Occupational Safety & Health for Fiscal Year 1988 under Public Law 91-596

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

CDC
CENTERS FOR DISEASE CONTROL

Report on

OCCUPATIONAL SAFETY AND HEALTH FOR FISCAL YEAR 1988

Prepared by
National Institute for Occupational Safety and Health

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

CONTENTS

EXECUTIVE SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) is the Federal agency charged with conducting a national program of occupational safety and health research and dissemination. The purpose of this program is to establish and disseminate scientific and public health information necessary to ensure safe and healthy working conditions for the 124 million American working men and women.

In 1970, Congress passed the Occupational Safety and Health Act (PL 91-596) which created NIOSH and mandated that the Institute conduct research, training, and related activities that assure safe and healthy working conditions for all workers in the United States. In 1973, NIOSH became a part of the Centers for Disease Control (CDC), an arm of the Public Health Service in the Department of Health and Human Services. NIOSH is unique among Federal research institutions because it has the authority to conduct research in the workplace, and to respond to requests for assistance from employers and employees.

NIOSH also consults with the Department of Labor (DOL) and other Federal, State, and local government agencies to promote occupational safety and health, and makes recommendations to DOL about worker exposure limits.

NIOSH estimates that over 7,000 people are killed at work each year, and nearly 12 million non-fatal injuries occur in the workplace. In addition to death and injury, it is estimated that over ten million men and women are exposed to hazardous substances in their jobs that can eventually cause fatal or debilitating diseases. To help establish priorities in developing research and control of these hazards, NIOSH developed a list of the ten leading work-related diseases and injuries. They are:

1. Occupational Lung Diseases
2. Musculoskeletal Injuries
3. Occupational Cancers
4. Occupational Cardiovascular Disease
5. Severe Occupational Traumatic Injuries
6. Disorders of Reproduction
7. Neurotoxic Disorders
8. Noise-Induced Hearing Loss
9. Dermatological Conditions
10. Psychological Disorders

In 1985, NIOSH held a symposium to develop strategies for preventing the first five of these conditions, and published the strategies in 1986. The remaining five conditions were discussed in a symposium in 1986, and strategies were published in 1988. In both symposia, NIOSH defined the nature of each disease, described preventive measures, and identified areas needing further research. Much of the Institute's current program involves activities directed at the ten conditions on this list.

This report presents a summary of highlights from the FY 1988 activities of NIOSH and meets the reporting requirements of sections 22 (f) and 26 of the Occupational Safety and Health Act of 1970.

Recommended Standard for Occupational Exposure to Radon Progeny in Underground Mines: In 1988, NIOSH issued a criteria document, ***Criteria for a Recommended Standard ... Occupational Exposure to Radon Progeny in Underground Mines.*** Research in this document demonstrated that over a working lifetime, the Federal permissible exposures limit for radon still allowed a significant excess risk of lung cancer for underground miners. Although this risk declined with decreasing cumulative exposure, excess risk was still substantial for working lifetime exposure at one fourth of the current permissible exposure limit.

NIOSH made four recommendations to the Mine Safety and Health Administration (MSHA) based on these findings. These are:

- an annual exposure limit and average workshift concentration to comply with the cumulative limit;
- a sampling and analytic strategy to account for variable concentrations and provide incentives for maintaining low exposures;
- a respirator selection process for the use of these protective devices; and
- prohibiting smoking in mines and encouraging miners to quit smoking.

Endotoxins in Cotton Dust: Endotoxins in the dusts from carded cotton appear to have a causative role in the acute response of persons exposed to cotton dusts. Levels of these endotoxins vary with the type of cotton carded and the geographic area in which it is grown. Studies indicated that cotton mills processing cotton from growing areas in the Western United States were less contaminated by endotoxin than those using cotton grown in other areas.

NIOSH published a paper in the *New England Journal of Medicine* presenting a clear exposure-response relationship for endotoxin in the absence of a similar relationship for cotton dust. Laboratory research demonstrated a strong correlation between acute pulmonary function changes and airborne endotoxin levels with no correlation between airborne cotton dust concentration and lung response. This new information is the most significant development in the understanding of byssinosis over the past 15 years, and it has stimulated development of new concepts regarding preventive strategies.

Fatal Accident Circumstances and Epidemiology (FACE): The Fatal Accident Circumstances and Epidemiology (FACE) project describes fatal occupational injuries, identifies potential risk factors, and develops countermeasures for reducing injury. NIOSH distributes project information to workers, company management and other appropriate users through FACE reports, NIOSH Alerts and journal articles. During FY 1988, NIOSH modified the FACE study design to increase data validity and to reduce methodologic difficulties in obtaining appropriate controls.

NIOSH also conducted a FACE Workshop at the National Mine Health and Safety Academy in Beckley, W.V. The workshop provided a forum for individuals from different disciplines to discuss problems of traumatic occupational deaths, and was attended by health department officials, Department of Labor officials, OSHA personnel, union representatives, physicians, nurses, safety specialists, epidemiologists, and medical examiners. Attendees formed six task forces for increasing collaboration between NIOSH scientists and others interested in decreasing the number of occupational deaths.

Revision of Respirator Certification Regulation: More than 1,600 NIOSH/MSHA certifications are in effect for more than 7,000 industrial respirator models. Between six and seven million American workers wear NIOSH-certified respirators to protect themselves from hazards in their workplaces. Many of these certified respirators are worn in toxic or lethal environments where a momentary lapse in respiratory protection could result in serious injury or death.

In 1987, NIOSH published a proposed revision to the current regulations specifying the performance tests and certification criteria for NIOSH certified respirators. The revisions were aimed at changing certification tests that were obsolete, and those not representing typical use conditions for NIOSH certified respirators.

In 1988, the Institute held two public meetings to receive comments about the revisions. Based on the large number of comments, the Institute made extensive changes to its original proposal which will be published as a second proposal in 1989.

Joint American Academy of Dermatologists/NIOSH National Conference on Prevention of Occupational Dermatoses: The symposium was held in Washington D.C. and represented an important milestone in implementing the national strategy for the prevention of one of the ten leading occupational diseases and injuries. The American Academy of Dermatologists (AAD) has emerged as a leader in implementing these strategies for preventing occupational dermatological conditions.

Fourth Finnish-U.S. Joint Symposium on Occupational Safety and Health (With Swedish Participation): The symposium was held in Turku, Finland and was the fourth symposium deriving from a Memorandum of Understanding signed in 1982 between the U.S. Department of Health and Human Services and the Ministry of Social Affairs and Health of Finland. For the first time, scientists from the Swedish Institute of Occupational Health participated in the program.

The theme for this symposium was **Occupational Safety and Health Research: the Leading Edge in Prevention.** Topics discussed included the development of the NIOSH strategy for preventing the ten leading work-related diseases and injuries in the United States; Finland's plans for improving occupational health services to meet the challenge of new workplace technology, and the increased frequency of musculo-skeletal disorders in Sweden associated with the shift to a service economy.

Scientists from the three institutes presented papers on topics judged to be of mutual concern to all three countries. These included exposure assessment, occupational allergies, occupational injuries, measures of physical and psychological workload, cancer epidemiology, and remedial approaches.

Worker Notification: Informing workers of their potential exposure to occupational disease or injury, or worker notification, is a national issue involving the Federal government, unions, and industry. NIOSH has been active in both studying and providing information about individual worker notification since 1977. Since that time, NIOSH has conducted pilot studies, submitted reports, and convened panels of experts to study many aspects of this issue.

In FY 1988, NIOSH participated in two worker notification efforts. The first resulted from a mortality study NIOSH conducted in 1986 to evaluate the effects of carbon monoxide exposure on mortality from heart disease among bridge and tunnel officers. The study concluded that exposure to carbon monoxide was responsible for the excess rates of heart disease among bridge and tunnel workers. On the basis of these findings, in 1988, NIOSH, with the cooperation of the Triborough Bridge and Tunnel Authority of New York, and the Bridge and Tunnel Officers Benevolent Association contacted all surviving members of the study cohort and next-of-kin, informed them of the study findings, recommended periodic individual monitoring for carbon monoxide exposure, and provided other pertinent health information. (See also Occupational Cardiovascular Diseases.)

In the second worker notification effort, as a result of the NIOSH mortality study, Union Carbide conducted notification of the cohort. Results from

this 1986 study indicated that although overall mortality from the cohort was lower than that of the overall mortality rate for males in the United States, excessive mortality was found for liver cancer, leukemia, pancreatic cancer, non-Hodgkins lymphoma, and arteriosclerotic heart disease. On the basis of these findings, Union Carbide informed its employees and retirees of the study results, and made recommendations for medical care and other preventive measures. (See also Occupational Cancers.)

NIOSH also provided technical expertise to State health departments on issues of worker notification, and briefed groups representing industry, labor, academia, and health officers on NIOSH plans for notification.

VII International Conference on Coal Workers' Pneumoconioses: This conference was the seventh meeting on Coal Workers Pneumoconioses since the early 1930's, and was the largest of its type ever held. It was also the first time it was hosted in the United States. Over a thousand research physicians, scientists, and lawyers attended, representing fifty-seven countries. The size and scope of this conference illustrated the impact that the NIOSH preventive strategies for occupational lung disease have had on lung disease research world wide. Scientists reported findings on the effects of silicosis, asbestosis, and other pneumoconioses. The conference was sponsored by NIOSH and the International Labour Organization, and cosponsored by OSHA, MSHA, and the Bureau of Mines.

Human Immunodeficiency Virus (HIV): NIOSH became involved in activities to prevent workplace exposure to bloodborne diseases in 1987, after a CDC publication of three cases of human immunodeficiency virus (HIV) infection transmitted to health care workers after exposure to the virus in the workplace. NIOSH activities include assessing workplace exposure to bloodborne diseases, and developing control technology, administrative controls and recommending appropriate personal protective equipment, and disseminating information to worker groups at high risk.

In FY 1988, NIOSH published the Joint Advisory Notice for Protection Against Occupational Exposure to Hepatitis B Virus (HBV) and HIV. NIOSH also provided technical assistance to the Occupational Safety and Health Administration (OSHA) in the Department of Labor in the preparation of rulemaking proposals regarding new bloodborne diseases.

INTRODUCTION

BACKGROUND

From earliest times, men and women have been subjected to injuries and illnesses associated with providing a livelihood for themselves and their families. Work hazards have posed a threat to people of all cultures, from primitive hunters and gatherers, agricultural and mining villages, through the industrial revolution, and into today's service and information economy. For much of our history, occupational hazards have been accepted as an unavoidable by-product of work. Often, the link between illness and exposure to harmful substances in the workplace went unrecognized.

Today, although the relationship between exposure to toxins and illness and injury is better understood, technological advances are adding workplace hazards at an unprecedented rate. The National Institute for Occupational Safety and Health (NIOSH) estimates that between three and nine million American workers are exposed to potential carcinogens in their jobs each year. Eight million people in the United States are exposed to one or several of 750 neurotoxic agents. As many as 15,000 chemicals pose reproductive hazards, such as birth defects, spontaneous abortions and infertility. And physical and psychological stresses imposed by service jobs are causing an increasing number of musculoskeletal and psychological problems.

We look upon these hazards as intolerable: a person's means of earning a living should not be a source of pain and illness. In addition to the immeasurable costs suffered by sick or injured workers and their families, the United States loses billions of dollars in lost work days, insurance, medical and administrative costs. Such enormous costs are unnecessary. Research has shown that work-related diseases and injuries can be prevented and controlled.

GOVERNMENT INVOLVEMENT

In 1798, the fifth Congress of the United States recognized the value of protecting the health of its workers, and established the first Federal health program--the Marine Hospital Service for merchant seamen. This program later became the U.S. Public Health Service, with responsibilities for protecting the health of all citizens, although its origins were in occupational health.

The first permanent government agency devoted solely to occupational safety and health was established in 1914 as the Office of Industrial Hygiene and Sanitation. In subsequent decades, during several name and organizational structure changes, the Office developed into an organization committed to preventing injury and illness among America's workers.

The Occupational Safety and Health Act of 1970 (PL 91-596) transformed the Office into the National Institute for Occupational Safety and Health (NIOSH), and placed it in the Department of Health, Education, and Welfare (now Health and Human Services). NIOSH became the lead Federal agency for research into occupational safety and health problems.

In 1973, NIOSH became part of the Centers for Disease Control (CDC), an arm of the Public Health Service in the Department of Health and Human Services. CDC is responsible for safeguarding the health of all Americans by controlling or preventing disease and injury.

By directing national efforts in scientific research and dissemination of its results, NIOSH strives to improve conditions in the workplace. All of the Institute's efforts are directed toward stewardship of the good health of the nation's workers.

OSHA: THE REGULATORY AGENCY

The 1970 Act also created the Occupational Safety and Health Administration (OSHA) as a regulatory agency and placed it in the Department of Labor (DOL). OSHA is responsible for promulgating standards for occupational safety and health, for enforcing those standards, and for investigating any suspected violation of standards. It also provides consultation and training services for employers and employees.

NIOSH: THE RESEARCH AGENCY

NIOSH, by contrast, is a research agency. It is responsible for protecting the health and safety of America's workers by conducting research and analyzing the results to prevent illness and control hazards in the workplace. In addition to the Occupational Safety and Health Act, NIOSH has other legislative mandates under the Federal Mine Safety and Health Act and the Public Health Service Act. NIOSH also carries out responsibilities under the Toxic Substances Control Act, the Superfund Amendments and Reauthorization Act (SARA), the Clean Air Act, and the Outer Continental Shelf Lands Act.

Because NIOSH is a scientific research agency, its influence depends on the scientific quality of its findings and recommendations. It is unique among Federal research institutions in its ready response to requests for assistance from employers and employees, and it maintains broad interaction--both nationally and internationally--with other groups and individuals that have similar concerns to foster a cooperative effort in combating these problems.

To help establish priorities, both internally and in its interactions with others, NIOSH scientists developed a list of ten leading work-related diseases

and injuries (Table 1), and proposed strategies to prevent each of them. NIOSH invited leading experts to improve and elaborate on these strategies at two national symposia. The strategies define the nature of each problem, describe preventive measures that can be taken now, and indicate knowledge needed for the future. Common themes in the strategies include:

- improved surveillance of hazards and health effects
- identification of research needs
- implementation of control measures before adverse health effects appear
- the need for better definitions and diagnoses of certain conditions
- better preparation before introducing new agents and processes
- education, especially about risks
- improved training in basic concepts of occupational health for primary care providers, professionals, design engineers, and others.

TABLE 1
Leading Work-Related Diseases and Injuries--United States

1. Occupational Lung Diseases
2. Musculoskeletal Injuries
3. Occupational Cancers
4. Severe Occupational Traumatic Injuries
5. Occupational Cardiovascular Diseases
6. Disorders of Reproduction
7. Neurotoxic Disorders
8. Noise-Induced Hearing Loss
9. Dermatological Conditions
10. Psychological Disorders

NIOSH ACTIVITIES

To carry out its mandated duties, NIOSH:

- conducts research, experiments, or demonstrations, either directly or by grants and contracts;
- develops innovative methods and approaches to deal with occupational safety and health problems;
- produces criteria for toxic substances and physical agents that 1) describe safe exposure levels for various employment periods, including (but not limited to) exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy resulting from work experience, and 2) emphasize ways to discover latent disease and establish causal relationships between work conditions and diseases/injuries;
- determines, on written request, whether a given substance has potentially toxic effects in the concentrations normally found or used in the workplace;
- serves as a principal focus for training programs that increase the number and competence of personnel engaged in the practice of occupational safety and health;
- publishes an annual list of all known toxic substances and the concentrations at which such toxicity is known to occur;
- develops and coordinates appropriate reporting procedures to help accurately describe the nature of national occupational safety and health problems;
- conducts and publishes industrywide studies on the potential for illness, disease, or loss of functional capacity resulting from chronic or low-level exposure of workers to industrial materials, processes, and stresses;
- consults with DOL; other Federal, State, and local government agencies; industry and employee organizations; and other appropriate individuals, institutes, and organizations to promote occupational safety and health;
- surveys toxic substances and hazardous physical agents in mines and recommends worker exposure limits to the Mine Safety and Health Administration (MSHA), DOL;
- administers the x-ray surveillance program for coal miners;
- tests and certifies respirators and coal mine dust measuring devices.

These tasks are organized into four program strategies: identification, evaluation, control, and dissemination.

Identification: Before action can be taken to reduce or eliminate occupational health and safety hazards, the hazards must first be identified. NIOSH identifies problems in two ways. First, it 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 (HHEs), are made available to all involved and interested parties and to the Department of Labor.

Second, NIOSH conducts surveillance. Although no national program exists for surveillance of occupational safety and health, NIOSH uses data available from the Bureau of Labor Statistics, the Social Security Administration, the National Center for Health Statistics, the National Institute for 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.

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.

Control: The ultimate 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.

The Institute 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.

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. 1) 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. 2) NIOSH presents its findings at scientific meetings and also 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). 3) NIOSH 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. 4) NIOSH maintains a library, several databases, a mailing list of 18,000 professionals, and a publication office to answer questions and to distribute publications on occupational safety and health matters. 5) NIOSH provides for data retrieval 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. 6) NIOSH responds to queries from individuals in the continental United States through its toll free number, 1-800-35-NIOSH.

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 (Table II). 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 reducing wear-and-tear musculoskeletal injuries of the upper and lower limbs due to poor tool design, work station layout, or tasks necessitating repetitive, forceful movements. Guidelines to reduce biomechanical stressors and musculoskeletal strains inherent in such work are being developed and evaluated to determine their effectiveness in the workplace.

Physical agents research evaluates occupational hazards posed by noise, heat, vibration, and nonionizing radiation. Noise studies address the risks to hearing of impulse versus steady-state noise and the adequacy of current hearing conservation practices. 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 prevent occupational diseases and injuries before they occur 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 widespread application of these preventive engineering control measures.

DPSE conducts research to develop and improve methods for analysis of toxic substances found in the workplace using state-of-the-art analytical instrumentation. Research is also conducted 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. The division (working with the American Industrial Hygiene Association), determines the analytical competence of participating laboratories, and assists those laboratories in improving analytical performance. The division 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/physiology, including the role of microbiological organisms, to elucidate the effects of environmental exposure associated with occupational respiratory diseases and to identify factors associated with early detection and differential rates of susceptibility to 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 or mitigating traumatic injury and death to workers. DSR plans and conducts laboratory and worksite studies to identify and establish effective methods for minimizing workers' risk to injury and disease through 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 priorities, 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 take the form of 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 record-keeping. 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 health hazard evaluations (HHE's) and 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/morbidity and exposure-assessment studies to 1) identify the occupationally related causes of disease in the working population and their offspring, 2) 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 3) 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 HHEs 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 which is then sent to OSHA and to both the employer and the employee representative in the plant involved.

Using new and existing data sources from government agencies (Federal, State, and local), 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 (ERCs), 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.

INFORMATION CONTACTS

NIOSH publications are available from:

Publications Dissemination, DSDTT
National Institute for Occupational
Safety and Health
4676 Columbia Parkway, 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 1988 Administrative Summary

NIOSH operated in FY 1988 with 776 allocated full-time equivalents and a total budget of $69,688,000, of which $9,718,000 was allocated for training grants and $6,224,000 for research grants. In all, 114 research/demonstration grants were active during some portion of FY 1988, and 73 awards were made. Currently, 16 officers from the CDC Epidemic Intelligence Service (EIS) are assigned to NIOSH.

This report presents a summary of highlights from the FY 1988 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).

IDENTIFICATION

SURVEILLANCE

One of the primary goals of NIOSH is the development of a comprehensive, nationwide system for surveillance of occupational diseases and injuries. NIOSH is developing a system that provides complete surveillance data as quantitative measures of occupational health events. These data are accumulated through a Memorandum of Understanding with the Bureau of Labor Statistics and the National Center for Health Statistics; cooperation with the Surveillance Coordinating Group of the Centers for Disease Control; and the establishment of the NIOSH Surveillance Coordinating Activity and Group. NIOSH will use these data to determine the need for public health action and to ascertain the effectiveness of intervention programs.

The NIOSH surveillance plan, published in FY 1987, has six objectives:

- Develop a model occupational disease reporting system for health care providers;
- Incorporate occupational health issues into national and regional surveys;
- Improve hazard surveillance;
- Develop uniform information and share methodology;
- Disseminate information and share methodology; and
- Perform surveillance of conditions described in the NIOSH Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries.

In support of these goals, NIOSH conducted the following activities:

SENSOR: The Sentinel Event Notification System for Occupational Risks (SENSOR) is a network of physicians and State health departments operating through cooperative agreements between NIOSH and participating States. The objective of SENSOR is to promote reporting of illnesses and injuries in the workplace. Sentinel doctors in SENSOR States report cases of potentially work-related illness to their State health departments for analysis. If the illness is determined to have resulted from exposures in the workplace, the health department notifies the worker and evaluates co-workers' health and workplace conditions.

In FY 1988, NIOSH began funding cooperative agreements for SENSOR with three States; Massachusetts, New York, and Ohio; and continued funding agreements made in FY 1987 to California, Colorado, Michigan, New Jersey, Oregon, Texas, and Wisconsin.

In FY 1988, NIOSH continued to collect data on incidences of carpal tunnel syndrome, occupational asthma, pesticide poisoning, lead poisoning, and silicosis. In FY 1989, the scope of the system is to be expanded to collect data on pneumoconioses, occupational burns, and hypersensitivity pneumonitis.

Capacity-Building Cooperative Agreements: In FY 1988, NIOSH funded the final year of its five-year cooperative agreements for Capacity Building in Occupational Safety and Health. These cooperative agreements were made to enhance surveillance capabilities of occupational disorders at State, territorial and local levels, and emphasized occupational safety and health activities and injury and fatality surveillance. Cooperative agreements were made with Colorado, Kentucky, Massachusetts, New Jersey, North Dakota, Ohio, South Carolina, Virginia and Wisconsin.

Standard Case Definitions: The Board of Scientific Counselors formed a subcommittee to critically review standard case definitions, which met to review and propose a surveillance definition of work-related carpal tunnel syndrome. NIOSH has also completed drafts of standard case definitions for silicosis, and, with the Association of Environmental and Occupational Health Clinics, will further evaluate a standard definition for occupational asthma.

National Center for Health Statistics: An Occupational Health Supplement was administered as part of the 1988 National Health Interview Survey (NHIS). NHIS was administered as a door-to-door survey to 50,000 households, and all data have been collected. The survey is to determine the prevalence of work-related conditions including back pain, hand and wrist discomfort, dermatitis, and mucosal irritations of the ear, nose and throat.

Inventory of Surveillance Systems: NIOSH conducted an inventory of all surveillance activities underway at the Institute during FY 1988. A compendium of these activities was developed including a listing of all activities in each division of the Institute and a brief description of each project. NIOSH defined surveillance *systems* as ongoing systematic collection and analysis of data on trend monitoring for specific occupationally related health conditions or occupational exposures. Surveillance *projects* are studies conducted for a finite period to identify specific conditions or cases, exposures, and intervention strategies that may later be integrated into a surveillance system.

Silicosis in Foundry Workers: Prevention of silicosis is possible through controlling levels of workers' exposure to silica. NIOSH, with the support of the CDC Prevention Research and Development Program, is conducting a project to explore the feasibility of environmental control of silica levels in foundries in Ohio. NIOSH initiated a cooperative agreement making Ohio part of the NIOSH Sentinel Event Notification System for Occupational Risks (SENSOR). Under this agreement, Ohio will emphasize foundries as the primary target industry for workplace evaluations.

During FY 1988, the Ohio Department of Health prepared a list of plants with foundries. Activities and interventions for silicosis will be evaluated by compiling and analyzing silica dust levels collected by State and Federal inspectors in these foundries. Ohio also analyzed workers' compensation claims for silicosis over the past two years.

In FY 1989, the State will compile silica dust measurements taken in compliance with regulations at these workplaces, and where appropriate, conduct or coordinate effective evaluations to reduce silica exposures. Then the State will determine whether preventive recommendations have been followed, and whether silica dust levels have been reduced.

NHANES III:

In FY 1988, NIOSH completed the development of two study modules to be included in the third National Health and Nutrition Examination Survey (NHANES III). NIOSH also participated in developing the preliminary design of data quality control procedures to be carried out for these modules for the duration of the survey. The two study modules are components of the NHANES III, in which, over the next six years, approximately 40,000 people will be interviewed and an estimated 30,000 will also be examined. Results from the two modules will provide NIOSH with pulmonary and neurobehavioral data.

NIOSH used other currently available data systems for the following:

- Approximately 200,000 data requests are filled from the National Occupational Hazard Survey (NOHS) data base each year. In FY 1988, NIOSH filled requests for information from within NIOSH, from industry, other Federal agencies, State agencies, academia, foreign countries and from private citizens.
- NIOSH continued gathering information for the National Occupational Exposure Survey (NOES) list of product ingredients from trade-name products. In FY 1988, NIOSH mailed 187,000 requests for product ingredients and received 99,800 responses.
- To help determine the prevalence of pneumoconiosis in coal miners, NIOSH received and evaluated autopsy reports from over 3,000 former underground coal miners. The study demonstrated that 13 percent of the miners had silicosis, and that quartz particles remained in the lungs long after exposure. NIOSH also continued screening coal workers for coal workers pneumoconiosis (CWP) under its CWP Chest X-Ray Screening Program. Under this 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, but if the miner is found to have CWP, the miner has the right under MSHA's authority to be transferred to other work without reduction in pay.
- NIOSH analyzed data from the National Center for Health Statistics' multiple-cause-of-death listings to determine the prevalence of silicosis. Analysis showed a downward trend in deaths with silicosis over the past 15 years (See Occupational Lung Diseases).
- NIOSH continued development of the Institute's Job/Exposure Matrix to provide a national data base to identify potential occupational hazards throughout the country. In FY 1988, NIOSH linked the matrix with information from the National Health Interview Surveys. This linkage represents a mechanism for associating health effects with specific chemical exposures.
- In support of the Environmental Protection Agency's epidemiologic program to develop sensitive/specific early markers for occupational disease, NIOSH is evaluating hospital workers to determine whether certain biological markers, such as chromosome aberrations and hemoglobin alkylation, are associated with exposure to ethylene oxide. Laboratory analysis of industrial hygiene and cytogenetic results was begun in FY 1988 and will continue during FY 1989.
- Cooperation with the Conference of State and Territorial Epidemiologists continued toward the goal of an occupational disease-reporting system. In FY 1989, NIOSH will present findings from surveillance of occupational lead poisoning carried out in five States and will encourage and offer assistance to other States to participate in similar surveillance activities.
- Numerous uses were made of Social Security Disability Files, Occupational Safety and Health Administration records, Annual

Survey tapes from the Bureau of Labor Statistics, Employment Earnings records, Health Interview Surveys, Workers' Compensation files, National Health and Nutrition Examination Survey II, Mine Safety and Health Administration records, the Supplementary Data System, and County Business Patterns.

- NIOSH submitted four National Occupational Health Survey-Mining (NOHSM) commodity reports to MSHA, and completed approximately 80 mine surveys.
- NIOSH researchers used Ohio Workers' Compensation data to identify cases of work-related lead poisoning, and identified sources of continuing lead exposure and problems related to control of lead hazards. As a result of these findings, NIOSH researchers made recommendations to employers and employees to reduce or eliminate the lead hazards. NIOSH is exploring the value of compensation data for identifying and preventing other occupational diseases. (See Neurotoxic Disorders.)

HEALTH HAZARD EVALUATIONS

Another means for identifying occupational health problems is through the NIOSH Health Hazard Evaluation Program. The Institute responds to requests for technical assistance or hazard evaluation of workplace health problems by conducting medical, industrial hygiene, and epidemiologic investigations. These results are made by employees and their representatives, employers, and Federal, State, and local agencies when health problems arise or are suspected from exposure to chemical, biologic, or physical agents in the workplace.

NIOSH received 394 requests for Hazard Evaluation/Technical Assistance (HETA) FY 1988, and completed 434 HETA's (some of which were requested in the previous year). NIOSH completed and disseminated 93 full technical reports, 262 letter reports following site visits, and 79 other closing statements. Types of exposures that prompted requests for HETA's are listed in Table III.

Health Hazard Evaluations of special significance were:

- High incidence of carpal tunnel syndrome among workers at a large meat packing facility;
- Evaluation of hospital personnel exposure to ribavirin, an antiviral drug administered as an aerosol;
- Evaluation of high incidence of asthma attacks at a meat processing plant;
- Evaluation of employee exposure to PCBs at a PCB incineration facility;
- Evaluation of the effects of smoke inhalation in fire fighters at Yellowstone National Park during the 1988 forest fire; and
- Evaluation of the cause for respiratory effects in workers at a narcotics production company.

Representative findings of completed Health Hazard Evaluations included:

- Electrical burnout of fluorescent light ballasts resulted in PCB air/surface levels above background requiring ventilation;
- A high prevalence of musculoskeletal disorders including carpal tunnel syndrome, ganglionic cysts, and tendonitis were found in ammunition assembly production;
- Workers at a turkey processing plant experienced ergonomic related injuries of carpal tunnel syndrome and other musculoskeletal problems;
- Researchers looked for residual concentrations of PCB, dioxin, and furans after a transformer burned in an office building, and found that levels were below cleanup criteria following decontamination;
- Hazardous waste incinerator workers were exposed to PCBs at levels in excess of guidelines recommended by NIOSH; skin findings and serum PCB were not correlated;
- Workers in vapor/solvent decontamination operation for PCB contaminated transformers were exposed to dioxins and furans.
- Exposure to cadmium caused kidney disease in production workers;
- Vitreous china workers were exposed to excessive concentrations of respirable silica dusts. Respiratory symptoms and pulmonary function impairment was found;
- Hazardous exposures to heat, noise, asbestos, coal dust and silica were identified in a municipal coal and refuse derived fuel power plant.
- Meat processing plant workers occupationally exposed to proteolytic enzymes meat tenderizers developed asthmatic reactions;
- A potential hazard exists from exposure to smoke generated by electrocautery knives during reduction mammoplasty surgical procedures.

EVALUATION

OCCUPATIONAL LUNG DISEASES

Because the lung is subject to exposure from many industrial dusts, fumes, and fibers, this organ is both a means of entry for toxic substances and a target for injury and disease. Some toxic substances recently introduced into the workplace have been identified as harmful to pulmonary tissue, but because the disease or injury process can be very long, their effects may not be seen until 30 to 40 years after exposure. NIOSH is evaluating substances found in the workplace and their effects on this vital organ.

Endotoxins in Cotton Dust: Endotoxins in the dusts from carded cotton appear to have a causative role in the acute response of persons exposed to cotton dusts. Levels of these endotoxins vary with the type of cotton carded and the geographic area in which it is grown. Studies indicated that cotton mills processing cotton from "western" growing areas were less contaminated by endotoxin than were those using cotton grown in other areas.

NIOSH published a paper in the *New England Journal of Medicine* presenting a clear exposure-response relationship for endotoxin in the absence of a similar relationship for cotton dust. Laboratory research demonstrated a strong correlation between acute pulmonary function changes and airborne endotoxin levels with no correlation between airborne cotton dust concentration and lung response. This new information is the most significant development in the understanding of byssinosis, (a respiratory disease caused by exposure to fibers of cotton or flax) over the past 15 years, and it has stimulated development of new concepts regarding preventive strategies.

Lung Testing Equipment: NIOSH developed a specialized lung function (spirometry) testing device for use by NIOSH and the National Center for Health Statistics in their National Health and Nutrition Examination (NHANES) study. This spirometry system has been evaluated and meets all of the recommendations of the American Thoracic Society.

Silicosis: Silicosis is a slowly progressive disease resulting in impairment of lung function, found in workers after prolonged exposure to dust containing silica. NIOSH demonstrated that 13 percent of the more than 3,000 miners autopsied as part of the National Coal Workers Autopsy Study had silicosis, and that quartz particles less than 1 micrometer remained in the lungs long after exposure. The final report was completed and delivered to the Bureau of Mines (BOM) for the development of control technology for these respirable particles.

NIOSH also made significant progress in developing and testing models for silicosis and byssinosis. Testing of the responses to silica and cotton demonstrated major changes in lung cell functions as well as overall changes in lung functions.

A scanning electron microscopy technique was developed for the analysis of surface composition properties of crystalline silica. NIOSH is currently receiving samples to be used in support of respiratory disease studies and respirator research. Test results indicate that surface composition of a particle and absorbed substances may radically alter its toxicity.

NIOSH developed a computer programming capability to analyze National Center for Health Statistics multiple cause of death listings for silicosis. Preliminary tabulations indicate a downward trend in deaths with silicosis over the past 15 years, showing 831 deaths with silicosis in U.S. residents in 1970, and 334 deaths with silicosis in 1985. A presentation was given on "Multiple Cause of Death Data for Occupational Respiratory Diseases" to State health department representatives at the NIOSH Surveillance Workshop in November 1988.

Histopathological standards for diseases associated with exposure to silica and nonfibrous silicate minerals were published in the *Archives of Pathology and Laboratory Medicine.* In previous years NIOSH published standards for coal workers' pneumoconiosis and asbestosis in the same journal.

Mine Dust Exposures: NIOSH completed a project involving the interaction of benzo [a] pyrene (B[a]P) and occupation-related particulates on a cellular defense mechanism, the interferon system. B[a]P is a widespread environmental pollutant, and evidence indicates that it is a carcinogen. When B[a]P is acted upon by enzymes in the body, many of its metabolites, or by-products, adversely affect the ability of cells to manufacture interferon when they are exposed to viruses. Inhibition of this cellular defense mechanism causes cells to be more vulnerable to viruses and the growth of tumors. Particulates such as metals, asbestos, and coal enhance the adverse effect of B[a]P on the interferon system. These findings were published in the *Journal of Interferon Research,* and a final report is being prepared for publication in 1989.

Final reports on the anthracite surface coal miners and on MSHA coal mine dust exposure data have been completed. Results of these studies suggest the need for a greater emphasis on dust control, and medical surveillance for surface coal mine drillers, helpers, and bulldozer operators.

Occupational Asthma: As part of an ongoing investigation of pulmonary reactivity to industrial agents, NIOSH completed reports describing reactions to exposures of vanadium pentoxide. This compound is widely used as a catalyst for a number of reactions and in the production of high strength steel alloys. Occupational exposure can also occur from contact with ash remaining after some types of fuel oil are burned.

Varying levels of exposure to vanadium pentoxide produced corresponding asthmatic responses accompanied by acute inflammatory reactions. Analysis indicated that toxic, nonallergenic inflammatory mechanisms can be involved in the development of pulmonary hyperreactivity to vanadium pentoxide.

Asbestos: NIOSH completed research on an inter-laboratory variability of asbestos fiber counting data using the phase contrast microscope technique. The research will inform industrial hygiene laboratories on how to report variability of results. Scientists also studied how electrostatic effects impact asbestos sampling. This research will help analysts and industrial hygienists improve efficiency in asbestos sampling. Findings from this research were published in the *Journal of Applied Industrial Hygiene.*

Studying Pulmonary Genotoxicants: Researchers established a DNA synthesis (DNA repair) assay for the multi-genetic endpoint genotoxicity assay system using primary lung cells. Results of evaluation indicate that the system is useful for studying industrial pulmonary genotoxicants.

MUSCULOSKELETAL INJURIES

Musculoskeletal disorders occur more frequently than any other health problem, affecting nearly half the workforce during their working years. Back problems, inflamed joints, sprains, strains and disorders of the ankle, knee and shoulder exceed any other single health disorder in terms of lost earnings and worker compensation payments. These disorders occur not only in purely physical occupations, but are appearing with greater frequency in the service sector and in office settings.

Ergonomic Hazards: Researchers determined that hand and wrist manipulations and upper torso light duty arm movements accounted for 30 percent of the musculoskeletal exposure reported in the National Occupation Exposure Survey (NOES). Approximately 20 percent of all exposure occurred in industries manufacturing machinery and electrical equipment. In addition, there appeared to be a greater risk of exposure to musculoskeletal hazards in smaller industries employing between 100 and 250 people.

Information from the National Occupational Health Survey-Mining (NOHSM) data set indicated that almost 25 percent of all exposures to musculoskeletal hazards in the mining industries were to the neck and back. Occupations at greatest risk to exposure for ergonomic hazards are general laborers and mechanics working at surface facilities.

Carpal Tunnel Syndrome: Carpal tunnel syndrome is a repetitive motion injury resulting from frequent, repetitive movements of the wrist. Tendons in the wrist become swollen and press against the nerve in the carpal tunnel, causing pain and loss of motor ability in the hand.

In response to a request from OSHA, NIOSH provided technical assistance for an enforcement action in a meat processing plant. As part of the evaluation, staff analyzed 200 tasks for biomechanical analysis. These results, along with the medical record data, were used to assess the risk of carpal tunnel syndrome and other chronic trauma disorders suffered by workers in this plant. Final results of this evaluation will be completed in 1989.

Knee Injuries: NIOSH scientists are developing techniques for determining biomechanical stresses imposed on the knee joint, found in jobs such as carpet laying. A new kinematic system allowed more detailed analyses of reactions at the knee joint caused by postures and movements associated with carpet laying work. These data, together with force data obtained from a biomechanical model, will provide a means for rating high risk activities involving the lower extremities and the benefits of control interventions such as the use of knee pads.

Scientists also developed a prototype kneeling pad dosimeter to measure load factors such as kneeling time, kneeling frequency, and knee-impact which can then be related to a physiological response. A method for monitoring such responses was developed; liquid crystal thermography patches reflect increased accumulation of heat and "hot spots" on knees as a result of workload and length of time spent kneeling. Efforts are underway to validate the thermographic measures through similar "patch" tests on persons having chronic knee problems.

Nursing Personnel: In conjunction with the Johns Hopkins School of Public Health, NIOSH published a comprehensive annotated bibliography of research on low back injuries among nursing personnel. The bibliography will provide useful information in identifying and developing effective prevention strategies and help researchers avoid duplication of research.

Low Back Pain: NIOSH completed its Low Back Atlas (LBA) of Standardized Tests and

Measures. For the first time in medical history, clinicians and researchers will be able to use standard, reproducible test criteria and terminology in assessing low back pain. Use of the LBA will help improve surveillance and communications among people who study low back injury by allowing for a standard collection of data about symptoms of movement dysfunction in low back problems.

Publication of the LBA completes the first phase in the development of a comprehensive NIOSH Low Back Evaluation (LBE) System. The goal of the LBE is to provide a scientifically valid approach for diagnosing low back injuries and targeting effective treatment and rehabilitation regimens, and for improving ergonomic job assessment in the workplace.

Work Practices Guide to Asymmetric Lifts: NIOSH prepared a revised lifting equation modeled after an earlier equation developed in 1981. The new equation provides for an action limit and maximum permissible limit and adjusts for the effects of handles and asymmetric lifting. Members of the NIOSH lifting committee prepared an outline for the revised Work Practices Guide for Permissible Limits for Asymmetric Lifts, which will be transmitted to OSHA in 1989.

Over-head Work: NIOSH initiated laboratory research to delineate shoulder and neck muscle fatigue associated with over-head work. Initial research established relations between workload, work pace and duration in a simulated parts insertion task involving shoulder, neck and upper arm movements. Researchers found that subjects can adjust work durations to offset more demanding workload or work pace factors to minimize discomfort. Results of these experiments will provide data to be used in developing an equation to define acceptable work-rest levels, similar to the equation used to evaluate safe lifting levels.

Compensation: NIOSH initiated efforts to review workers' compensation claims for cumulative trauma disorders in Ohio to identify work situations with on-going musculoskeletal problems.

OCCUPATIONAL CANCERS

Although the long latency periods associated with cancer development make it difficult to identify causative agents, several environmental factors have been suggested as contributing to the process: diet, alcohol, drugs, tobacco, pollutants, and occupational exposures.

More than 50,000 synthetic chemicals are currently in use in the workplace, and approximately 1,000 new chemicals are introduced each year. Because cancer is the second leading cause of death in the United States, NIOSH is working to determine links between workplace exposures and the incidence of cancer, and to reduce the incidence of occupational cancer by developing ways to control or prevent these exposures.

Epidemiologic Studies: NIOSH is conducting epidemiologic studies of potential carcinogens to which workers are exposed in a variety of occupations. In each of the studies, scientists are assessing the association between exposure to a potential carcinogen and the risk of developing cancer. Antimony, beryllium, vinyl chloride, diesel exhaust, halowax, lead chromate paints, TDI, and radon daughters are among the substances being studied. NIOSH is also studying methanol, acrylonitrile, glycol ethers, 1, 3 butadiene, and methylene dianiline to determine to what extent workers are exposed to them.

Occupational Cancer Surveillance: NIOSH is providing technical assistance to groups involved in developing population-based registries in Detroit, San Francisco, and in Massachusetts. The primary objective of these registries is to identify high risk industries and occupations for cancer in these areas.

Coal tar pitch: Workers in road paving, roofing, and smelting operations may be exposed to the fumes of coal tar pitch. NIOSH utilized the biological monitoring method for 1-pyrenol in urine as a marker of worker exposure to polyaromatic hydrocarbons (PAHs) derived from coal tar pitch. This method was used in a study of workers exposed to PAHs in the anode bake area of an aluminum reduction plant.

Urine samples from workers were collected both before and after their workshifts. Workers showed concentrations of 1-pyrenol that were about five times higher than levels found in controls who smoked. These results indicate that urinary 1-pyrenol can be used to assess occupational exposure to PAHs containing pyrene. Results of this study were presented to the 196th American Chemical Society National Meeting in September 1988.

MBOCA: Methylene bis-orthochloroaniline (MBOCA) is a chemical additive to which workers are exposed during the manufacture of plastics. Although MBOCA is no longer manufactured in the United States, NIOSH is studying approximately 500 workers who were exposed when it was last manufactured in this country. Sixty-seven of these participants agreed to have cystoscopy examinations. Two participants--both under 30 years of age--were found to have tumors of the bladder. As a result, cystoscopy was offered to the other individuals in the study. These examinations were completed in FY 1988, and NIOSH published an article describing

the tumors diagnosed in the study in the *American Journal of Industrial Medicine*. A full report of the study will be published in FY 1990.

Chemical Plant Workers in Kanawha Valley: NIOSH is conducting an epidemiologic study assessing the association between exposures in a large chemical plant in Kanawha Valley, W.V. and the risk of developing cancer and other chronic diseases. In FY 1988, NIOSH completed data abstraction for the coal hydrogenation study. Researchers also collected hospital records and coded them for selected causes of death including liver cancer, leukemia, pancreatic cancer, non-Hodgkins lymphoma and arteriosclerotic heart disease. Researchers found excessive mortality for these causes. As a result of the research, the company notified plant employees and retirees of the findings and provided recommendations for medical care and other preventive measures. (See Worker Notification, Executive Summary.)

Ethylene Oxide: As part of the need to improve the prevention aspects of controlling ethylene oxide exposure in hospitals, NIOSH performed a hazard assessment for ethylene oxide sterilizers. This assessment identified a number of potential process failure sources and subsequent recommendations for improvement not previously identified in field surveys. Assessment information will be disseminated working with the American Hospital Association and sterilizer manufacturers.

Dioxin: As part of a larger study on the effects of 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin on the body, NIOSH is evaluating this type of dioxin to determine whether it is a carcinogen. The Dioxin Morbidity Study involves 600 workers at two plants that manufacture chemicals contaminated with dioxin. These workers were matched with an unexposed individual of the same gender, race, age (plus or minus five years), and community of residence. Researchers conducted an in-home demographic and occupational history interview for each of the workers and the unexposed cohorts, and completed medical examinations for 280 workers and 261 unexposed individuals. Results reveal that workers exposed to dioxin have levels of dioxin in serum that can be up to 30 times higher than those found in the general population.

SEVERE OCCUPATIONAL TRAUMATIC INJURIES

Severe occupational traumatic injuries may result in amputations, fractures, eye loss, lacerations, and death. NIOSH estimates that at least ten million persons suffer traumatic injuries on the job each year, about 7,000 of which are fatal. In 1987, occupational injuries cost Americans 75 million lost workdays and $42.4 billion wages, insurance, medical and administrative costs. These figures may underestimate the total costs to industry and do not include the immeasurable toll in human suffering.

Fatal Accidents: Through the Fatal Accident Circumstances and Epidemiology (FACE) project, NIOSH provides surveillance and technical assistance to identify potential risks for occupational fatalities, and develops and disseminates countermeasures to reduce their future occurrence. The project attempts to expand results obtained from a relatively small number of fatality investigations to prevent similar deaths in an entire population of workers at risk.

During FY 1988, the FACE project was restructured to improve ways of conducting on-site fatality investigations. NIOSH increased the scope of the FACE program by training State workers to utilize FACE data gathering methodology in their investigations. NIOSH also improved validity of field data by revising the data collection instrument used in conducting on-site investigations, and changed the study design from a case control to case study design. NIOSH conducted 47 FACE investigations in 11 States.

NIOSH published four Alerts (See Publications for titles of Alerts) and distributed approximately 10,000 copies of **A Guide to Safety in Confined Spaces.**

NTOF: The National Traumatic Occupational Fatality (NTOF) database provides a comprehensive count of occupational deaths resulting from trauma for people over 16 years of age in the United States, utilizing State data sources to create a national database. The database is being used to monitor trends in occupational fatalities and to identify occupations at highest risk of fatal injury so that prevention efforts can be effectively implemented.

In FY 1988, NTOF was updated to include automated records of fatal occupational injuries from 1980-1985 for all 50 States and the District of Columbia. The first six years of these data have been published and reported to public health professionals around the country.

Homicide, Rape and Assault: NIOSH completed a study describing industries and occupations at risk for homicide and other injuries resulting from violent behavior toward employees. Using Ohio workers' compensation claims, researchers found that law enforcement officers, gasoline and service station workers, real estate agents and managers, hotel and motel employees, and food store workers are at higher risk of homicide, rape and assault in their jobs than are workers in other occupations. Results of this study were published in the *June 1988 Journal for Occupational Medicine.*

Suicides at Work: NIOSH completed and submitted for publication in 1989 a study of workplace suicides. Results indicated that military personnel were at higher risk of dying from suicide at work because they spend more time in the workplace and had increased exposure to more lethal weapons, (i.e. guns).

Falls from Painted Steel Structures: NIOSH completed an evaluation of hazards associated with pre-painted structural steel. Research findings supported claims that some types of structural steel coatings cause beams to become slippery, and supported the generally accepted value of minimum coefficient of friction necessary to keep workers from slipping. The scientists advised that workers should be made aware that contaminants on the bottoms of shoes can increase the slipperiness of coated beams. Results of this research were published in the Center for Excellence in Construction Safety Newsletter.

Safe Distance Requirements for Mechanical Power Presses: NIOSH completed an epidemiologic study indicating that 18-year-old press operators had especially excessive amputation rates compared to older operators. The laboratory study provided data to develop a more accurate formula for calculating the safe distance for locating dual palm button actuators on power presses based upon palm button location and new hand speed data. The analysis of press-related injuries helped characterize the circumstances associated with amputations on presses. Results were published in a book chapter and in the *Journal of Safety Research*, and presented at the International Industrial Ergonomics and Safety Conference in June 1988. Results of this research will also be used by OSHA when considering revisions of the standards for power press safety.

Robotics Safety: NIOSH completed a pilot study on human reaction to dangerous motions. The experiment provided scientific documentation for an otherwise unsubstantiated standard for slow speed thresholds.

OCCUPATIONAL CARDIOVASCULAR DISEASES

Each year, more Americans die from cardiovascular disease than from any other cause. Lifestyle factors such as cigarette smoking, diet, and obesity play an important role in deciding whether a person will develop cardiovascular disease. However, exposure to toxic substances in the workplace can also be contributory. Over 1,400 chemicals listed in the Registry of Toxic Effects of Chemical Substances (RTECS) have notations on cardiovascular activity. NIOSH is studying effects of workplace factors to assess cardiac toxicity.

Cardiac Toxicants: NIOSH is studying cellular and molecular cardiac toxicology by developing *in vitro* methods for screening potential cardiotoxins, and evaluating mechanisms of actions of known cardiotoxins. In FY 1988, scientists continued studying toxic effects of allylamine, and submitted a report to *Toxicology and Applied Pharmacology* on the effects of allylamine on oxidative phosphorylation and electron transport in cardiac mitochondria.

Scientists also tested the effects of a stimulant on an enzyme in cultured heart cells, and found that, in order to get heart cells to respond to stimulants in culture, a co-factor such as insulin is needed. Several years ago it had been demonstrated that adrenergic stimulation increased cardiac activity in the body, but until now, this effect had not been observed in cultured cells. This phenomenon will serve as a physiological end point for assessing the effects of cardiac toxicants on receptor mediated responses in cultured heart cells.

Video Image Analysis: NIOSH developed a technique using video image analysis to measure surface area of cardiac myocytes (heart cells) in culture. This capability will allow scientists to assess the effects of cardiac toxicants on myocyte growth.

A video image analysis method was also developed for measuring cell motion, and was used to measure contractility of cardiac myocytes. Rate, velocity of contraction, and peak acceleration of contraction can all be measured for cardiac myocytes maintained in a flow-through chamber. Scientists used this method to study the cardiac depressant effects of halogenated hydrocarbons. Preliminary data indicates that this effect is reversible.

Identifying Occupations at Higher Risk for Cardiovascular Disease: During FY 1988, NIOSH initiated a surveillance effort to identify high risk occupations through use of National Health and Nutrition Examination Study (NHANES) data. NIOSH will use the data to define job context variables associated with cardiovascular disease. Preliminary findings indicate that managers have higher odds of cardiovascular mortality than blue collar workers. It was not determined that similar odds exist for other types of illnesses.

DISORDERS OF REPRODUCTION

Occupational exposure to toxic substances may result in reproductive problems such as spontaneous abortions, birth defects, sterility or impotence. NIOSH is seeking to identify teratogens, mutagens and other hazards to reproduction and develop a means of controlling or preventing exposure to them.

VDT Users: NIOSH is conducting a reproductive epidemiologic study using reproductive

history questionnaires to investigate clusters of spontaneous abortions among video display terminal (VDT) users. Approximately ten million women in the United States use VDT's in their jobs. NIOSH selected an industry with a large population of female full-time VDT users and is interviewing them about their pregnancy outcomes. During FY 1988, NIOSH contacted 81 percent of the study population, and 96 percent of these women agreed to participate. Researchers have now completed interviewing the women, and are collecting medical and vital records. The study is expected to be completed in December 1989.

Assessing Reproductive Hazards in the Workplace, a symposium sponsored by NIOSH and the National Institute of Environmental Health Sciences (NIEHS), was held in June 1988. Topics discussed included new methods for analysis of reproductive effects, and reports and evaluations of completed studies.

The symposium featured speakers from NIOSH, OSHA, the Environmental Protection Agency, the Food and Drug Administration, NIEHS and the National Center for Toxicology, and was attended by physicians, university researchers, industrial hygienists, and officials from the National Institutes of Health and the National Institute for Childhood Health and Human Development. The proceedings were published as a special issue of the journal *Reproductive Toxicology* in 1988.

Semen Analysis: NIOSH has been studying hazardous exposures on the male reproductive system for several years, and has completed the data collection phase of a longitudinal study to provide baseline data for various semen measurements used in evaluating effects of workplace exposures.

The current test battery for evaluating semen samples does not evaluate how toxic agents affect genetic information encoded during spermatogenesis. NIOSH is evaluating methods to assess mutations in germ cells in semen samples obtained from laboratory animals exposed to mutagens, as well as semen samples from workers exposed to chemical mutagens. In FY 1988, NIOSH scientists selected two methods for in-depth evaluation: flow cytometric analysis to determine DNA stability; and isolation of sperm chromosomes for studying chromosome characteristics.

Wives of Workers Exposed to Dioxin: As part of the larger study on the effects of 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin on the body, NIOSH is studying effects of this type of dioxin on the reproductive system. (Also see Occupational Cancers.) To assess affects of dioxin on the reproductive system, researchers contacted the wives and former wives of workers exposed to dioxin, and the wives of a cohort group of unexposed individuals. Approximately 85 percent of the women agreed to participate, and completed a reproductive history questionnaire. This research will help NIOSH determine whether exposure to dioxin causes adverse reproductive effects such as spontaneous abortions and reduced fertility.

Monitoring Reproductive Health of Working Women: Current monitoring methods for evaluating reproductive health of working women have low sensitivity because they rely on memory and medical records which may be incomplete. These methods only detect significantly-impaired reproductive health such as spontaneous abortions. NIOSH conducted a bibliographic search to determine what clinical methods are available for determining earlier and more sensitive indicators of reproductive health. These indicators will help researchers focus on reproductive problems, such as inability to conceive. Among such potential indicators are ovulation, hormone profiles, and uterine cytology.

Surveying Reproductive Health of Working Parents: Findings from four NIOSH surveillance analyses are being prepared for journal publication. Researchers used birth and fetal death certificates received from the New York City Health Department to analyze congenital malformation and maternal and paternal employment, and low birth weight and maternal and paternal employment. The goal of these projects is to establish a flow of birth and fetal death data to NIOSH, to support measurement of reproductive outcomes, and to set priorities for further NIOSH research.

In another study of parental employment and birth outcome, researchers analyzed six years of birth and stillbirth records from the State of Washington. Researchers created a computer file from certificates for approximately 493,000 live births and 3,400 stillbirths, and tabulated parental employment categories by various birth outcomes including sex, plurality, malformation, birth status, weight by sex, and type of exposure. The parental employment categories were created by grouping types of workplace exposures together (workers exposed to solvents, metal workers, etc.) and by social class. Results of this study are being prepared for publication.

RF Radiation: NIOSH is currently conducting several studies of the effects of radiofrequency (RF) radiation on the reproductive system. RF radiation exposure may occur where workers use heat sealing equipment for plastics, and when curing some furniture sealing glues.

In one of the studies, researchers recorded two complementary types of RF radiation exposure

measurements: RF radiation exposure in body currents, which are induced in the body as the worker becomes part of the RF electrical circuit; and radiative fields, which are generated around the operator by stray emissions from heat sealers.

Researchers collected blood and semen samples from study participants to assess blood hormone levels and semen quality, and made industrial hygiene measurements of acids, hydrocarbons, and other chemicals to determine whether there were confounding chemical exposures. A reproductive health questionnaire and medical examination were administered to the 56 study participants, and results from the questionnaire have been analyzed. The study will be completed in 1989.

Additional RF radiation research measured body currents in workers exposed to RF radiation while using dielectric heaters at a waterbed factory in Indiana. Researchers found that about 33 percent of the body currents exceed the limit proposed by the American National Standards Institute (ANSI). NIOSH also developed equipment to measure magnetic-fields, and will design new sensors for magnetic-field induced body currents.

Effects of Industrial Alcohols on Prenatal Development: NIOSH assessed a total of 13 industrial alcohols for standard teratology, four of which were also assessed for behavioral teratology. Using laboratory rats, researchers completed inhalation exposures and data analyses for standard teratology assessments of alcohols used in manufacturing processes, including 1-octanol, 1-nonanol, and 1-decanol. Because of their low volatility, only low-level vapor concentrations of these three alcohols could be generated, and these concentrations did not produce developmental toxicity. Offspring from rats exposed to tertiary-butanol were also assessed for behavioral teratology, but few significant changes were detected.

Waste Anesthetic Gas in Dental Operating Areas: NIOSH initiated field research on developing controls for waste anesthetic gas exposures (nitrous oxide) in dental operating areas. (See Controls.)

NEUROTOXIC DISORDERS

The nervous system controls motor, sensor, and cognitive functions of the body. Over 850 chemicals have been identified as potential toxins to this system, and many of these are neurotoxic at or below levels that cause other health effects. They also may be present at exposure levels below those needed to produce other, more obvious effects.

Neurotoxins cause diverse effects ranging from numbness and tingling in the hands and feet, to impairment of work ability. Neurotoxins affecting the central nervous system can cause changes in cognitive functions and personality. NIOSH estimates that 7.7 million workers are exposed full time to one or more neurotoxic agents.

NCTB Reliability Assessment: NIOSH is participating in a cross-cultural reliability assessment of the Neurobehavioral Core Test Battery (NCTB) recommended by the World Health Organization (WHO) and NIOSH. NIOSH established contacts with six countries in Latin America to stimulate further interest in the reliability assessment, and held a class to teach administration in the NCTB for Latin American scientists who indicated an interest in the cross-cultural assessment or in using the NCTB. NIOSH also trained scientists from Beijing and Guangzhou in the People's Republic of China, Japan, Austria, and the United States.

For the U.S. portion of the reliability assessment, NIOSH tested 240 workers at two worksites. The subjects were tested for memory, coordination, ability to learn and repeat simple tasks, and manipulation. Researchers will develop baseline information from these results, and will use them to test neurotoxicity of chemicals.

Spray Paint Agents: NIOSH continued studying neurotoxicity of aliphatic hydrocarbons, which are found in surface coating industries in spray paint agents and dyes. Researchers studied effects of aliphatic hydrocarbons on the startle reflex of rats and mice exposed to methyl ethyl ketone and methyl isobutyl ketone, two compounds found in spray paints.

These studies demonstrated that mild neurobehavioral performance decrements are reliably found in subjects following exposure to acetone at the NIOSH recommended exposure limit to 250 parts per million for four hours. The performance decrements closely parallel blood acetone concentrations in the exposed subjects.

Dioxin: In 1984 and 1985, NIOSH developed a protocol for a cross-sectional study of workers exposed to dioxin. The study included morbidity and mortality studies for the effect of dioxin on the body (See Occupational Cancers). As part of this protocol, testing for certain neurologic disorders will be evaluated in fiscal year 1989.

Lead Poisoning: NIOSH researchers conducted a series of follow-up investigations at worksites identified from the Ohio workers' compensation system as having cases of work-related lead poisoning. Sources of continuing lead exposure and problems related to control of lead hazards were pinpointed, and recommendations were made to employers and employees to reduce or eliminate the lead hazards.

While workers' compensation data do not give a complete enumeration of illnesses caused by

hazards in the workplace, they can be used to identify hazardous working conditions and can serve as a basis for follow-up investigations. The value of compensation data in the identification and prevention of other occupational diseases is currently being explored.

NOISE-INDUCED HEARING LOSS

Over nine million Americans may be subject to noise-induced hearing loss because their jobs involve processes that produce noise. NIOSH research has shown that hearing protectors often give less than half the noise attenuation they are reported to provide. Because noise damages the inner ear, this type of hearing loss is irreversible and cannot always be corrected with hearing aids. During the ten-year period from 1978-1987, workers' compensation claims for occupational hearing impairment cost nearly $1 billion.

Impact Noise: NIOSH research indicated that impact noise produced substantially greater hearing loss than did continuous noise, even though the two conditions had the same noise energy. These results suggest that criteria for safe noise exposures based on acoustic energy considerations may not provide sufficient protection to workers subject to impact sounds. Results of this study are being prepared for publication in 1989. Future studies will evaluate which parameters of impact noise (rise time, peak level, repetition rate) are most significant in inducing hearing loss.

Hearing Conservation Manual: A group of national experts in hearing conservation assembled to assist NIOSH staff in developing a manual describing effective hearing conservation programs and practices. The manual will be released in 1989.

Factors Causing Changes in Hearing: NIOSH continued analyzing audiometric records from company hearing conservation programs to determine factors relative to hearing changes. Analysis of one of these data bases revealed that employees with high blood pressure were more likely to show shifts in hearing than those with normal pressure readings, and that women tend to show fewer changes in hearing than men. A report of these findings is being prepared for publication in 1989.

Hearing Protectors: NIOSH researchers continued to collect data on the effects of wearing hearing protectors in noisy environments, and their influence on speech reception for both normal and hearing-impaired listeners. NIOSH is also conducting research to determine the feasibility of improving speech communications in high noise fields.

DERMATOLOGICAL CONDITIONS

Toxic substances in the workplace may enter the body through the skin, or affect the skin directly, causing dermatological disease or disorders. According to recent data from the Bureau of Labor Statistics, dermatological conditions resulting from occupational exposures account for 34 percent of all occupational diseases. Although most prevalent in agriculture and manufacturing, these disorders affect workers in many occupations.

Joint American Academy of Dermatologists/NIOSH National Conference on Prevention of Occupational Dermatoses: The American Academy of Dermatologists (AAD) and NIOSH jointly sponsored a symposium to explore ways of implementing the national prevention strategy for dermatological conditions. AAD has been innovative in contributing to the prevention of occupational dermatoses, and its leadership is important to accomplishing the goals set forth in NIOSH prevention strategy.

Chemical Protective Clothing: NIOSH continued its involvement in researching and disseminating information on Chemical Protective Clothing (CPC) and is developing a guide for selecting CPC. A senior NIOSH researcher is current chairman of the Federal Work Group on Chemical Protective Clothing and Equipment, which was formed to coordinate federally funded CPC research. The work group includes members from EPA, OSHA, the Coast Guard, Los Alamos National Laboratories, the United States Fire Administration, and the National Aeronautics and Space Administration. The Army and Navy also participate on the work group.

NIOSH continued to research the chemical resistance of Chemical Protective Clothing, focusing on how permeation occurs. Researchers are attempting to determine how chemical and material composition affect permeation by studying the transport of liquid chemicals through polymer materials. Continuing research also included an interlaboratory validation of a proposed American Society of Testing and Materials pesticide permeation test method.

Health Hazard Evaluations: NIOSH completed 20 Health Hazard Evaluations at workplaces where employees reported skin problems including rashes, irritations, burns and allergic reactions.

PSYCHOLOGICAL DISORDERS

Job stress can result in several psychological disorders, such as emotional and behavioral disturbances, and mental and psychosomatic illnesses. Studies have shown that many factors may

contribute to job stress, including work overload, lack of control over one's work, nonsupportive supervisors or co-workers, limited job opportunities, role ambiguity, rotating workshifts, and machine-paced work.

These factors can cause anxiety and irritability, substance abuse, psychiatric disorders, and somatic complaints such as headaches and gastrointestinal symptoms. Stressful working conditions may also have a systemic influence, as suggested by recent studies of stress-related immunologic suppression.

Video Display Terminals: NIOSH sponsored a workshop presenting methods for reducing stress and strain from work at Video Display Terminals (VDT). Methods included equipment/work station redesign, changes in job content, clinical treatment of symptomatic workers, and labor/management initiatives. Select papers from this workshop will be published for use as models for more widespread application of stress prevention techniques in VDT work.

Nursing Home Staff: NIOSH researchers found that the major problems creating stress for nursing home staff were patient lifting, physical and verbal abuse from patients, time pressures, and crowding. During FY 1989, researchers will delineate specific stressors amenable to intervention.

Identifying Risks for Mental and Cardiovascular Disorders: NIOSH researchers used Social Security Administration beneficiary data files and the Position Analysis Questionnaire job ratings to identify occupational risks for mental and cardiovascular disorders. Beneficiary data files indicated elevated risk for mental disability in clerical/sales, service, and agricultural occupations. Risk for cardiovascular disorders was higher than expected for professional/technical/management, machine trades, and structural workers. Merging the beneficiary data with the job ratings failed to reveal a clear association between particular job activities and disorders.

Extended Workshifts: Continued testing of the NIOSH fatigue test battery was conducted at two test sites where the work week had been shortened from an eight-hour workday to a twelve-hour rotating work shift. Decrements in performance and alertness, and reports of reduced sleep were associated with the longer shift hour in both worksite studies. Results were published in *Human Factors 1988.*

In a related study, researchers identified and analyzed interventions for minimizing excessive fatigue and promoting better adjustment to extended workshifts. Intervention included shift rotations, napping, exposure to bright lights to adjust circadian rhythms, dietary changes for promoting relaxation or alertness, short-acting benzodiazepines to promote day sleep after night work, and exercises for promoting alertness and adjusting circadian rhythms. Critical reviews of these interventions will be submitted for publication in 1989.

CONTROL

Exposure to harmful substances and conditions in the workplace can be controlled by eliminating hazardous materials from the work site, modifying work procedures, and placing a barrier between the hazard and the worker. NIOSH responds to requests for assistance in controlling workplace hazards by evaluating exposures and finding ways to help prevent them. The Institute's control activities include testing and certifying respirators, evaluating chemical protective clothing, and developing and testing ventilation systems.

Respirators: NIOSH evaluated respirators and coal mine personal sampling units in accordance with regulations, and issued a total of 574 certification decisions (approvals, extensions, or denials). NIOSH also performed 90 post-certification evaluations on respirators purchased from the open market, and performed 27 in-plant quality assurance audits of maufacturers' production facilities. NIOSH investigated 19 complaints from respirator users and 28 defects found by the NIOSH respirator audit program. The *NIOSH Certified Equipment List* was updated and published in April 1988.

Two public meetings were held to receive comments on the Institute's revised respirator certification regulations (proposed 42 CFR 84). The new regulations will stimulate development of improved respirators that when properly used, will increase protection against workplace agents responsible for hazardous exposures.

NIOSH continued to examine the performance of respirators. Researchers collected performance data at a battery manufacturing plant for a study to determine workplace protection factors (WPF), and in a study of the protection afforded fire fighters by self-contained breathing apparata (SCBA). Laboratory studies of aerosol respirator filtration efficiency and methods of modeling respirator performance continued in FY 1988.

The John M. White award was presented to Dr. Ernest Moyer in 1988 by the American Industrial Hygiene Association (AIHA) Respirator Committee for the best respirator paper of 1987, "Organic Vapor (OV) Respirator Cartridge Testing--Potential Jonas Model Applicability."

A project titled "Firesmoke" is using in-facepiece sampling to evaluate the performance self-contained breathing apparatus (SCBA) used by fire fighters during structural fire fighting activities, and characterizing the exposures encountered by means of industrial hygiene techniques and medical monitoring. Successful surveys demonstrated that a mixed sampling approach including sorbent collection, whole gas sampling into collection bags, and direct reading monitors could be used to characterize exposures.

Bioaerosol Sampling Techniques: NIOSH initiated a research project to evaluate alternate bioaerosol samplers, with an emphasis on sampling efficiencies. The goal of this research is to fill voids in the knowledge about bioaerosol sampling techniques that will apply in biotechnology and in evaluating indoor air quality problems.

Wood Dust: Laboratory research was completed on control of wood dust produced during contour routing. The control techniques that were developed achieved a significant reduction (80 to 90 percent) in wood dust emissions. This research, along with previous work on wood shapers and horizontal belt sanders, will provide useful control feasibility information for OSHA in its deliberations on an occupational health standard for wood dust.

Chemical Dusts: Field research was completed on evaluating control measures (work table modifications, varied local exhaust techniques, and low-velocity fresh air supply) that will reduce dust exposures during weighing of chemical powders.

Enzyme Fermentation Processes: NIOSH completed research on a control technology assessment of enzyme fermentation processes used in the pharmaceutical industry. This research can be used to establish baseline information on the equipment and related occupational safety and health practices used in this industry.

Halogen Gas: NIOSH initiated research on a sampling and analytical method for halogen gases (chlorine, bromine and iodine) that will simplify field techniques used by industrial hygienists.

Ethylene Oxide: As part of the need to improve the prevention aspects of controlling ethylene oxide exposures in hospitals, a hazard assessment was performed for ethylene oxide sterilizers. This assessment identified a number of potential process failure sources and subsequent recommendations for improvement that had not been identified in field surveys. This information will be disseminated via the American Hospital Association and sterilizer manufacturers. (See also Occupational Cancers.)

Air Curtain: Research was completed on an air-curtain exhaust ventilation system for controlling formaldehyde exposures from wood panel veneering presses. Reduction levels of approximately 94 percent were achieved.

Waste Anesthetic Gas in Dental Operating Areas: NIOSH initiated field research on evaluating and developing controls for exposure to waste anesthetic gas (nitrous oxide) in dental operating areas. Control of these exposures is important because of the causal association with workers' miscarriages and malformations in their offspring. This research is being conducted in collaboration with the American Dental Association, the National Institute of Dental Research and the CDC Center for Infectious Diseases. (See also Disorders of Reproduction.)

Methylene Chloride in Furniture Stripping: NIOSH initiated a control technology assessment of exposure to methylene chloride found in furniture stripping. This program will develop recommendations on engineering controls, work practices and personal protective equipment that should be used to protect workers from exposure to this neurotoxin. Furniture stripping operations are generally small businesses, so a national dissemination effort will be mounted to transfer recommendations to associations that can oversee implementations of control programs.

NIOSH Manual of Analytical Methods: NIOSH completed and disseminated a supplement to the 3rd Edition of the NIOSH Manual of Analytical Methods containing 51 new or modified methods. The manual describes more than 200 sampling and analytical methods for approximately 350 substances, and is used nationally and internationally as a primary source for these methods. As a result of a Memorandum of Understanding between NIOSH and the Canadian Centre for Occupational Health and Safety, the manual is now available in electronic format.

Formaldehyde: NIOSH initiated research on a sampling and analytical method for determination of formaldehyde in airborne dust. If successful, the method will allow industrial hygienists to measure both formaldehyde vapor and formaldehyde that is adsorbed to dust and fibers.

Sampling Expired Breath: NIOSH continued laboratory research on direct and integrated sampling methods for solvents in expired breath. The sampling device was also used in a field study of workers exposed to methylene chloride, a compound found in furniture stripping chemicals. To date, three technical articles have been prepared as a result of this laboratory and field research.

DISSEMINATION

Only when results from research on occupational hazards are widely disseminated can they be implemented to prevent hazardous conditions in the workplace. NIOSH uses its research findings to inform legislators, workers, employers and others who strive to improve the safety and health of workers.

NIOSH also uses its findings to recommend criteria and standards; issue hazard alerts, intelligence bulletins, manuals and scientific journals; to develop education and manpower training; and to consult with industry and labor representatives. The following section discusses some of the highlights of the Institute's dissemination activities during FY 1988.

POLICY DEVELOPMENT-- CRITERIA AND STANDARDS

NIOSH provided comments to OSHA on the following subjects:

Permissible Exposure Limits to Air Contaminants: NIOSH testified at OSHA hearings on generic, industrywide standards applying to workplace air contaminants. Over 600 chemicals found in the work place have the capacity to contaminate air in the workplace by becoming airborne.

Hazardous Waste Operations and Emergency Response: This rule sets standards for the protection of workers at hazardous chemical disposal facilities. NIOSH provided comments based on a research project with the Coast Guard, OSHA, and EPA. The Institute recommended exposure levels at which protective clothing should be worn, and commented on proposed sampling procedures and training programs at disposal facilities.

HBV/HIV Occupational Exposure: In a coordinated effort with the Center for Infectious Disease, NIOSH provided comments to OSHA for an advance notice proposed rule for blood borne diseases and vaccination/immunization for Hepatitis B Virus (HBV) and for worker handling of needles.

Control of Hazardous Energy Sources: Lockout/Tagout: NIOSH commented on this general industry standard applying to any energy source. Lockout/Tagout refers to ways of preventing machinery from being activated during maintenance. Energy sources can be locked out, whereby a lock is placed on the circuit preventing accidental activation; or tagged out, whereby a tag is placed on control levers warning other workers not to turn on the machine.

NIOSH testified that lockout is more effective than tagout in controlling hazardous energy sources because it prevents accidental activation (from controls being pressed by something leaning against them, wires dragging across them, etc.) and should be used whenever possible.

Safety Standards for Excavation in Construction: NIOSH testified in support of OSHA's proposed rule for standards providing guidelines for safe walling and slopes in excavation ditches. The NIOSH position on these standards was based on the Institute's Fatal Accident Circumstances and Epidemiology (FACE) data.

Ethylene Oxide: NIOSH research has shown that ethylene oxide, a sterilizing agent used in hospitals, has harmful effects on the reproductive system. (See Disorders of Reproduction.) At OSHA hearings on a proposed rule for limiting exposure to ethylene oxide, NIOSH testified that peak exposure standards are necessary and should be included in the rule. NIOSH used health hazard evaluation data to demonstrate the feasibility of operating under peak exposure limits.

Electrical Safety Related Work Practices: This rule addressed work practices, personal protective equipment and lockout/tagout procedures to safeguard workers from electrocution. The standards were designed for the safety of electrical workers within private facilities and persons (for example, tree trimmers) who work in close proximity to electrical power lines. NIOSH provided FACE data on electrocutions, and recommended that lockout procedures be used whenever possible.

NIOSH testimony at MSHA hearings addressed the following:

Ionizing Radiation Standards for Underground Metal and Nonmetal Mines: NIOSH recommended lower limits for exposure based on the Institute's risk assessment which indicates an increased risk of lung cancer that correlated to radon exposure in underground mines. NIOSH published its criteria document for Radon Progeny in Underground Mines, which included results of this risk assessment.

Mine Ventilation: NIOSH testified on MSHA's new mining ventilation rule. NIOSH advised MSHA of its findings that chronic overexposure to respirable coal mine dust were occurring in longwall mining.

Electric Mine Lamps: The Institute commented on MSHA standards for new technology

electric mine lamps. NIOSH recommended that the new lamps not be introduced until testing procedures for them are developed in detail.

Mobile Equipment Automatic Warning Devices: NIOSH provided comments about MSHA's rule which would call for automatic warning devices such as backup lights and beepers on mobile equipment. NIOSH supported this rule and added that mobile equipment should also have safety belts.

Hazard Communication: NIOSH commented on MSHA's Hazard Communication Rules.

Automatic Emergency-Parking Brakes: NIOSH agreed with MSHA that there should be a standard to have automatic parking brakes, and further specified that equipment should have safety belts.

Comments were also transmitted to EPA on polychlorinated biphenyls in electric transformers and hexavalent chromium.

Policy documents: In FY 1988, NIOSH prepared the following documents for dissemination:

- Seven policy documents including; Radon Progeny in Underground Mines (Criteria Document); Welding, Brazing, and Thermal Cutting (Criteria Document); Summary of Recommendations for Occupational Safety and Health Standards; Current Intelligence Bulletin #50 on Carcinogenic Effects of Exposure to Diesel Exhaust; Current Intelligence Bulletin Summary; NIOSH/Swedish Grain Dust Document; and Guidelines for Protecting the Safety and Health of Health Care Workers.
- Four NIOSH Alerts: DMEA; Unstable Surfaces of Stored Grain; Electrical Energy; and Gallium Arsenide;
- Thirty-five Occupational Safety and Health Guidelines for Chemical Hazards;
- Seventeen International Programme for Chemical Safety (IPSC) data cards;
- "NIOSH Recommendations for Occupational Safety and Health Standards" was published in the Morbidity and Mortality Weekly Report (MMWR).

TRAINING AND PUBLIC INFORMATION

Training Grants: A total of 48 training grant applications were received and reviewed. NIOSH visited two Educational Resource Centers (ERC's) in Illinois and Texas and approved their renewal applications for 2 years. Grants were awarded to:

14 ERC's	$8.25 Million
25 Training Projects	$1.30 Million
1 Industrial Medical Center	$ .24 Million

Continuing Education: A total of 474 trainees received education in the latest research and technological advances at 24 NIOSH continuing education courses. The Educational Resource Centers (ERC's) provide continuing education to 17,383 trainees through 389 courses.

Schools of Business-Project Minerva: The cooperative agreement with the Minerva Education Institute was funded for a second year to promote the prevention of occupational injuries and illnesses through the education of students in schools of business. Project activities included:

- an evaluation of a training technique using a simulation model for introducing safety and health issues to students and practicing managers, done in collaboration with the College of Business Administration at Xavier University in Cincinnati, Ohio;
- an exhibit presenting the goals and objectives of Minerva Project at the American Academy of Management Annual Meeting;
- a business faculty workshop promoting occupational safety and health issues in business college curricula at West Virginia University, attended by faculty from 12 States;
- an overview of the Minerva Project presented at the annual meeting of the Organizational Resource Counselors in Washington, DC.
- the addition of three new members to the Minerva Institute Board of Trustees;
- development of an 1800 member mailing list of individuals requesting information and materials related to Project Minerva;
- a visit from a member of the Canadian Board of Safety and Health to the NIOSH facility in Cincinnati to explore the possibility of introducing Minerva materials into Canadian Business Schools;
- a contract awarded to develop occupational safety and health materials for inclusion in college business texts.

Schools of Engineering--SHAPE: The Safety and Health Awareness in Preventive Engineering (SHAPE) Engineering Faculty Network (EFN) continued to expand and in FY 1988 had over 100 participants. A presentation on Project SHAPE was delivered at the annual meeting of the Engineering

Dean's Council.

The safety and health accreditation criteria adopted by the Accreditation Board for Engineering and Technology (ABET) are being implemented for the first time during the 1988-89 school year. Plans are underway to develop guidelines for institutions and ABET program evaluators during FY 1989 that will assist in implementing the new ABET criteria.

Curriculum Development: Through its curriculum development activity, the Institute creates and revises courses and educational materials based on new research findings, technological advances and changing job requirements of workers. In FY 1988, NIOSH updated several of its courses, including **Organization Theory and Program Development for Occupational Health Nurses** and **Sampling and Evaluating Airborne Asbestos Dust.** NIOSH also outlined new courses in Occupational Toxicology, Epidemiology, and Stress Management, and introduced a course schedule reflecting eighteen months of training programs.

NIOSH tested a training program that utilizes a self-assessment questionnaire to help personnel recognize safety and health hazards in the utility industry. NIOSH anticipates that the industry association will recommend this training approach at power generation facilities.

ATPM Cooperative Agreement: The Association of Teachers of Preventive Medicine (ATPM) revised the Directory of Educational Opportunities in Occupational Medicine, and disseminated a limited number of copies at the Prevention 1988 meeting. A copy with further revisions suggested by meeting participants will be printed and disseminated to all medical schools in FY 1989.

Working through a CDC Cooperative Agreement, NIOSH and ATPM held a meeting of Directors of Occupational Medical Residency Programs, and established the Occupational Medical Residency Directors Group for the advancement of occupational medicine as a specialty.

Hazardous Substance Training: The Hazardous Substance Training Program (HST) was established at NIOSH with funds provided through an Interagency Agreement with the National Institute for Environmental Health Sciences (NIEHS). NIOSH awards grants to Educational Resource Centers to develop and implement courses for training State and local professionals engaged in hazardous waste activities.

Improving Health Risk Messages: NIOSH used previously developed guidelines for improving health risk messages to workers exposed to toxic chemicals in their jobs to evaluate existing messages (Manufacturers Safety Data Sheets) and to develop and test modified messages at two work sites.

Results at both work sites showed improvement in worker knowledge of the chemicals, but the modified messages did not improve knowledge more than the original messages did. And while messages generated greater knowledge of the chemicals, they did not create more interest in their effects.

These results suggest that the important factor in improving worker knowledge may be simply directing workers' attention to health risk information. The results also indicate that there are limitations in the use of printed material alone to promote a substantial protective behavior by workers. The NIOSH guidelines acknowledge that in addition to printed messages, effective health risk communications require training and other more active health and safety measures.

Quantitative Risk Assessment: Risk Assessment is a tool for maximizing use of available information for decision making. NIOSH staff have presented assessments on the risk of lung cancer for underground uranium miners, feasibility evaluations on assessments for risks of chronic lung disease and cancer associated with exposure to silica, and on the risk of cancer associated with man-made mineral fibers. Through the NIOSH/Massachusetts Institute of Technology Cooperative Agreement, risk assessment techniques have included pharmacokinetic modeling of human exposure to 1,3-butadiene and assessment of cancer risks; pharmacokinetic modeling of exposures to glycol ethers and risk assessments on developmental toxicology and male reproductive system risks; and pharmacokinetic modeling and acrylamide exposure and neurotoxicity risks.

Information Transfer: During FY 1988, NIOSH completed 7,935 requests for in-house material and responded to approximately 7,600 requests for occupational safety and health information. These included queries received on the NIOSH toll-free telephone number. Also, NIOSH filled 34,800 requests for Institute publications, and provided exhibits at ten conferences.

NIOSH continued to expand its three primary data bases. The NIOSHTIC data base was increased by over 10,000 abstracts to approximately 157,200. Approximately 4,500 new chemicals, 11,000 new synonyms, and 72,000 data lines were added to the Registry of Toxic Effects of Chemical Substances (RTECS). And the Document Information Directory System (DIDS), which is comprised of citations for NIOSH developed articles, documents, contracts, and other materials increased from 6,572 to 7,509 records.

NIOSH Toll-Free Number: In FY 1987, NIOSH established a toll-free number that may be used by callers in the continental United States to request Health Hazard Evaluations or other technical information. In FY 1988, NIOSH received 4,354 calls on this number. The calls were from all 50 States and the District of Columbia, and were received from television viewers who had seen specials on Video Display Terminals and Carpal Tunnel Syndrome; NIOSH offices; OSHA regional offices; Public Health Services regional offices; readers of magazine articles where NIOSH information was published; Directory Assistance, and by previous callers. Information disseminated as a result of these calls included:

Television Packets (Video Display Terminals Report)	207
Television and Magazine Packets (Carpal Tunnel Syndrome)	525
NIOSH Publications and Reports	839
Health Hazard Evaluation Forms	21
Guidance for Indoor Air Quality Investigations	346
Training	136
Miscellaneous	
Asbestos	208
Chemicals or Solvents	742
Personal Protective Equipment	186
Other	894
Total	4,354

PUBLICATIONS

Abell M. Quality Audit Samples and the Asbestos Analyst Registry. Appl Ind Hyg 1988;3(3):R-4-R-5.

Abrons HL, Petersen MR, Sanderson WT, Engelberg AL, Harber P. Symptoms, Ventilatory Function, and Environmental Exposures in Portland Cement Workers. Brit J Indust Med 1988;45(6): 368-375.

Alam R, Lewis DM, Olenchock SA. Production and Properties of Histamine-Releasing Factor of Guinea Pigs. J Immunol 1988;140(6):1946-1952.

Alam R, Lewis DM, Olenchock SA. Activation of Guinea pig Lymphocytes and Mast Cells by Grain Dust Extract. J Allergy Clin Immunol 1988;81:598-604.

Alam R, Lewis DM, Olenchock SA. Identification of a Histamine Release Inhibitory Factor (HRIF) and an Inhibitor of Histamine Releasing Factor Synthesis (IHS) Produced by Guinea Pig Lymphoid Cells. Cellular Immunol 1988;115:447-459.

Albrecht William N. Polymer-Fume Fever Associated with Smoking and Use of a Mold-Release Spray Containining Polytetrafluoroethylene. J Occup Med 1988; 29(10):817-819.

Althouse R, Attfield M, Hodous T. Inter-reader Variability Among X-ray Readers Using ILO 1971 and 1980 Classifications of the Pneumoconioses. Abstracts of Communications, VII International Pneumoconioses Conference, Pittsburgh, PA 1988;174.

Amandus HE, Piacitelli G. Dust Exposures at U.S. Surface Coal Miners in 1982-83. Arch Environ Hlth 1987;42:374-381.

Ameres M. A Prototype Capacitive Sensor-Based Robot Safety System. National Technical Information Service. Springfield, VA. 1987, NTIS #PB88163175.

Anger WK. Report of the Sixth Annual Behavioral Toxicology Society Meeting, 1987. Neurotoxicol Teratol 1988;10(2):181.

Attfield MD. Epidemiological Evidence on Smoking, Dust Exposure, and Lung Disease in Coal Miners. Proc. XVIII Annual Institute on Coal Mining Health, Safety and Research, August 1987; Faulkner E. et al, eds.; Blackburg, VA; Virginia Polytech Institute; 89-98.

Attfield MD, Hodous TK, Althouse R. A Comparison of the Profusion and Type of Small Opacities Reported with the 1980 and 1971 ILO Classifications Using Readings for the Coalworkers' X-ray Surveillance Program. Abstracts of Communications, VII International Pneumoconioses Conference, Pittsburgh, PA, 1988;20.

Badger DW. Updating the NIOSH Work Practices Guide for Manual Lifting: A Preliminary Report. Am Ind Hyg Conference Abstracts 1988;249.

Banks MA, Robinson VA, DeLong DS, Frazer DG, Castranova V. Effect of Dietary Vitamin C on Guinea Pig Pulmonary Response to Inhalation of Cotton Dust. Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, TN; National Cotton Council; 99-102.

Baron P. Asbestos Analysis--NIOSH Method 7400. Appl Ind Hyg 1987;2(6):R-8-R-10.

Baron P. Modern Real-Time Aerosol Samplers. Advances in Air Sampling, Lewis Publishers, Inc., Chelsea, MI: 1988:205-223; Appl Ind Hyg 1988;3(3):97-103.

Beauchamp Y, Jaraiedi M, and Etherton J. Safe Manual Control of Slow-Moving Industrial Robots. Proceedings of Canadian Human Factors Society Meeting. Montreal, Canada. October 1987.

Beaumont James J. Lung Cancer Mortality in Workers Exposed to Sulfuric Acid Mist and Other Acid Mists. JNCI 1987;79(5):911.

Belinky BR, Cooper V, Niemeier RW. Fractionation and Analysis of Asphalt Fumes for Carcinogenicity Testing. In: Cameron TP, Adamson RH, Blackwood IC, eds. Proceedings of the Fourth NCI/EPA/ NIOSH Collaborative Workshop: Progress on Joint Environmental and Occupational Cancer Studies. Washington, DC, National Institute of Health 1988:117-128. (NIH Publication No. 88-2960).

Bennett DE, Mathias CGT, Susten AS, Fannick WL, Smith AB. Dermatitis from Plastic Tote Boxes Impregnated with an Antistatic Agent. J Occup Med 1988;30(3)252-255.

Berardinelli SP. Prevention of Occupational Skin Disease through Use of Chemical Protective Gloves. Dermatologic Clinics 1988;6(1):115-119.

Berardinelli SP, Moyer ES. Chemical Protective Clothing Breakthrough Time: Comparison of Several Test Systems: Am Ind Hyg Assoc J 1988;49(3):89-94.

Bernstein IL. Immune Responses of Cynomolgus Monkeys to Phthalic Anhydride. J Allergy Clin Immunol 1988;82(1):23-29.

Bhattacharya A, Mansori M, Habes D. Design and Development of a Lower Extremity Dosimeter. Am Ind Hyg Conference Abtracts 1988;68-69.

Biagini RE, Bernstein DI, Gallagher JS, Moorman WJ, Knecht EA, Smallwood WA, Bernstein IL. Immune Responses of Cynomolgus Monkeys to Phthalic Anhydride. J Allergy Clin Immunol 1988;82(1):23-29.

Biagini RE, Clark JC, Moorman WJ. Cold Air Inhalation in Cynomolgus Monkeys: Development of a Method and Evaluation of the Onset and Duration of Response. Am Rev Respir Dis 1988;137(2, Part 2):483.

Biagini RE, Moorman WJ, Lal JB, Gallagher JS, Bernstein IL. Normal Serum IgE and IgG Antibody Levels in Adult Male Cynomolgus Monkeys. Lab Anim Sci 1988;38(2):194-196.

Bierbaum P. Current Perspective on Occupational Safety and Health Issues. In: Proceedings of the Sixty-Third Convention of the Metal Trades Department of the American Federation of Labor and Congress of Industrial Organizations, Miami Beach, FL, October 19-20, 1987:70-73.

Bierbaum, PJ, Murray WE. Case-Control Study of Lung Cancer in Civilian Employees at the Portsmouth Naval Shipyard, Kittery, Maine. Am J Epidemiol 1988;127(1):55-64.

Bloom TF. Industrial Hygiene Study: Extent of Exposure to Organotins. Proceedings of the Fourth NCI/EPA/NIOSH Collaborative Workshop. Progress on Joint Environmental and Occupational Cancer Studies. 1988:297-332.

Boeniger M. Formate in Urine as a Biological Indicator of Formaldehyde Exposure: A Review. AIHAJ 1987;48(11):900-908.

Boeniger M. Occupational Exposure to Silicate Fibres and PAHs During Suger-Cane Harvesting. Ann Occupational Hygiene 1988;32(2):153-169.

Boeniger M, Choudhary G, Foley G. Determination of Airborne Triethylenediamine and 2,2'-Oxybis (N,N-dimethyl) ethylamine in the Workplace. Appl Ind Hyg 1987;2(6):210-221.

Bohrman JS, Burg JR, Elmore E, Gulati DK, Barfknecht TR, Niemeier RW, Dames BL, Toraason M, Langenbach R. Interlaboratory Studies with the Chinese Hamster V79 Cell Metabolic Cooperation Assay to Detect Tumor Promoting Agents. Environ Mol Mutagen 1988;12(1):33-51.

Bohrman JS, Elmore E, McGregor D, Toraason M. Interruption of Cell-Cell Communication in Chinese Hamster V79 Cells by Fractions of Asphalt Fume. In Vitro 1988;24(3)18A.

Boiano JM, London MA, Habes DJ. Health Hazard Evaluation Report No. HETA 85-534-1855, ICI Americas, Inc. Indiana Army Ammunition Plant, Charleston, IN. Cincinnati, OH, National Institute for Occupational Safety and Health 1987:26 pages.

Brackbill R, Frazier T, and Shilling S. Smoking Characteristics of U.S. Workers, 1978-1980. Am J Ind Med 1988;13:5-41.

Brackbill R. Jobs and the Heart. Medical Beat, News and Reports (Heartbeat), Summer, 1988.

Braddee RW. Booms and Power Lines: A Deadly Combination. Concrete Construction 1988:416-418.

Brightwell WS, Robertson SK, Nelson BK, Kahn A, Burg JR, Krieg Jr E, Massari VJ. Behavioral Teratology Investigation of 1-Butanol Administered by Inhalation to Rats. Teratology 1988;37(5):523.

Brown M. NIOSH and NIOSH Basis for an Occupational Health Standard: Grain Dust--Health Hazards of Storing, Handling, and Shipping Grain. Solna, Sweden Arbete och Halsa, 1988:14.

Brown WD, Setzer JV, Dick RB, Phipps FC, Lowry LK. Body Burden Profiles of Single and Mixed Solvent Exposures. J Occup Med 1987;29(11): 877-883.

Burroughs G, Woebkenberg M. Effectiveness of Real-Time Monitoring. Advances in Air Sampling, Lewis Publishers, Inc., Chelsea, MI; 1988:243-250.

Cassitto M, Anger WK, Hanninen H, Xintaras C. Field Evaluation of WHO Neurobehavioral Core Test Battery. East African Newsletter on Occupational Health and Safety, November 1987;10(2):26.

Castellan R, Olenchock SA, Kinsley KB, Townsend MC, Keimig DG, Ghio AJ, Piacitelli GM. Airborne Endotoxin Concentrations in the Cotton Industry: Effect of Cotton Growing Area. Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, TN; National Cotton Council; 43-46.

Castranova V, Rabovsky J, Tucker JH, Miles PR. The Alveolar Type II Epithelial Cell: A Multifunctional Pneumocyte. Toxicol Appl Pharmacol 1988;93:472-483.

Castranova V, Robinson VA, DeLong DS, Mull J, Frazer DG. Pulmonary Response of Guinea Pigs to Inhalation of Cotton Dust: Effect of Depletion of Peripheral Leukocytes. Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, TN; National Cotton Council; 92-95.

CDC Vietnam Experience Study (Schrader SM, contributor). Health Status of Vietnam Veterans. II. Physical Health. JAMA 1988;259(18):2708-2714.

Cheever KL, Cholakis JM, El-hawari AM, Kovatch RM, Weisburger EK. The Influence of Disulfiram or Ethanol on 1,2- Dichlorethane Carcinogenicity, Metabolism, and DNA Binding. In: Cameron TP, Adamson RH, Blackwood IC, eds. Proceedings of the Fourth NCI/EPA/NIOSH Collaborative Workshop: Progress on Joint Environmental and Occupational Cancer Studies. Washington, DC. National Institutes of Health 1988;49-115. (NIH Publication No. 88-2960).

Cheever KL, Richards DE, Weigel WW, Begley KB, Savage Jr RE, Daniel FB. Macromolecular Adduct Formation by 4,4'-Methylene-bis(2-Chloraniline) (MBOCA) in the Adult Male Rat. In: Lindstrom K, ed. Proceedings of the Fourth Finnish-US Joint Symposium on Occupational Safety and Health with Swedish Participation. Scand J Work Environ Health 1988;14(Suppl 1):57-59.

Cheever KL, Richards DE, Weigel WW, Lal JB, Dinsmore AM, Daniel FB. Metabolism of Bis (2-Methoxyethyl) Ether in the Adult Male Rat: Evaluation of the Principal Metabolite as a Testicular Toxicant. Toxicol Appl Pharmacol 1988;94(1):150-159.

Chideckel EW, Frost JL, Mike P, Fedan JS. The Effect of Ouabain on Tension in Isolated Respiratory Tract Smooth Muscle of Humans and Other Species. Brit J Pharmacol 1987;92:609-614.

Cohen A. Evolving Efforts at NIOSH to Tie Worksite Health Promotion with Worksite Health Protection Activities. Proceedings of the XIII World Conference on Health Education, Vol 1, 1988;80-81.

Conover DL, Moss EC, Murray WE, Edwards RM, Cox C, Grajewski B, Smith JM. Body Current Measurements for RF Dielectric Heater Operators. Bioelectromagnetics Society Tenth Annual Meeting Abstracts 1988;49.

Costello J, Graham WGB. Vermont Granite Workers' Mortality Study. Am J Indust Med 1988;13:483-497.

Cox J, Ayer HE, Saltzman BE, Cox C, Hornung RW. Characterization of Exposure to Coke Oven Emissions. Am Ind Hyg Conference Abstracts 1988;196-197.

Dutkiewicz J, Skorska C, Sitkowska J, Ochalska B, Kaczmarski F. Properties of the Endotoxins Produced by Various Gram-negative Bacteria Present in Occupational Environments. Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, TN; National Cotton Council; 187-189.

Eller P. Availability of the 1987 Supplement to the NIOSH Manual of Analytical Methods, Third Ed. Appl Ind Hyg 1988;3(3):86; Am Ind Hyg Assoc J 1988;49(3):135.

Eller P, Ed. Supplement to: NIOSH Manual of Analytical Methods, Third Ed. Government Printing Office, 1988.

Elliott LJ, Mortimor V, Ringenburg V, Kercher S, O'Brien D. Effect of Engineering Controls and Work Practices in Reducing Ethylene-Oxide Exposure During the Sterilization of Hospital Supplies. Scand J Work Environ Health 14 1988; Supp 1:40-42.

Elliott L, Mortimer V, Ringenburg V, Kercher S, O'Brien D. Effect of Engineering Controls and Work Practices in Reducing Ethylene-Oxide Exposure during the Sterilization of Hospital Supplies, Proceedings of the Fourth Finnish-US Joint Symposium on Occupational Safety and Health, Turku, Finland, May 31-June 2, 1988. In: Lindström K., Guest Editor, Scand J Work Environ Health 1988;14:Suppl 1,40-42.

Elliott LJ, Ringenburg VL, Morelli-Schroth P, Halperin WE, Herrick RF. Ethylene Oxide Exposures in Hospitals. Appl Ind Hyg 1988;3(5):141-145.

Elmore E, Langenbach R, Bohrman JS. Inhibition of Metabolic Cooperation in V79 Cells: Potential Correlations with Tumor Promotion. In: Langenbach R, Elmore E, Barrett JC, eds. Tumor Promoters: Biological Approaches for Mechanistic Studies and Assay Systems--Progress in Cancer Research for Therapy Series, Vol 34. New York, Raven Press 1988;149-160.

Etherton JR. Factors Reported in Amputation and Other Injury Cases at Mechanical Power Press Between 1976 and 1984. In: Trends in Ergonomics/Human Factors V, Aghazadeh (ed.), North-Holland, Amsterdam. 1988;629-638.

Etherton JR. Safe Maintenance Guidelines for Robot Workstations. NIOSH Technical Report, March 1988, DHHS (NIOSH) Publication No. 88-108.

Etherton JR. Unexpected Motion Hazard Exposures on a Large Robotic Assembly System. In: Egonomics of Hybrid Automated Systems I, Karwowski, Parsaei, Wilhelm (ed.) Elsevier Press, Amsterdam. 1988;411-419.

Eurell TE, Parnell MJ, Henningsen GM. Comparison of Alpha-2 U Globulin Isolated from the Urine of Albino and Non-Albino Rats. Toxicologist 1988;8(1):135.

Fedan JS, Hay DWP, Raeburn D. Ca2+ and Respiratory Smooth Muscle Function: Is There a Role for Calcium Entry Blockers in the Therapy of Asthma? In: Hollinger MA, ed. *Current Topics in Pulmonary Pharmacology and Toxicology*. Elsevier 1987;53-94.

Fingerhut, Marilyn A. Dioxins, Chlorophenols, and Phenoxy Herbicides. In Zenz (led) Occupational Medicine Principles & Practical Applications--2nd Edition, Year Book Medical Publishers, Inc., Chicago, 1988;723-729.

Franks, JR. The Effects of Hearing Protectors on Head Diffraction. J Acoust Soc Am 1987;82 (Suppl 1):S114.

Franks JR, Davis RR, Dunn DE. A Chamber for Simultaneous Noise Exposure of Chinchillas. Abstracts of the Eleventh Midwinter Research Meeting of the Association for Research in Otolaryngology 1988;15-16.

Franks JR. Management of Hearing Conservation Data With Microcomputers. In: Lipscomb, DM, ed. Hearing Conservation in Industry, Schools, and the Military. Boston, College Hill Press 1988; 113-144.

Frazer DG, Robinson VA, DeLong DA, Petsonk EL, Weber KC, Jones TS. Mechanism of Airflow Interruption in Guinea Pigs Exposed to Cotton Dust. Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, TN; National Cotton Council; 153-157.

Glaser R. Direct Sampling of Organic Solvents in Expired Breath with a New Solid Sorbent Sampling Device, Proceedings of the Fourth Finnish-US Joint Symposium on Occupational Safety and Health, Turku, Finland, May 31-June 2, 1988. In: Lindström K, Guest Editor, Scand J Work Environ Health 1988;14:Suppl 1:63-65.

Gould M, Olenchock S. Endotoxin extraction method for organic dusts. In: Rylander R, Burrell R, eds.; Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, TN; National Cotton Council; 204-205.

Greife AL, Hornung RW, Stayner LG, Steenland KN, Development of a Model for Use in Estimating Exposure to Ethylene Oxide in a Retrospective Cohort Mortality Study. Scand J Work Environ Health 1988;14:Supp 1:29-30.

Gressel M, O'Brien D, Tenaglia R. Emissions from the Evaporative Casting Process. Appl Ind Hyg 1988;3:11-17.

Guidelines for Reporting Occupation and Industry on Death Certificates. National Center for Health Statistics. Hyattsville, MD, March 1988, DHHS Publication No. (PHS) 88-1149).

Habes DJ, Wickstrom R, Blatman H, Bhattacharya A. The Use of Liquid Crystal Thermography for Evaluating Occupational Joint Stress. Am Ind Hyg Conference Abstracts 1988;42-43.

Hahon N, Booth JA. Benzo[A]Pyrene: Kinetics in *In Vitro* Bioactivation in Relation to Inhibition of Viral Inferferon Industion. J. Interferon Res 1988;8:151-167.

Hahon N, Booth JA, Stewart JD. Interferon Induction Inhibition and Mutagenic Activity of Nitrosated Coal Dust Extract. Environ Res 1988;45(2):213-223.

Hales T. Occupational Injuries Resulting from Violence, Ohio Monitor, February 1988; Vol. 3.

Hales T. Occupational Injuries Due to Violence. J Occup Med 1988;30(6):483-487.

Hampl V, Johnston O, Murdock D. Application of An Air Curtain-Exhaust System at a Milling Process. Am Ind Hyg Assoc J 1988;49(4):167-175.

Hankinson JL, Gardner RM. Standardization of Spirometry - Letter to the Editor, Am Rev Respir Dis 1988;137(2):493-494.

Harber P, Shimozaki S, Gardner G, Billet E, Vojtecky M, and Kanim L. Importance of Non-Patient Transfer Activities in Nursing-Related Back Pain: Observational Study and Implications. J Occup Med 1987 29(12):971-974.

Harner L (1988). Standard Morbidity Ratios for Work-Related Amputation and Fractures by Occupation. J Safety Research 19(3):103-113.

Hay DW, Farmer SG, Raeburn D, Muccitelli RM, Wilson KA, Fedan JS. Differential Effects of Epithelium Removal on the Responsiveness of Guinea Pig Tracheal Smooth Muscle to Bronchoconstrictors. Brit J Pharmacol 1987;92:381-388.

Helander MG, Karwan MH, and Etherton JR (1987). A Model of Human Reaction Time to Dangerous Robot Arm Movements. Proceedings of Human Factors Society 31st Annual Meeting. New York. October 1987.

Helander MG, and Karwan MH. Human Motor Reactions to Dangerous Motions in Robot Operation. National Technical Information Service, Springfield, VA, 1987, NTIS #PB87222196.

Henningsen GM, Eurell TD, Koller LD. Assessment of Hemoglobin Isovarients as a Factor of Chemical-Induced Polycythemia in Wistar Rats. Toxicologist 1988;8(1):82.

Herrick RF. Development of an Air Sampling Method Based on the Reactive Properties of a Contaminant. Scand J Work Environ Health 1988;14,Supp 1:31-32.

Herrick RF. Measurement of the Epoxy Content of Paint Spray Aerosol: Three Case Studies. Appl Ind Hyg 1988;3(4):123-128.

Hills B, Fajen J. Leather Manufacturing. Occupational Medicine--Principles & Practical Applications--2nd Edition 1988; 1036-1039.

Hull DR. Metals in Urine. In: Kneip TJ, Crable JV, eds. Methods for Biological Monitoring--A Manual for Assessing Human Exposure to Hazardous Substances. Washington, DC, American Public Health Association 1988;229-235.

Hurrell JJ Jr, Coletta GC, Mansdorf SZ, Berardinelli SP. Chemical Protective Clothing Standard Test Method Development: Part II. Degradation Test Method. Am Ind Hyg Assoc J 1988;49(1):26-33.

Hurrell JJ Jr, Murphy LR, Sauter SL, Cooper CL, eds. Occupational Stress: Issues and Developments in Research. New York, Taylor & Francis 1988; 219 pages.

Jensen R, Nestor D, Myers A, and Rattikner J. Low Back Injuries Among Nursing Personnel, an Annotated Bibliography. Injury Prevention Center of Johns Hopkins University 1988; Baltimore, MD.

Jensen RC (1988). Epidemiology of Work-Related Back Pain. Topics in Acute Care and Trauma Rehabilitation 2(3):1-15.

Jensen RC and Etherton JR. Comparative Hazardousness of Metalworking Machines. In: Trends in Ergonomics/Human Factors V, Aghazadeh (ed.), North-Holland, Amsterdam 1988;639-645.

Jensen RC, and Sinkule E. Press Operator Amputations: Is Risk Associated with Age and Gender? J Safety Research 1988;19(3):125-133.

Johnson BL, Baker EL, El Batawi M, Gilioli R, Hanninen H, Seppalainen AM, Xintaras C, eds. Prevention of Neurotoxic Illness in Working Populations. New York, John Wiley & Sons 1987;257 pages.

Keller GE III, Lewis DM, Olenchok SA. Demonstration of Inflammatory Cell Population Changes in Rat Lungs in Response to Intratracheal Instillation of Spring Wheat Dust Using Lung Enzymatic Digestion and Centrifugal Elutriation. Comp Immun Microbio Infect Dis 1987;10(3-4):219-226.

Kelsey KT, Wiencke JK, Eisen EA, Lynch D, Lewis T, Little JB. Factors Influencing the Detection of Persistently Elevated SCE After In-Vivo Inhalation Exposure to Ethylene Oxide in Non-Human Primates. Environ Mol Mutagen 1988;11(Suppl 11):52.

Kelsey KT, Wiencke JK, Eisen EA, Lynch DW, Lewis TR, Little JB. Persistently Elevated Sister Chromatid Exchanges in Ethylene Oxide-Exposed Primates: The Role of a Subpopulation of High Frequency Cells. Cancer Res 1988;48(17):5045-5050.

Kelsey KT, Wiencke JK, Eisen EA, Lynch D, Lewis T, Little JB. Persistently Elevated SCE in Ethylene Oxide-Exposed Primates Involve a Subpopulation of High Frequency Cells. Environ Mol Mutagen 1988;11(Suppl 11):52.

Kennedy E. Sampling Reactive Materials. Advances in Air Sampling, Lewis Publishers, Inc., Chelsea, MI; 1988:175-188.

Klein M. The Air Flow Characteristics of an Annular Exhaust Hood. Appl Ind Hyg 1988; 3(4): 105-109.

Kneip T, Crable J, eds. Methods for Biological Monitoring. A Manual for Assessing Human Exposure to Hazardous Substances. American Public Health Association, Washington, DC, Publ. No. ISBN 0-87553-1482, 1988.

Kominsky John R. Use of Risk Assessment Methods in the Certification of Decontaminated Buildings. Risk Analysis 1987;7(4):487-495.

Kovein R, Hentz P. A Digital Current Capacity Tester for Rechargeable Batteries. Appl Ind Hyg 1988;3(2):51-54.

Krishna G, Nath J, Peterson M, Ong T. *In Vivo* and *In Vivo/In Vitro* Kinetics of Cyclophosphamide-induced Sister-chromatid Exchanges in Mouse Bone Marrow and Spleen Cells. Mutation Res 1988;204(2):297-305.

Lalich L, Schuster L. An Application of the Sentinel Health Event (Occupational) Concept to Death Certificates. Amer J Public Health 1987;77: 1310-1314.

Langenbach R, Bohrman JS, Spalding J, Burg J, Elmore E, McGregor D, Toraason M. Activities of Genetoxic and Nongenotic Carcinogens and Noncarcinogens in the Metabolic Cooperation Assay. Toxicologist 1988;8(1):195.

Lary JM, Conover DL, Edwards RM, Werren DM. Tissue Destruction in Rats from Exposure to 10-MHz Electric Fields at Low Whole-Body SARs. Bioelectromagnetics Society Abstracts 1988;50.

Lewis DM, Bledsoe T, Dement JM. Laboratory Animal Allergies: Use of the Radioallergyosorbent Test Inhibition Assay to Monitor Airborne Allergen Levels. Scand J Work Environ Health 1988;14:(Suppl 1):74-76.

Lewis DM, Lynch DW. Toxicity of Inhaled Isobutyl Nitrate in BALB/c Mice: Systemic and Immunotoxic studies. In: Haverkos HW, Dougherty JA, eds.; Health Hazards of Nitrite Inhalants, NIDA Research Monograph 83, U. S. Government Printing Office, Washington, DC, 1988;50-58.

Lowry LK. The Biological Exposure Index: Its Use in Assessing Chemical Exposures in the Workplace. Toxicology 1987;47(1):55-69.

Lowry LK. Biological Limit Values. In: Kneip TJ, Crable JV, eds. Methods for Biological Monitoring --A Manual for Assessing Human Exposure to Hazardous Substances. Washington DC, American Public Health Association 1988;109-119.

Lynch DW, Moorman WJ, Lewis TR, Stober P, Hamlin RL. Subchronic Inhalation Toxicity of Ethylamine (EA) Vapor in F-344 Rats. Toxicologist 1988;8(1):250.

Ma JYC, Ma JKH, Weber KC, Bowman L, Reasor MJ, Miles PR. Association of Chlorphentermine with Phyospholipids in Rat Alveolar Lavage Materials, Alveolar Macrophages and Type II cells. Biochimica et Biophysica Acta 1988;958:163-171.

Mansdorf SZ, Berardinelli SP. Chemical Protective Clothing Standard Test Method Development Part 1. Penetration Test Method. Am Ind Hyg Assoc J 1988;49(1):21-25.

Martinez K, Sheehy J, Jones J. Control Technology Assessment of Enzyme Fermentation Processes, Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-114.

Martinez K, Sheehy J, Jones J, Cusick L. Microbial Containment in Conventional Fermentation Processes. Appl Ind Hyg 1988;4(6):177-181.

Mastin JP, Stettler LE, Shelburne, JD. Quantitative Analysis of Particulate Burden in Lung Tissue. Scan Microse 1988;2(3):1613-1629.

Mathias Toby C.G. Occupational Dermatoses, In Zenz, (led) Occupational Medicine Principles & Practical Applications--2nd Edition, Year Book Medical Publishers, Inc., Chicago, 1988:132-165.

McCammon CS, Wells VE, Glaser RA, Phipps FC. Worker Exposure to Methylene Chloride in the Furniture Stripping Industry As Determined by Air, Breath and Blood Samples. Am Ind Hyg Conference Abstracts 1988;29.

McGlothlin J, Jensen P, Gressel M, Heitbrink W. Ergonomic Applications and Control of Chemical Aerosols. In: Aghazadeh, F. ed., Trends in Ergonomics/Human Factors V, Proceedings of the International Industrial Ergonomics and Safety Conference, June 8-10, 1988, New Orleans, LA; 333-343.

McLaney MA. Exposure to Job Stress--A New Psychometric Instrument. In: Lindström K, ed. Proceedings of the Fourth Finnish-U.S. Joint Symposium on Occupational Safety and Health with Swedish Participation. Scand J Work Environ Health 1988:14(Suppl 1):27-29.

Mickelsen RL, Hall RC. A Breakthrough Time Comparison of Nitrile and Neoprene Glove Materials Produced by Different Glove Manufacturers. Am Ind Hyg Assoc J 1987;48(11):941-947.

Middleton DC, and Trent RB. Emergency Medical Response to Occupational Locations in West Virginia. Journal of Occupational Accidents 1988;10:131-139.

Miles PR, Ma JYC, Bowman L. Degradation of Preliminary Surfactant Disaturated Phosphatidylcholines by Alveolar Macrophages. J Applied Physiol 1988;64(6):2474-2481.

Molina D, Abell M. An Ion Chromatographic Method for Insoluble Chromates in Paint Aerosol. Am Ind Hyg Assoc J 1987;48(10):830-835.

Moorman WJ, Knecht EA, Biagini RE, Hull D. Delayed Bronchial Responsiveness to Acute V_2O_5 Aerosol Challenge in Monkeys. J Aerosol Med 1988;1(3):280-281.

Muldoon JT, Wintermeyer LA, Eure JA, Fuortes L, Merchant JA, VanLier SF, Richards TB. State Activities for Surveillance of Occupational Disease and Injury, 1985. CDC Surveillance Summaries, MMWR 1987;36(SS #2):7-12.

Murphy LR. Workplace Interventions for Stress Reduction and Prevention. In: Cooper CL, Payne R, eds. Causes, Coping and Consequences of Stress at Work. New York, John Wiley & Sons, 1988;301-339.

Murphy LR, Sorenson S. Employee Behaviors Before and After Stress Management. J Organ Behav 1988;9(2):173-182.

Myers JR (1988). National Surveillance of Occupational Fatalities in Agriculture. In: Proceedings, Agricultural Occupational and Environmental Health: Policy Strategies for the Future. Iowa City, IA. September 18-21, 1988.

Nath J, Krishna G, Petersen M, Ong T. Sister-chromatid Exchanges Induced by Triethylenemelamine: *In Vivo* and *In Vivo/In Vitro* Studies in Mouse and Chinese Hamster Bone Marrow and Spleen Cells. Mutation Res 1988;206(1):73-82.

National Institute for Occupational Safety and Health (1988). NIOSH Certified Equipment List, as of October 1, 1987. DHHS (NIOSH) Publication No. 88-107.

Nelson BK. Distinctions Between Research on Pharmaceutical Agents and Environmental/Industrial Chemicals. Teratology 1988;37(5):515.

Nelson BK, Brightwell WS, Kahn A, Hoberman AM, and Krieg EF Jr. Teratological Evaluation of 1-Pentanol, 1-Hexanol, and 2-Ethyl-1-Hexanol Administered by Inhalation to Rats. Teratology 1988;37(5):479-480.

Nelson BK, Brightwell WS, Taylor BJ, Kahn A, Burg JR, and Massari VJ. Behavioral Teratology Investigation of 1-Propanol Administered by Inhalation to Rats. Teratology 1988;37(5):523.

Nelson BK. Teratogen: A Case Against Redefinition. (Lett) Teratology 1987;36(3):399-400.

Nelson BK, Brightwell WS, MacKenzie-Taylor DR, Burg JR, Massari VJ. Neurochemical, but not Behavioral, Deviations in the Offspring of Rats Following Prenatal or Paternal Inhalation Exposure to Ethanol. Neurotoxicol Teratol 1988;10(1):15-22.

Nelson BK, Brightwell WS, MacKenzie-Taylor DR, Kahn A, Burg JR, Weigel WW, Goad PT. Teratogenicity of n-Propanol and Isopropanol at High Inhalation Concentrations to Rats. Food Chem Toxicol 1988;26(3):247-254.

Nelson RM, and Nestor DE. Standardized Assessment of Industrial Low Back Injuries: Development of the NIOSH Low Back Atlas. Topics in Acute Care and Trauma Rehabilitation 1988;2(3):16-24.

Nelson RM, and Nestor DE. Atlas of Standardized Low-Back Tests and Measures of the National Institute for Occupational Safety and Health. Scand J. Work Environ Health 1988;14(Suppl 1):82-84.

Nestor DE. Hospital Bed Design and Operation--Effect on Incidence of Low Back Injuries among Nursing Personnel. In: Trends in Ergonomics/ Human Factors V. Aghazadeh (ed.), North Holland, Amsterdam. 1988;729-740.

Neumeister C. Environmental Sampling and Analysis for Zeranol. Am Ind Hyg Assoc J 1987;48(11): 919-921.

NIOSH Alert: Request for Assistance in Reducing the Potential Risk of Developing Cancer from Exposure to Gallium Arsenide in the Microelectronics Industry. Cincinnati, OH: National Institute for Occupational Safety and Health, 1987. DHHS (NIOSH) Publication No. 88-100.

NIOSH Recommendations for Occupational Safety and Health Standards, 1988. MMWR 1988;37(S-7).

NIOSH Radon Progeny in Underground Mines; A Recommended Standard for Occupational Exposure. Cincinnati, OH: National Institute for Occupational

Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-101.

NIOSH Alert: Request for Preventing Entrapment and Suffocation Caused by the Unstable Surfaces of Stored Grain and Other Materials. Cincinnati, OH: National Institute for Occupational Safety and Health, 1987. DHHS (NIOSH) Publication No. 88-102.

NIOSH Alert: Request for Assistance in Preventing Vision Disturbances and Acute Physical Distress Due to Dimethylethylamine (DMEA) Exposure. Cincinnati, OH: National Institute for Occupational Safety and Health, 1987. DHHS (NIOSH) Publication No. 88-103.

NIOSH Alert: Request for Assistance in Preventing Electrocutions by Undetected Feedback Electrical Energy Present in Power Lines. Cincinnati, OH: National Institute for Occupational Safety and Health, 1987. DHHS (NIOSH) Publication No. 88-104.

NIOSH Certified Equipment List as of October 1, 1987. Cincinnati, OH: National Institute for Occupational Safety and Health, 1987. DHHS (NIOSH) Publication No. 88-107.

NIOSH Welding, Brazing, and Thermal Cutting; Criteria for a Recommended Standard. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-110 (abridged edition publication no. 88-110(a)).

NIOSH. Projects of the National Institute for Occupational Safety and Health, 1988. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-113.

NIOSH. Research and Demonstration Projects: Annual Report FY 1987. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-115.

NIOSH. Carcinogenic Effects of Exposure to Diesel Exhaust; Current Intelligence Bulletin 50. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-116.

NIOSH. Guidelines for Protecting the Safety and Health of Health Care Workers. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-119.

NIOSH. Occupational Safety and Health Guidelines for Chemical Hazards, Supplement 1. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-118.

NIOSH. Current Intelligence Bulletins: Summaries. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-120.

Niemeier RW, Thayer PS, Menzies KT, Von Thuna P, Moss CE, Burg J. A Comparison of the Skin Carcinogenicity of Roofing Asphalt and Coal Tar Pitch Fumes. In: Cooke M, Dennis AJ, eds. Polynuclear Aromatic Hydrocarbons. Proceedings of the Tenth International Symposium. Columbus, OH, Battelle Press 1988;609-647.

Olenchock SA. Quantitation of Airborne Endotoxin Levels in Various Occupational Environments. Scand J Work Environ Health 1988;14;(Suppl 1):72-73.

Olenchock SA, Castellan RM. Effects of Differences in Areas of Growth and Plant Varieties on Endotoxin Contamination of Airborne Dusts From Carded Cottons. In: Llewellyn GC and O'Rear CE, eds., *Biodeterioration Research;* Plenum Publisher, NY; 1987; 198-199.

Olenchock SA, Lewis DM, Mull JC, Keenan NJ. Analysis of Environmental Dusts by the Quantitative Chromogenic *Limulus* Amebocyte Lysate Test. In: Rylander R, Burrell R, eds.; *Proc. Endotoxin Inhalation Workshop,* National Cotton Council; Memphis, TN, 1988;198-199.

Ong T, Stewart J, Whong W-Z. Detection of the Genotoxicity of Complex Chemical Mixtures with the SOS Umu-Test. In: Sandhu SS, DeMarini DM, Mas MJ, Moore MM, Mumford JL, eds. Short-Term Bioassays in the Analysis of Complex Enivronmental Mixtures V, Plenum Publishing 1987;181-188.

Petersen MR. Post Study Power Estimation by Computer. J Stat Comput Simul 1988;29(3):195-210.

Peterson MR, Hodous TK. Lung Volume Reference Values for Blue Collar Workers Not Exposed to Occupational Respiratory Hazards. J Occup Med 1988;30(8):626-632.

Pizatella TJ, Nelson RM, Nestor DE, and Jensen RC. The NIOSH Strategy for Reducing Musculoskeletal Injuries. In: Work Injuries: Management and Prevention (edited by S.J. Isernhagen) 1988;Section 5:39-51. Rockville, MD: Aspen Publishers.

Proceedings of the Workshop on Needs and Resources for Occupational Mortality Data.

Documents and Committee Reports, Series 4, No. 26. National Center for Health Statistics. DHHS Publication No. (PHS) 88-1463, 1988, Hyattsville, MD.

Putz-Anderson V, ed. Cumulative Trauma Disorders--A Manual For Musculoskeletal Diseases of the Upper Limbs. New York, Taylor & Francis 1988;151 pages.

Putz-Anderson V. Impact of Automation on Musculoskeletal Disorders. In: Karwowski W, Parsaei HR, Wilhelm MR, eds. Ergonomics of Hybrid Automated Systems I. New York, Elsevier Science Publishers 1988;645-651.

Putz-Anderson V. Prevention Strategies Adopted by Select Countries for Work-Related Musculoskeletal Disorders from Repetitive Trauma. In: Aghazadeh F, ed. Proceedings of the Annual International Industrial Ergonomics and Safety Conference. Trends in Ergonomics/Human Factors, V. New York, Elsevier Science Publishers B.V. 1988;601-611.

Rabovsky J, Judy DJ. The Non-linear Dependence of Cytochrome P450 Activity at Low Microsome Concentration. Biochem Intn'l 1987;15(7):1033-1041.

Rao KM, Castranova V. Phenylmethylsulfonyl Fluoride Inhibits Chemotactic Peptide-induced Actin Polymerization Superoxide Anion Generation, H202 Production and Chemiluminescence in Human Neutrophils, Biochim Biophys Acta, 1988;969(2): 131-138.

Richardson FD, Habes D, Boiano J, Wilcox T. Health Hazard Evaluation Report No. HETA 86-505-1885, Longmont Turkey Processors, Inc. Longmont, CO. Cincinnati, OH, National Institute for Occupational Safety and Health 1988;30 pages.

Rinsky RA, Melius JM, Hornung RW, Zumwalde RD, Waxweiller RJ, Landrigan PJ, Murray WE. Case-Control Study of Lung Cancer in Civilian Employees at the Portsmouth Naval Shipyard, Kittery, ME. AM J Epidemiol 1988;127(1):55-64.

Robinson VA, DeLong, DS, Frazer DG, Castranova V. Dose-response Relationships for Pulmonary Reactions of Guinea Pigs to Inhalation of Cotton Dust. Proc. Twelfth Cotton Dust Research Conf., Beltway Cotton Research Conferences, Endotoxin Inhalation Conference; 1988; Jacobs RR, Wakelyn PJ, eds.; New Orleans, LA; Memphis, RN; National Cotton Council; 149-152.

Rosa RR, Colligan MJ. Long Workdays versus Rest days: Assessing Fatigue and Alertness with a Portable Performance Battery. Hum Factors 1988;30(3): 305-317.

Rosa RR, Bonnet MH. Performance and Alertness on 8-Hour and 12-Hour Rotating Shifts. Sleep Research 1988;17:88.

Russo JM, Junnila M. Behavioral Assessment of Xylene and Ethylbenzene Using the Startle Reflex of the Rat. Toxicologist 1988;8(1):77.

Schnorr T. Toluene Diisocyanate and Other Isocyanates. In Zenz (led) Occupational Medicine Principles & Practical Applications--2nd Edition, Year Book Medical Publishers, Inc., Chicago, 1988;1016-1020.

Schoeborn T. Latest Information on Protecting Health Care Workers Who Use Ethylene Oxide. Communique January/February 1988;13-17.

Schrader SM, Ratcliffe JM, Turner TW, Hornung RW. The Use of New Field Methods of Semen Analysis in the Study of Occupational Hazards to Reproduction: The Example of Ethylene Dibromide. J. Occup Med 1987;29(12):963-966.

Schulte PA, Ward Elizabeth, Boeniger M, Hills B. Occupational Exposure to N-Substituted Aryl Compounds. Proceedings of the Third International Conference on Carcinogenic and Mutagenic N-Substituted Aryl Compounds 1987;23-35.

Schulte PA. Exposure Registries. Archives of Environmental Health 1988;43(2):155-161.

Schulte PA. Methodologic Issues in the Use of Biologic Markers in Epidemiologic Research. American Journal of Epidemiology 1987;126(6): 1006-1016.

Schulte PA. The Role of Genetic Factors in Bladder Cancer. Cancer Detection and Prevention 1988;11:379-388.

Schulte PA. Simultaneous Assessment of Genetic and Occupational Risk Factors. J Occup Med 1987;29:884-891.

Seligman PJ. Use of Workers' Compensation Claims Data for Surveillance of Cumulative Trauma Disorders. Journal of Occupational Medicine June 1988;488-492.

Seligman PJ, Mathias CFT, O'Malley MA, Beier RC, Fehrs LJ, Serrill WS, Halperin WE. Phytophotodermatitis from Celery Among Grocery Store Workers, Arch. Dermatol November 1987;123:1478-1482.

Seligman PJ. HIV Seropositivity in IV Drug Users in Ohio. AJPH, June 1988;78:6,720.

Seligman P, Fidler AT, Crandall M, Habes D. Health Hazard Evaluation Report No. HETA 84-240-1902. Western Publishing Co., Racine, WI. Cincinnati, OH, National Institute for Occupational Safety and Health 1988;36 pages.

Seta JA, Sundin DS, Pedersen DH. National Occupational Exposure Survey Field Guidelines. Cincinnati, OH: National Institute for Occupational Safety and Health, 1988. DHHS (NIOSH) Publication No. 88-106.

Seta JA, Sundin DS, Pedersen DH. National Occupational Exposure Survey, Field Guidelines. DHHS (NIOSH) Publication No. 88-106; March 1988.

Smith J, Shulman S. An Evaluation of H2S Continuous Monitors Using Metal Oxide Semiconductor Sensors. Appl Ind Hyg 1988;3(7): 214-221.

Sheehy J, McJilton C. Development of a Model to Aid in Reconstruction of Historical Silica Dust Exposures in the Taconite Industry. Am Ind Hyg Assoc J 1987;48(11):914-918.

Smallwood A, DeBord K, Burg J, Moseley C, Lowry L. Determination of Urinary 2-Ethoxyacetic Acid as an Indicator of Occupational Exposure to 2-Ethoxyethanol. Appl Ind Hyg 1988;3(2):47-50.

Smith JM. Preface--A Review of Non-Ionizing Radiation Research. Health Phys 1987;53(6):567.

Smith JM, Conover DL, Cox C, Murray WE, Grajewski B. Limitations of Field Strength Parameters for Measurement of Radiofrequency of Radiation Exposure. Health Phys 1988;54(Suppl 1):S73.

Soler-Niedziela LT, Ong T, Nath J, Zeiger E. Mutagenicity Studies of Dioxin and Related Compounds with the *Salmonella Arabinose* Resistant Assay System. Toxicity Assessment 1988;3:137-145.

Stanevich RL, and Middleton DC. An Exploratory Analysis of Excavation Cave-In Fatalities. Professional Safety. February 1988:24-28.

Stanevich RL. The Human Factor in Construction Equipment Injuries. Center for Excellence in Construction Safety Newsletter 1987;1(3):6-7.

Stark GP, Hodous TK, Hankinson JL. The Use of Inductive Plethysmography in the Study of the Ventilatory Effects of Respirator Wear. Am Ind Hyg Assn J 1988;49(8): 401-408.

Stayner LT. Formaldehyde. Occupational Medicine --Principles & Practical Applications, 2nd Edition:734-736.

Stayner LT. A Retrospective Cohort Mortality Study of Workers Exposed to *Formaldehyde* in the Garment Industry. Am J Ind Med 1988;13:667-681.

Stettler LE, Proctor JE, Platek SF, Carolan RJ, Smith RJ, Donaldson HM. Fibrogenicity and Carcinogenic Potential of Smelter Slags Used as Abrasive Blasting Substitutes. J Toxicol Environ Health 1988;25(1):35-56.

Stettler LE, Tucker JH, Riley RD, Platek SF, Mastin JP, Green FHY. Inorganic Particles in Coal Miners' Lungs. VIIth International Pneumocioses Conference Abstracts of Communications 1988;193.

Stobbe TJ, Plummer RW, Jensen RC, and Attfield MD (1988). Incidence of Low Back Injuries among Nursing Personnel as a Function of Patient Lifting Frequency. J Safety Research 19(1):21-28.

Stout-Wiegand N. Characteristics of Work-Related Injuries Involving Forklift Trucks. J Safety Research 1988;18(4):179-190.

Stout-Wiegand N. Fatal Occupational Injuries in U.S. Industries, 1984: Comparison of Two National Surveillance Systems. Am J Public Health 1988;78(9):1215-1217.

Tanaka S. Chlorinated Toluenes. Occupational Medicine--Principles & Practical Applications, 2nd Edition 1988;715-716.

Tanaka S. Manganese and Its Compounds. Occupational Medicine--Principles & Practical Applications, 2nd Edition 1988;583-589.

Tanaka S, Seligman P, Halperin WE, Thun M, Timbrook CL, Wasil JJ. Use of Workers' Compensation Claims Data for Surveillance of Cumulative Trauma Disorders.

Thum M, Tanaka S, Smith AB, Halperin WE, Lee ST, Luggen ME, Hess EV. Morbidity from Repetitive Knee Trauma in Carpet and Floor Layers. Brit J Ind Med 1987;44:611-620.

Tolos W. Methyl Ethyl Ketone, Toluene and Ethanol in Blood. In: Kneip TJ, Crable JV, eds. Methods for Biological Monitoring--A Manual for Assessing Human Exposure to Hazardous Substances. Washington, DC, American Public Health Association 1988;327-331.

Tolos WP, Lowry LK, MacKenzie BA, Deng JF. 1-Pyrenol: A Biomarker Compound for the Assessment of Workers' Exposure to Coal Tar Pitch. Abstracts of Papers, 196th ACS National Meeting. Washington, DC, American Chemical Society 1988;CHAS 0002.

Toraason M. Activities of Genetoxic and Nongenotoxic Carcinogens and Noncarcinogens in the Metabolic Cooperation Assay. Toxicologist 1988;8(1):195.

Toraason M, Breitenstein M. Prenatal Ethylene Glycol Monomethyl Ether (EGME) Exposure Produces Electrocardiographic Changes in the Rat. Toxicol Appl Pharmacol 1988;95(2):321-327.

Toraason M, Krueger JA. Growth of Cultured Cardiac Myocytes Monitored Using Video Image Analysis. In Vitro 1988;24(3):30A.

Toraason M, Luken ME, Breitenstein MJ, Krueger JA, Biagini RE. Allylamine and Acrolein Toxicity in Cultured Fibroblasts and Myocytes from Neonatal Rat Heart. Toxicologist 1988;8(1):34.

Toraason M, Luken ME, Krueger JA. Synergistic Action of Insulin and Catecholamines on Ornithine Decarboxylase Activity in Cultured Myocytes from Neonatal Rat Heart. FASEBJ 1988;2(4):A329.

Turner TW, Schrader SM, Simon SD. Sperm Head Morphometry as Measured by Three Different Computer Systems. J Androl 1988;9(1):45.

Usmen MA (1988). Center for Excellence in Construction Safety, Conference Proceedings of the American Society for Engineering Education. Zone II Meeting, April 1988.

Ward E, Smith AB, Halperin WE. 4,4'-Methylenebis (2-Chloroaniline): An Unregulated Carcinogen. Am J Ind Med 1987;12:537-549.

Ward E. Polychlorinated Naphthalene. Occupational Medicine--Principles & Practical Applications, 2nd Edition 1988;765-766.

Ward E. 4,4-Methylene-bis-(2-chloroaniline). Occupational Medicine--Principles & Practical Applications, 2nd Edition 1988;1023-1024.

Wells V. The Estimated Predictive Value of Screening for Illicit Drugs in the Workplace. Am J Public Health 1988;78:817-819.

Wilcox T, Doyle TE, Tubbs RL. Health Hazard Evaluation Report No. HETA 83-349-1901, Weyerhaeuser Corporation, Longview, WA. Cincinnati, OH, National Institute for Occupational Safety and Health 1988;33 pages.

Winston GW, Biagini RE, Narayan S, Talbot R, Toraason M. The Cardiotoxic Agent Allylamine: An Inhibitor of the Mitochondrial Electron Transport Chain. Toxicologist 1988;8(1):158.

Zaebst D. Phosphine Exposures in Grain Elevators During Fumigation with Aluminum Phosphide. Applied Industrial Hygiene 1988;3(5):146-154.

Zaebst D, Blade L, Burroughs G, Morelli-Schroth P, Woodfin W. Phosphine Exposures in Grain Elevators during Fumigation with Aluminum Phosphide. Appl Ind Hyg 1988;3(5):146-154.

☆U.S. GOVERNMENT PRINTING OFFICE 1991–548–188/20631