Respirator Certification

In addition to respirator research, NIOSH tests and certifies respirators to ensure that they meet minimum performance standards established in the certification regulations (30 CFR Part 11). During FY 1990, NIOSH processed 429 applications for approval, granted 363 approvals and extensions of approvals, and granted 49 non-functional minor revisions. NIOSH also conducted performance audits of 88 new off-the-shelf (those purchased directly from respirator retail outlets) models. Ten audits resulted from complaints or problems reported by respirator manufacturers or users. To ensure that respirator manufacturers maintain high quality production of NIOSH/MSHA certified respirators, NIOSH reviews the quality assurance plans and procedures of respirator manufacturers. In FY 1990, NIOSH reviewed and evaluated the quality assurance plans of 429 certification applications to determine compliance with the Regulations and conducted 29 in-plant quality assurance audits of MSHA/NIOSH-certified respirator manufacturers.

In addition to respirators, NIOSH also tests and certifies Coal Mine Dust Personal Sampler Units (CMDPSU's). CMDPSU's are exposure-monitoring devices required by the regulations governing health and safety in the mining industry, which are administered by the Mine Safety and Health Administration (MSHA). During FY 1990, NIOSH approved seven modifications to the approvals for currently certified CMDPSU's, and conducted quality assurance audits of all certified CMDPSU's.

Workplace Protection Factor Research

The level of protection provided by a respirator is expressed as a workplace protection factor (WPF), which is the ratio of the concentration of airborne contaminant in the atmosphere of a working environment to the concentration inside a respirator facepiece, i.e., in the worker s breathing zone. NIOSH analyzed samples from a survey of a lead-battery facility to find out whether area particle size distribution (PSD) is a reasonable approximation of the PSD in the worker's breathing zone as would be determined by a personal sampler. The data from 12 workers showed a statistical difference between area and personal samplers for the majority of stages for the five elements evaluated. The differences in the resulting adjusted WPFs, however, were less than 15 percent.

NIOSH has conducted preliminary studies to evaluate simulated workplace protection factor measurements (those derived from laboratory tests designed to simulate as closely as possible conditions in the working environment) as predictors of the performance of respirators in actual workplaces. Preliminary analysis indicates a very low correlation between the simulated laboratory test developed to predict workplace performance and the measured workplace protection factor. Related research is underway to develop and apply techniques to estimate workplace performance of positive pressure self-contained breathing apparatus (SCBA), such as those used in firefighting. Work conducted to date indicates that analytical methods to predict WPF values of positive pressure SCBA when used in firefighting are possible. Future work will include assessment of how various characteristics and levels of respirator programs affect the protection afforded workers who wear respirators. Information on the efficiency of respirator programs and the components of respirator programs will enable employers to develop practical, effective programs that result in optimal worker protection.

Filter Loading Effects with a "Worst Case" DOP Aerosol

Previous NIOSH research identified that particles within a specific size range penetrate respirator filter media more readily than other-sized particles. This size range is known as worst case. NIOSH tested the efficiency of respirator filters against a dioctyl phthalate (DOP) aerosol with particles in this range. Particles evaluated include dust and mist; dust, fume, and mist; paint, lacquer, and enamel mist; and high efficiency particulate filters from various manufacturers of commercial respirator particulate filters. The results indicate that commercially available high efficiency filters were effective against a worst case DOP aerosol. Filter efficiency values greater than 99.97 percent were observed in all cases, and loading effects appeared to be minimal for the high efficiency filter tested.

Development of Emission Controls for Laser Processes

The use of lasers in surgery has generated concern about potential health effects of exposure to emissions from the interaction of the laser beam with tissue. These emissions may contain benzene, aldehydes, and polycyclic aromatic hydrocarbons, which are potentially harmful to the lungs. NIOSH evaluated the control of emissions from laser processing and provided guidelines for a wide range of applications for the controls developed.

Through laboratory analysis, researchers found that a number of factors affect the collection of emissions by a smoke evacuator, including evacuator flow rate, nozzle configuration, and the velocity and direction of external air flow in relation to the nozzle flow. When the external air is in the same direction as the nozzle flow, efficiency collection of emissions at further distance from the tracer gas release point is possible, while for other directions, efficiency degrades rapidly with distance. In subsequent field demonstrations, researchers found that at 30 watts of laser power, collection of emissions was similar to that observed in the laboratory tracer gas study. At 60 and 100 watts of laser power,

higher air velocities were needed for control and the nozzle needed to be placed closer to the site of laser interaction. During FY 1990, a paper on factors affecting emission collection by surgical smoke evacuators was published in *Lasers in Surgery and Medicine.*

Control of Lead Exposures in Indoor Firing Ranges

Over the past 13 years, NIOSH has received many requests for assistance in reducing exposures from airborne lead at firing ranges used by law enforcement personnel for periodic qualification tests. About 1.3 million law enforcement employees who are required to be proficient in the use of firearms may receive exposures to lead in firing ranges. To develop recommendations for implementing a ventilation control system for firing ranges, NIOSH constructed a model firing range to evaluate airflow patterns that will be effective in airflow patterns and in the creation of large-scale eddies. These large-scale eddies can carry airborne gun emissions from downrange positions back to the shooter's breathing zone, which leads to lead exposures. The effectiveness of several inlet configurations was tested in the model firing range by videotaping generated smoke and by measuring tracer gas. The inlet configurations that provide for firing range airflow that is free of back flow have been further documented, and a double pegboard wall used to baffle the inlet was found to eliminate backflow due to large scale eddies. Further improvements were achieved when a variable airflow system was used. When air is supplied alternatively to one side or the other of the double inlet, the air at points in the range flows correspondingly in two different directions. This upsets the stable flow necessary to maintain large scale eddies, thereby suppressing or eliminating eddy-generated backflows as a cause of exposure. A patent application has been filed for the variable airflow eddy control and efforts are underway to commercialize this concept. A paper has been accepted for publication in the *American Industrial Hygiene Association Journal.*

Asbestos Removal Control Technology Assessment

In conjunction with the Environmental Protection Agency, NIOSH evaluated the effectiveness of glove bags as a control measure in asbestos removal, as well as sampling and analytical procedures to determine clearance levels. (This is done to make sure asbestos fibers have not been released in the air during the removal process.) The results of this research indicated that the glove bag control method is not effective protection in asbestos removal. NIOSH evaluated alternate control technology that may overcome some of the deficiencies of the glove bag control method, including a custom-made glove bag that uses local exhaust. During this research, NIOSH confirmed that there were significant deficiencies in the state-of-the-art for transmission electron microscopy (TEM) clearance methodologies. While the research supported the need for TEM methods, it also was found that there is a lack of standardization and validation of the method. TEM is now incorporated in the EPA Asbestos Hazard Emergency Response Act regulations as the required clearance method for larger jobs. NIOSH prepared a Technical Report on its research of glove bags for dissemination during FY 1991.

Methods for Evaluating Indoor Air Ventilation

Indoor air quality (IAQ) can be affected by biological contamination of ventilation system components, poor system maintenance, chemical contamination from inside and outside the building and inadequate amounts of outside air delivered to the zones occupied. Poor IAQ, in some cases, has resulted from energy conservation measures taken in response to the energy crisis of the 1970's since these measures often sought to limit the exchange of heated or cooled air inside the building with the air outdoors. The health effects of poor IAQ can range from increased incidence of respiratory diseases to irritation of the eyes, nose, and throat. NIOSH researchers are evaluating procedures for determining the adequacy of ventilation systems in providing outside air to building occupants and developing a guidance document for conducting field investigations of building ventilation systems. By the end of FY 1990, researchers had developed and evaluated four methods: 1) a

tracer decay method used to estimate ventilation rates; 2) the use of tracer gas to measure the airflow in short ducts; 3) the use of temperature- and humidity-measuring instruments to determine percent outside air in the supply air; and 4) the use of flow measuring instruments to determine the outside air flows delivered to the occupants. A journal article on the comparison between flow measurements and trace decay methods was submitted to the *Building and Environment Journal.* A NIOSH guidance document, to be published as a Technical Report, is planned for FY 1991.

Development of Predictive Models for Determining Control Effectiveness

Local exhaust systems are an important means of capturing contaminants before they escape into the workplace and cause harmful exposures. Recently, there has been a great deal of interest in predicting hood flow patterns to determine their effectiveness in directing contaminants away from the worker. Currently, the ability to predict the performance of a ventilation control is limited. A general approach, based on potential flow theory, has been developed that may be used in the calculation of the equal velocity contours of unobstructed local exhaust openings using a two-dimensional configuration. The approach involves solving a boundary value problem in which the shape and location of the boundary (the velocity contour) is not known initially. The boundaries of the flow, consisting of the surfaces of constant velocity potential and the desired constant normal derivative of the potential, are initially assumed. Numerical methods based on comparison of the calculated normal derivatives and the desired value, are used to arrive at the correct shape and location of the boundary (constant air velocity surface). Earlier research was conducted on a finite difference method for solving Laplace's Equation (based on experiments, this equation governs the flow of air into exhaust hoods) in the region interior to the boundary of the flow into an exhaust opening. An article on this research was published in the *American Industrial Hygiene Association Joumal.*

Dust Control for Falling Solids

Dustiness tests have been proven to be effective in evaluating the potential of dry materials to cause workplace exposures. This is important because chemical manufacturers can use these procedures to develop or improve existing products with lowered hazard potential. Similarly, industrial consumers of dry materials can utilize these tests to select suppliers of dust-free products. The dustiness tests were evaluated by NIOSH by comparing dustiness test results to worker exposure measurements for various powder handling operations in three plants. Improved controls for a manual chemical weight-out station were developed. Overall, an approximately 20-fold reduction in exposures was achieved through a combination of fresh air supply, local exhaust, and ergonomic improvements.

Two of these dustiness tests were also subjected to field and laboratory evaluations. The laboratory evaluations showed that dustiness tests are strongly affected by variations in test parameters. During the field evaluation of these testers, a good correlation between worker dust exposure and dustiness tests results was observed at only one out of four study sites. To identify the various processes that may lead to aerosol formation, the effect of handling parameters on dust generation was studied in a test chamber. In general, the data show that the creation of airborne dust by falling powders involves two different generation processes that are in series with a dispersion process.

A summary report was written for the Environmental Protection Agency (EPA) which partially supported this research through an interagency agreement. This report contains an exposure estimation procedure that could be used during Premanufacturing Notice Reviews conducted by EPA. The exposure estimation procedure is based upon the observed correlation between worker dust exposure and dustiness test results. The limitations of this procedure are discussed in the summary report. Two articles, one reviewing the field studies indicating that exposures were not always correlated with material dustiness, and the other based on the laboratory studies, were published in *American Industrial Hygiene Association Journal.* A third paper containing suggestions for reducing dust generation was submitted to the *American Industrial Hygiene Association Journal.*

Control Technology for Small Businesses

NIOSH is conducting research to provide control technology information for preventing disease in small businesses that may not have access to current technology. The focus of this research has been to develop and disseminate control technology information to radiator repair shops, many of which are small businesses. This industry was selected because: 1) contacts with state occupational health programs have identified radiator repair shops as a high-risk small business, 2) the high incidence of violations for exposure to lead (e.g., 80% incidence of violations in one state), 3) the large number of high blood lead levels reported for small businesses including radiator repair (California), 4) the large number of radiator shops in the U.S., and 5) these shops typically do not have the resources to evaluate or develop controls on their own. In collaboration with NIOSH industrial hygienists, a low-cost ventilation control system was evaluated that appeared to have the potential for widespread application to relatively small shops without resources to buy an elaborate ventilation system. NIOSH developed a control that would protect workers from exposure to lead. Using this design, a ventilated booth was fabricated and installed in a Denver radiator repair shop. The ventilation booth, consisting of an enclosure around a workstation, was installed over the radiator repair tank. The ventilated booth provided excellent control of lead exposures. Prior to installation of the ventilation control, a NIOSH industrial hygienist found lead exposures in the shop that were five times the OSHA permissible exposure levels (PELs). A case study of this cost-effective ventilation control for radiator repair shops will be published in the next fiscal year.

Also, an in-depth control technology survey report for a high production radiator repair shop in Reno, Nevada, was finalized and submitted to the National Technical Information Service. A report summary was published in the *Automobile Cooling Joumal*, which is distributed to 10,000 radiator repair shops.

Two in-depth control technology surveys were conducted in the summer of 1990. A survey was conducted at a radiator repair shop in Chamblee, Georgia, to evaluate a newly designed ventilated booth. Suggestions for the design of this ventilation control were made by NIOSH researchers, based on previous control technology work from this project. A health hazard evaluation conducted at this shop a year before the control technology survey showed excess blood lead levels and lead exposures up to four times the OSHA PEL. The other control technology survey was conducted at a radiator repair shop in Charlottesville, Virginia, to evaluate a ventilation control consisting of a flexible duct with a canopy-shaped hood.

Sensor Development (Optically Read Sensor)

NIOSH developed a device for monitoring exposures to ammonia and mercury vapor in the personal breathing zones of workers. This device can monitor for both real-time exposure (while they are occurring), and time-history determination (cumulative exposures over a period of time or at intervals). The monitor operates on a colorimetric reaction of contaminant with a translucent layer of reactant, the color of the coating on this film changing in intensity with the level of contaminant. This color change is monitored by dual beam optics to compensate for temperature and power fluctuations. The monitor is equipped with an alarm to warn the user if the exposure reaches a predetermined level, generally the eight-hour OSHA permissible exposure level. The advantages of this type of monitor are its small size, near real-time monitoring capabilities, cost effectiveness, and its ability to potentially eliminate the need for free-liquid containing devices, which may contain toxic liquids and are difficult to operate. A patent currently is pending on this device. If it is granted, a licensee with expertise in the production of thin film coatings could expand the device's capabilities to include a large number of analytes since fairly sensitive and specific colorimetric reactions are available. An article discussing this monitor will be published in FY 1991.

MUSCULOSKELETAL DISORDERS

Ergonomic Technical Assistance and Research Identification

NIOSH provided technical assistance in reducing injuries to the musculoskeletal system to a cabinet manufacturing operation, a poultry preparation plant, and a Veterans Administration Medical Center. NIOSH assisted ergonomists in evaluating tasks involving lifting and lowering, carrying, pushing/pulling, sustained posture, repetitive hand/arm motions, and operating vibrating tools. For each of these exposures, control strategies are listed in the order of preferred precedence from elimination to substitution to control. For example, at the cabinet manufacturing facility, jobs were identified that imposed potentially stressful biomechanical demands on workers. These included heavy lifting, pushing and transporting heavy loads, fatiguing postures, repetitive lifting involving twisting the trunk and excessive reaching, and repetitive motions of the trunk and upper limbs. Recommendations to reduce injury risk focused on redesigning equipment to reduce stress during heavy lifting, transporting loads, and while performing repetitive tasks. For example, installation of work stations that can be individually adjusted to suit individual workers and installation of powered conveyors in lieu of requiring workers to pull and push materials over flat surfaces or rollers, were suggested for specific tasks. NIOSH also recommended that basic safety training, which included information on body mechanics, safe lifting, care of the back and neck, machine safety, and first aid measures for injuries, be given at new employee orientation, and periodically as refresher training. A paper describing the cabinet manufacturing assessment will be published in FY 1991. At the poultry processing plant, workers had been pushing carts that weighed up to 2,000 pounds from a poultry production line to a weigh scale. NIOSH performed an engineering analysis of the forces exerted by workers to manipulate the cart at various points during the task and made recommendations principally aimed at reducing the risk encountered by pushing the cart up an inclined ramp to the scale. At the VA Medical Center site NIOSH evaluated the back injury prevention program for persons engaged in patient handling and other manual handling tasks. Suggestions included the purchase of additional patient handling and load handling equipment, and reviewing the quality of the training program for nursing staff.

Ergonomic Technical Assistance

NIOSH provided technical assistance in reducing injuries to the skeletal system to a cabinet manufacturing operation, a poultry preparation plant, and a Veterans Administration Medical Center. At all three locations, NIOSH evaluated tasks that involved lifting and lowering; carrying, pushing and pulling; sustained posture; repetitive hand and arm motions; and operating vibrating tools, and made recommendations for control strategies for reducing these injuries.

At the cabinet manufacturing facility, NIOSH identified jobs that imposed potentially stressful biomechanical demands on workers. These included heavy lifting, pushing and transporting heavy loads, working in fatiguing postures, repetitive lifting that involved twisting the trunk and excessive reaching, and repetitive motions of the trunk and upper limbs. NIOSH recommendations included redesigning equipment, installing work stations that could be adjusted to suit individual workers, and installing powered conveyors to eliminate the need for workers to pull and push materials over flat surfaces or rollers. NIOSH also recommended that basic safety training be given at new employee orientation and periodically as refresher training. This training should include information on body mechanics, safe lifting, care of the back and neck, machine safety, and first aid measures for injuries. A paper describing the cabinet manufacturing assessment will be published in FY 1991.

At the poultry processing plant, workers had been pushing carts that, when laden with poultry parts, weighed up to 2,000 pounds. The job required workers to push these carts from a processing line up an inclined ramp to a weighing scale. Researchers analyzed the forces exerted by workers during this task,

and provided recommendations to the requesters for reducing the risk encountered by pushing the cart up the ramp.

At the VA Medical Center site, NIOSH evaluated the back injury prevention program for persons engaged in patient handling and other manual handling tasks. NIOSH suggested to the requesters that additional patient handling and load handling equipment be purchased, and reviewed the quality of the training program for nursing staff.

Low Back Injury Control and Rehabilitation Strategies for Federal Workers

Twenty-four percent of all injuries occurring in Federal workplaces are to the lower back. Nearly 80 percent of the workers incurring low back injuries return to work in less than 6 weeks, however, the remaining 20 percent of the injured workers may be unable to return to work for more than one year. NIOSH was requested by the Department of Labor (DOL) to provide technical assistance in evaluating the efficiency of two injury control methodologies aimed at helping injured Federal workers return to work. One method involved predicting workers at risk for incurring low back injuries requiring long recovery periods; the other was a patient advocate system designed to facilitate an early return to work. NIOSH assisted DOL in developing proactive injury control methods for reducing low back injuries for those workers at risk for low back injuries. This technical assistance addressed epidemiologic analysis of compensation data on low back injuries; a summary of literature on the medical rehabilitation of low back injuries; and the development of an experimental protocol for examining the efficacy of a patient advocate system for workers suffering from low back injuries. This protocol will be implemented by DOL during FY 1991. Findings on the evaluation effort will be also reported during FY 1991.

OCCUPATIONAL TRAUMATIC INJURIES

Occupational Machine-Related Fatalities and Injuries

Occupational fatality data from NTOF indicate that approximately 840 traumatic workplace deaths every year can be attributed to machinery. This represents about 14 percent of all traumatic occupational fatalities. In the past, NIOSH has studied ways to make it safer for workers to work with industrial machinery such as mechanical power presses, metalworking lathes, forklifts, and robots. However, analysis of NTOF data reveals that agricultural machinery, particularly tractors, may be associated with more occupational deaths each year (over 200 per year) than any other single type of machine with the exception of motor vehicles. Tractor rollovers are the principal cause of traumatic fatalities among agricultural workers. The most effective way to prevent rollovers is the use of Rollover Protective Structures (ROPS). Although many manufacturers are including ROPS on new tractors, estimates indicate that perhaps 75 to 80 percent of all tractors in use do not have such protective equipment installed. During FY 1990, NIOSH submitted a manuscript on Agricultural Machine Fatalities to the *American Journal of Public Health* and conducted a workshop for developing a national strategy on farm tractor fatality prevention, where participants drafted a strategy document on fatality prevention.

OCCUPATIONAL CANCER

Control of Formaldehyde Exposures in Embalming Procedures

Formaldehyde-containing solutions are the predominant embalming agents used in most U.S. mortuaries. NIOSH has classified formaldehyde as a potential occupational carcinogen. To reduce exposure to formaldehyde in embalming procedures, NIOSH is developing ventilation controls and will disseminate this information to embalmers and funeral directors. Review of the literature showed that several studies had been conducted to evaluate embalmers' exposures to formaldehyde. Some of these studies related to the effects of dilution ventilation upon exposures, but few were found regarding local exhaust ventilation in mortuaries. A local exhaust ventilation system was developed by NIOSH researchers and evaluated in the laboratory to determine adequate air flow to control formaldehyde exposures in the mortuary setting. The exhaust hoods were then constructed and tested. The researchers found that a flow rate of 700 cfm would be sufficient to control the formaldehyde emissions. Following these laboratory tests, a local exhaust ventilation system was designed, constructed, and installed at an embalming laboratory of a college of mortuary science. The control system consisted of two slot hoods placed on each side of the embalming table. A total of 16 sampling runs were conducted to evaluate the effectiveness of the system. Samples collected over the entire embalming procedure showed the ventilation system controlled personal formaldehyde exposures to less than 0.75 ppm, the upper 95 percent confidence limit. The final survey report and a journal article are in preparation, and additional articles will be considered for trade journals serving the mortuary industry.

DISORDERS OF REPRODUCTION

Methylene Chloride in Furniture Stripping

Methylene chloride was once reported to be the least toxic of the chlorinated methanes; however, more recent research has shown methylene chloride to be a possible reproductive toxicant. In addition, solvents are known to affect liver function. NIOSH estimates that one million workers are potentially exposed to methylene chloride during its manufacture and use. Furniture strippers use methylene chloride as a major constituent of stripping solution and, in the furniture stripping industry, an estimated 20,000 workers are potentially exposed. NIOSH conducted three in-depth surveys to assist furniture strippers in reducing their exposures to methylene chloride. During these surveys, researchers found that currently available controls for methylene chloride in furniture stripping operations range from local ventilation to substitution of a less hazardous material. Controls also vary from shop to shop and range from no ventilation in an enclosed space to substitution of a highly flammable mixture of solvents. Furniture is stripped by hand, in a dip tank, or in an open tank that recycles solution. NIOSH found that the exposures were below the OSHA permissible exposure limit, but above the NIOSH recommended exposure limit. The researchers designed, installed, and tested a control system that appears to be more effective in the control of personal exposures to methylene chloride than existing systems. A prototype stripping tank for controlling methylene chloride exposures also was tested. Results of these tests will be summarized in a report for future dissemination to the furniture stripping industry.

Control of Anesthetic Gases in Dental Operating

Exposures to the anesthetic gas nitrous-oxide (N_2O) in dental operating rooms is potentially teratogenic (can harm a developing fetus). Although several scavenging systems have been approved and recommended by the American Dental Association, none of these consistently removes nitrous oxide to the NIOSH recommended levels of 25 parts per million (ppm) during dental surgery. NIOSH researchers reviewed 27 NIOSH Hazard Evaluation and Technical Studies in dental operating areas for information about scavenging systems and found that while scavenging systems significantly reduce nitrous oxide levels, the average exposure is still more than 200 ppm per procedure. Researchers then evaluated five different scavenging masks and determined that exposures to nitrous oxide can be reduced by improving both scavenging system design and work practices.

NIOSH also reviewed approximately 280 surveys of dental operating areas that the State of Wisconsin Health Department had conducted to determine waste nitrous oxide levels. After performing a statistical analysis of the records, researchers found that none of these systems consistently reduced nitrous oxide to the recommended level of 25 ppm during the time of administration. Further analysis of these records also showed deficiencies in scavenging system design. NIOSH and state health officials recommended guidelines for better scavenging system performance to the Wisconsin Dental Board. These guidelines were published in the *Wisconsin Regulatory Digest* and disseminated to over 5,000 dentists in Wisconsin.

Control of RF Exposures in Industrial Use of Dielectric Heaters

Dielectric heating is widely used to heat, cure, and melt plastic, rubber, and glue in processing vinyl materials, and in manufacturing furniture and other wood products. Worker exposures to radiofrequency (RF) radiation in these heating operations have been observed to exceed recommended occupational exposure guidelines and may have health consequences for reproductive functions. To protect workers from a potential reproductive hazard, NIOSH evaluated heaters and work processes at a waterbed manufacturing plant that used dielectric heaters in its production operations and identified the heater causing the greatest exposure. Researchers designed, fabricated, and installed a prototype shield to protect against radiation emitted from this type of heater, then compared RF levels for

operators using the shielded unit with the initial levels. RF electric and magnetic field strengths were reduced by factors of 200 times and 10 times, respectively. Foot current measures taken on the operators before and after the shield was in place indicated a drop of 4.3 times in magnitude. The shield was able to limit leakage of radiation without compromising product quality. The results of this project are planned for publication in both a technical journal and trade magazine in FY 1991.

NOISE-INDUCED LOSS OF HEARING

Hearing Conservation Practices

The current OSHA noise regulations provide minimal requirements for maintaining a hearing conservation program for workers who may be at risk for noise-induced hearing loss. To develop more effective hearing conservation program practices, NIOSH brought together a group of experts in noise-induced hearing loss. Input from this group provided the basis for a manual titled "*A Practical Guide to Effective Hearing Conservation Programs at the Workplace.*" The manual is directed to employers, middle managers, health and safety professionals, and union and worker representatives. It discusses program oversight, coordination, and implementation of various elements of an effective program. The elements include noise exposure monitoring, engineering controls, audiometric monitoring and recordkeeping, hearing protectors, and education. The manual will be distributed by professional societies, trade associations, and unions that represent groups at risk for noise-induced hearing loss. NIOSH published an article on the hearing conservation practices in the *Journal of the Acoustical Society of America.*

DISSEMINATION

To be effective in protecting workers, the results of research must be applied in the workplace. To help accomplish this, NIOSH disseminates its research findings to all organizations and individuals who are in positions to put them into practice. NIOSH makes recommendations for standards and submits them for regulatory action by OSHA and MSHA. These recommendations are produced in the form of Criteria Documents and testimony before the regulatory agencies. NIOSH also presents its findings at scientific meetings and publishes Current Intelligence Bulletins, the NIOSH Manual of Analytical Methods, control technology assessments, hazard alerts, fact sheets, research reports, and articles in scientific journals and the CDC Morbidity and Mortality Weekly Report (MMWR).

NIOSH also conducts training courses in occupational safety and health, supports 14 Educational Resource Centers for training professionals in these fields, and strives through its projects, **Minerva** and **Shape,** to incorporate occupational safety and health principles into the curricula of schools of business and engineering. NIOSH maintains a library, several databases, a mailing list, and a publications office to answer questions and to distribute publications on occupational safety and health matters.

Data retrieval is provided through its NIOSHTIC data base and information from the primary research literature to support occupational safety and health professionals who help protect workers at hazardous waste sites.

NIOSH responds to queries from individuals in the continental United States through its toll-free number, **1-800-35-NIOSH.**

NIOSH Manual of Analytical Methods

Volumes 1 and 2 of the Third Edition of the NIOSH Manual of Analytical Methods were published in 1984 and supplements to the Manual were subsequently published in 1985, 1987, and 1989. A fourth supplement is in press and will be available during FY 1991, bringing the total number of methods to 262, covering 476 toxic substances. With distribution through the Government Printing Office and NIOSH, over 7,000 national and international requests have been received for the Manual. The methods are used in a wide range of applications in NIOSH studies, including control technology assessments, health hazard evaluations, and epidemiologic investigations. Applicable methods also are incorporated into Criteria Documents produced by NIOSH for recommending standards to the Department of Labor.

NIOH/NIOSH Acrylamide Document

Acrylamide is an odorless, white, crystalline solid used as a monomer or as a raw material in the production of polyacrylamides. NIOSH estimates that more than 10,000 U.S. workers are potentially exposed to this chemical during its production and use in the manufacture of polyacrylamides and in grouting operations. Acrylamide is also widely used in research laboratories to make polyacrylamide gels for separation and analysis of molecules. Although the extent of exposure for laboratory personnel is unknown, 100,000 to 200,000 researchers and technicians are potentially exposed to acrylamide through inhalation or skin contact.

NIOSH, in cooperation with the National Institute of Occupational Health (NIOH) in Sweden, has reviewed and evaluated literature on the metabolism, toxicological mechanisms, and toxicity of acrylamide. The joint NIOH/NIOSH document titled *"NIOH and NIOSH Basis for an Occupational Health Standard, Acrylamide: A Review of the Literature"* is to be published in FY 1991.

Occupational Exposure to Ethylene Glycol Ethers

Glycol ethers are used primarily as solvents in protective coatings and as solvents for nitrocellulose, printing inks, textile dyes and pigments, and leather finishes. They are also used as chemical intermediates in the synthesis of ethylene glycol monoalkyl ether acetates. A draft criteria document on the ethylene glycol ethers and their acetates underwent external review in FY 1989. As a result

of that review, it was decided to develop two separate criteria documents - one on ethylene glycol monobutyl ether (EGBE) and ethylene glycol monobutyl ether acetate (EGBEA), the other on ethylene glycol monoethyl ether (EGEE), ethylene glycol monomethyl ether (EGME), and their acetates. The decision to develop two separate documents was based on the fact that although all these glycol ethers exert adverse effects on the kidneys, blood, and the hematopoietic and central nervous systems, only EGEE, EGME, and their acetates cause adverse reproductive and developmental effects.

The EGME/EGEE/acetates criteria document is being modified and is expected to be completed in FY 1991. The EGBE/EGBEA criteria document will be published in early 1991. In the EGBE/EGBEA document, NIOSH recommends that exposure limits for EGBE and EGBEA in the workplace be limited to 5 ppm as an 8-hour time-weighted average; dermal contact is prohibited because EGBE/EGBEA are readily absorbed through the skin.

Toluene Diisocyanate and Toluenediamine

In FY 1990, NIOSH published a Current Intelligence Bulletin (CIB) that describes the results of recent studies demonstrating that toluene diisocyanate (TDI) and toluenediamine (TDA) are carcinogens. Therefore, NIOSH recommends that all isomers of TDI and TDA be regarded as potential occupational carcinogens. TDI is used in the manufacture of flexible polyurethane foams, elastomers, surface coatings, fibers, sealants, and adhesives. Occupational exposure to TDI occurs during the production and use of TDI, particularly during the mixing and foaming processes in the polyurethane foam industry. An estimated 34,466 workers were exposed to TDI in the United States during the period 1981 to 1982. Nearly all of the TDA produced is used as part of a mixture for the production of TDI; TDA is also used to make dyes for textiles, leathers, furs, wood, and biological stains. Potential for worker exposure is minimal because more than 99 percent of the TDA produced is used captively to produce TDI, usually at the same site. An estimated 8,513 workers were exposed to TDA in the United States during the period 1981 to 1983. The CIB also recommends guidelines for minimizing occupational exposures.

Quantitative Risk Assessment

Quantitative risk assessment is a scientific discipline that seeks to estimate quantitatively the risk of adverse health effects at specific exposures to substances in the general and work environment. The goals of the risk assessment process in NIOSH are to estimate the adverse health risks to workers exposed to particular substances, provide a basis for ranking issues for regulatory recommendations, and provide a component for recommending exposure limits. During FY 1990, NIOSH conducted two major risk assessments. The first was a quantitative assessment of the risk of lung cancer associated with occupational exposure to diesel exhaust in mines. This assessment was performed at the request of the MSHA and was based upon the analysis of the results from exposure studies. The second assessment evaluated the risk of lung cancer associated with occupational exposure to cadmium. This assessment was performed as a part of the NIOSH submission to the OSHA rulemaking on cadmium. It was based on a dose-response analysis of a NIOSH epidemiologic study of workers who had been exposed to cadmium in their jobs. Reports from both risk assessments have been submitted to the regulatory agencies, and will be submitted in FY 1991 to peer reviewed journals for wider distribution.

Falls through Skylights and Roof Openings

Occupational fatalities caused by falls are a serious public health problem throughout the United States. The NIOSH National Traumatic Occupational Fatality data base indicates that during the period 1980-1985, falls accounted for nearly 10 percent (3,491 of 36,210) of all traumatic occupational deaths for which a cause was identified. Of this total, 28 deaths were caused from falls through skylights and 39 deaths were due to falls through roofs or roof openings. In FY 1990 NIOSH developed and distributed an Alert that describes cases that resulted in the death of eight workers. Recommendations for

preventing falls through roof openings and skylights are described in the document.

Manure Pits

Manure pit systems are used primarily on livestock farms (including dairy operations) to allow for the easy cleaning of animal confinement buildings and the efficient underground storage of large amounts of raw manure. Because large areas of the confinement building can be cleaned with a water hose or other similar methods, such handling of manure is more efficient than the historical method of shoveling solid animal waste. It is not known how many of the approximately 2.3 million farms in the United States contain manure pits or tanks.

Inside the pit, the manure undergoes bacterial fermentation and a number of potentially dangerous gases can be generated including methane, hydrogen sulfide, carbon monoxide, and ammonia. The accumulation of these gases within the confined space of the manure pit can produce an oxygen deficient, toxic, or explosive environment. Recent NIOSH investigations conducted under the NIOSH Fatal Accident Circumstances and Epidemiology (FACE) Program suggest that many farm workers are unaware of the danger and deaths continue to occur as a result of entry into manure pits. As a means of alerting farm workers to the hazards of entering manure pits, NIOSH developed an Alert which describes two case reports that resulted in seven deaths from suffocation following entry into manure pits. Recommendations for protection of workers who are required to enter manure pits are provided.

Dimethylformamide

Dimethylformamide (DMF) is a colorless, water-soluble liquid with a faint ammonia-like odor. This organic solvent is used in acrylic fiber spinning, chemical manufacturing, and pharmaceutical production; it is also present in textile dyes and pigments, paint stripping solvents, and coating, printing, and adhesive formulations. NIOSH estimates that more than 100,000 workers may be exposed to DMF in the United States. DMF is readily absorbed through the skin and is known to be toxic to the liver as well as cause skin problems and alcohol intolerance. Recent evidence indicates that DMF may cause liver damage in exposed workers who appear to be healthy. Some reports also suggest that there may be an increase in cancer among workers exposed to DMF. NIOSH has developed an Alert that describes engineering controls, good work practices, and personal protective equipment recommended for controlling exposures to DMF by inhalation and skin contact.

Carpet Layers

Approximately 100,000 carpet layers are employed in the United States. While carpet layers make up less than 0.06 percent of the U.S. workforce, they file 6.2 percent of all worker s compensation claims for traumatic knee injury, a rate 108 times that expected in the total workforce and the highest rate of any occupation reporting such claims. Carpet layers frequently report bursitis of the knee, fluid buildup requiring knee aspiration (knee taps), skin infections of the knee, and a variety of knee symptoms that are caused by frequent kneeling on hard surfaces and use of the knee kicker for stretching wall-to-wall carpet. Although kneeling cannot be eliminated, carpet layers should wear protective knee pads whenever kneeling on hard surfaces. In addition, they should use power stretchers, which are safe alternatives to the knee kicker. Employers should ensure that each carpet layer is trained in the proficient use of power stretchers and that a sufficient number of these devices are available to each crew of carpet installers. To bring this information to the attention of workers, contractors, safety and health officials, and other interested parties, NIOSH developed an Alert and distributed it to appropriate individuals and institutions such as trade journals, trade union representatives, and carpet installation schools.

NIOSH Data Bases

NIOSH maintains two computerized data bases that are available for use by the occupational safety and health community and the general public on CD-ROM and on-line systems.

Registry of Toxic Effects and Chemical Substances (RTECS®)

RTECS® is a computerized data base, compiled, maintained, and updated by NIOSH in compliance with a congressional mandate. The data base is a compendium of toxicity data extracted from the open scientific literature and also includes chemical identification data, regulatory information, and toxicological and carcinogenic reviews. The RTECS® file now contains over 106,000 substance entries.

NIOSHTIC®

NIOSHTIC® is a bibliographic data base of literature in the occupational safety and health field. Articles abstracted from approximately 160 current, English-language technical journals provide approximately 50 percent of the 6,000 annual additions to the data base. Retrospective information is also acquired and entered. The NIOSHTIC® data base now contains over 163,000 entries.

Technical Inquiries

Three years ago NIOSH established a toll-free telephone number (1-800-35NIOSH) to respond to technical inquiries from throughout the United States concerning occupational safety and health issues. During FY 1990, NIOSH responded to 11,735 telephone inquires. This represents an increase of almost 50 percent over FY 1989 in the number of 800 number responses received. The top states, in terms of numbers of callers, were New York California, Pennsylvania, Ohio, Illinois, Texas, New Jersey, and Florida. These eight states accounted for 49 percent of the total calls. The subjects most frequently asked about included indoor air quality, chemicals/solvents, the NIOSH health hazard evaluation program, asbestos, analytical/sampling methods, video display terminals, and personal protective equipment.

Dissemination

NIOSH disseminates its documents through a mailing list consisting of approximately 22,000 organizations and individuals. In FY 1990, NIOSH directly disseminated over 271,000 copies of NIOSH developed publications. NIOSH also disseminates information through its Exhibit Program. Through this program, NIOSH distributes recent NIOSH publications and specially prepared hand-out materials prepared for the conference. During FY 1990, NIOSH exhibited at 22 conferences.

Regulatory Responses

In FY 1990, NIOSH completed 27 responses to proposed rules and testified at 10 DOL rulemaking hearings. NIOSH provided comments to DOL on logging operations; cadmium; electric power generation, transmission, and distribution; bloodborne pathogens; confined spaces; and diesel-powered equipment in underground mines.

Confined Spaces

NIOSH testified on the OSHA proposed standard regarding entry into confined spaces, reiterating the recommendations of the Institute's 1979 criteria document on this subject. NIOSH also presented new information on frequency of injuries and deaths, entry, cardiopulmonary resuscitation, and respiratory protection for confined spaces. For example, NIOSH estimated from its National Traumatic Occupational Fatility (NTOF) data base that a minimum of 763 confined space fatalities occurred between 1980 and 1985. Also, NIOSH has investigated, through its Fatal Accident Circumstances and Epidemiology (FACE) program, 44 incidents resulting in 70 deaths in 5 years.

Asbestos

NIOSH testified on two OSHA proposed standards for asbestos regarding the regulation of nonasbestiform fibers (e.g, tremolite, actinolite, anthophyllite) and the lowering of the permissible exposure limit (PEL) from 0.2 to 0.1 fibers per cubic centimeter (f/cc) of air. NIOSH testified that there is no scientific basis for differentiating health risks between asbestiform and nonasbestiform fibers for regulatory purposes. NIOSH also supported OSHA in its proposed reduction of the PEL

to a level (0.1 f/cc), and provided technical expertise to OSHA in engineering controls, work practices, analytical methods, and respiratory protection.

Exhaust

NIOSH prepared a risk assessment on lung cancer associated with exposure to diesel exhaust in mining operations for MSHA proposed rulemaking. Based on an analysis of toxicological data, NIOSH determined the excess risk to miners of lung cancer at the upper range of the diesel particulate exposure reported (-1.5 mg/m^3) is approximately 1.5 to 3 in 100 miners exposed for 45 years. The results from this risk assessment were consistent with previous recommendations made by NIOSH in one of its recent Current Intelligence Bulletins, that diesel exhaust be regarded as a potential occupational carcinogen and that occupational exposures be reduced to the lowest feasible concentrations.

Cadmium

For OSHA's proposed rule regarding exposure to cadmium, NIOSH testified that cadmium is a potential occupational carcinogen and that occupational exposures be reduced to the lowest feasible concentrations. In addition to providing technical expertise on engineering controls, analytical methods, and medical surveillance, NIOSH prepared a risk assessment on lung cancer associated with exposure to cadmium. Based on analysis of human epidemiological data, NIOSH estimated the range of excess risk of lung cancer deaths to be 0.5 to 1.2 per 1,000 workers for the proposed EPS of l ug/m3 or 2.6 to 6.0 per 1,000 workers for the proposed PEL of 5 ug/m3.

Training Grants

In FY 1990, NIOSH awarded training grants to support over 33,000 continuing education trainees and to provide training for 1,100 full-time students through its 14 Educational Resource Centers (ERCs), 27 Training Project Grants (TPGs), and the Industrial Medical Center (IMC). Projects funded by these funds include research on preventing exposure to infective materials for health care workers and emergency medical service workers. Please see Appendix A for a list of recipients.

Grants provided by NIOSH in FY 1990 were:

14 ERC s	$8,686,598
27 TPG s	1,568,050
1 IMC	744,744
1 Scientific Eval.	77,608
TOTAL	$ 11,077,000

SHAPE

The Safety and Health Awareness in Preventive Engineering (SHAPE) program is designed to promote occupational safety and health through projects conducted within schools of engineering. In FY 1990, a project SHAPE regional engineering faculty workshop was conducted at the University of Utah. Thirty-four faculty members from 13 engineering schools participated. Also, work has begun to develop a series of instructional modules that can be used by engineering faculty to provide instruction on vital occupational safety and health topics. The current topics include occupational diseases, lab safety, hazard evaluation techniques, electrical safety, and epidemiology and toxicology. The first three modules have been completed and are planned for printing in FY 1991. One of the project participants, the Institute of Industrial Engineers in Norcross, GA, published a teaching format for an engineering approach to occupational safety and health in business and industry.

Minerva

The Minerva project promotes the prevention of occupational injuries and illnesses through the education of students in schools of business administration. It is a cooperative effort with the Minerva Education Institute at Xavier University in Cincinnati OH. Project activities in FY 1990 included:

- a MINERVA Workshop at Pepperdine University in Los Angeles, CA, which drew participants from academic institutions.

- a session on occupational safety and health at the annual organization behavior teaching conference.
- increased faculty participation and awareness of Minerva these efforts to over 2000 faculty members in the data base.

EPOCH-Envi

Project EPOCH-Envi (Educating Physicians in Occupational Health and Environment) focuses on the education of primary care resident physicians and medical students. Project participants include the occupational medicine programs at Duke University, the University of Alabama-Birmingham, the University of Kentucky, the University of South Florida, and West Virginia University. Project EPOCH-Envi is currently in its second year. Three of the five sites reported the addition of one or more new occupational medicine courses to the curriculum for residents and medical students. Additionally, five separate courses were added to schools of public health affiliated with the participants. All five sites modified existing curricula, with 3 sites adding a noon seminar series to family medicine residency programs. A total of 30 separate lectures ranging from 1 to 3 hours each were added as well. Other accomplishments included small group teaching, one-on-one precepting, chart audits, and prepared reading lists. A total of 25 clinical faculty in primary care attended faculty development sessions and over 250 family practice or internal medicine residents and medical students were reached through rounds or training sessions.

Promulgation of 42 CFR 84

Currently, NIOSH tests and certifies respirators according to 30 CFR part 11. These regulations have been extensively revised, and when promulgated will be issued as 42 CFR Part 84. This revision to the existing respirator certification regulations is nearing final adoption. Concurrent with the administrative rulemaking process, NIOSH has been planning, purchasing, and installing new laboratory and data processing equipment, revising administrative and operating procedures, and automating required tests in anticipation of the adoption of 42 CFR 84.

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