NIOSH REPORT ON OCCUPATIONAL SAFETY AND HEALTH FOR FISCAL YEAR 1981 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
August 1982

CONTENTS

I. INTRODUCTION

The mission of the National Institute for Occupational Safety and Health (NIOSH) is to protect the health and safety of American workers by conducting research and applying the research results to prevent illness and control hazards in the workplace. The Occupational Safety and Health Act of 1970 mandates research for solving work-related health problems, for developing innovative methods, techniques, and approaches to deal with these problems, and for exploring ways to discover latent diseases and to establish associations between these diseases and work conditions. NIOSH's strategies to carry out this mandate are organized into programs to:

- Identify occupational safety and health problems by detecting and defining epidemiologically significant changes and trends.

- Evaluate occupational safety and health problems and hazards so that their causes can be understood and the hazards prevented.

- Control occupational safety and health problems by developing, assessing, and improving measures to reduce hazards. These measures include engineering controls, personal protective equipment, and work practices.

- Disseminate scientific findings and appropriate recommendations to appropriate agencies, organizations, and individuals.

In carrying out these mandates, the NIOSH administration is both diligent and forward-looking. NIOSH emphasizes a strong prevention orientation for the Institute's programs and is rapidly implementing plans to involve State health departments to a greater degree in the surveillance of work-related problems. In addition, NIOSH assists the States in strengthening their capabilities for preventing those problems.

Through the four programs outlined above, NIOSH resources in both manpower and dollars are carefully marshalled and directed toward areas of greatest need. The Institute is focusing on the Nation's ten most serious occupational safety and health problems. NIOSH scientists are identifying these problems, pinpointing their causes, and attacking them with the skills proven in such public health successes as the smallpox eradication program. The injuries and illness that have cost the Nation so much, not only in suffering and death, but also in skyrocketing costs in workmen's compensation claims, lost productivity for industry, and loss to industry of its most significant resource, must be and are viewed as preventable conditions that can be remedied through public health techniques.

This report covers only the highlights of NIOSH activities during Fiscal Year 1981. It is not intended to be all inclusive, but instead to represent the Institute's accomplishments and goals achieved.

II. IDENTIFICATION

Worker- and employer-originated requests for health hazard evaluations provide insight into the nature and extent of current occupational safety and health problems. This information, along with other surveillance techniques, provides the background for setting NIOSH research and publication priorities. NIOSH identifies occupational safety and health problems through medical, industrial hygiene and safety, and surveillance methods. By using this information, priorities are set for research and for criteria documents and to measure progress toward reducing work-related injuries and illness.

HEALTH HAZARD EVALUATIONS

NIOSH evaluates workplace-related health problems in response to requests from employers, from employees or their representatives, or from Federal, State, or local agencies. The Health Hazard Evaluation (HHE) program, which was mandated by the Occupational Safety and Health Act of 1970, was extended to miners by the Mine Safety and Health Act of 1977 and, in certain cases, to Federal workers by an Executive Order. Under this program, NIOSH conducts cross-sectional medical and industrial hygiene investigations to identify occupational hazards, obtain insights into worksite processes and practices, consult directly with workers and employers on hazards in their workplaces, and make recommendations for control of these hazards.

In Fiscal Year 1981, NIOSH received 513 requests for mining and general industry HHE's, a 10 percent increase over 1980. Twenty-one percent of these requests came from employers, 55 percent from employees or unions, 23 percent from government agencies, and 4 percent from other sources. Twenty percent of these requests came from establishments with fewer than 100 employees. NIOSH investigators made over 600 site visits and produced 234 final reports documenting HHE's conducted.

Health Hazard Evaluations by Fiscal Year

	1980	1981
New HHE Requests		
General industry	377	488
Mining	51	25
Total	428	513
HHE's Completed		
General industry	287	371
Mining	30	30
Total	317	401

The following are examples of important Health Hazard Evaluations completed in Fiscal Year 1981.

Chronic Disability Due to Neurotoxic Exposures

NIOSH confirmed that significant long-term bladder and sexual dysfunction persisted in workers who had been exposed to dimethylaminopropionitrile (DMAPN), a component of a catalyst used in making polyurethane foam. In 1978, subacute bladder neuropathy from exposure to this chemical had been found in a large number of workers at two plants. The 1981 study found that those workers most severely affected from the earlier exposures suffered disability 2 years later. NIOSH is continuing to monitor the medical conditions of these workers.

Sensitization to an Enzyme in Bleach

A request to evaluate complaints from workers who were experiencing asthmatic symptoms at a bleach production plant led to a Health Hazard Evaluation, which documented that some workers had become allergic to an enzyme in the bleach. After NIOSH's evaluation, the company improved the medical surveillance and exposure controls at the five plants producing this bleach. The company also instituted a screening program to identify workers allergic to the enzyme.

Chemical Waste Sites

After receiving requests to evaluate protection programs and respiratory ailments in workers cleaning up chemical waste sites, NIOSH documented several problems at two waste sites. The problems included improper respirator use, insufficient heat stress abatement, and inadequate air monitoring. Although NIOSH observed no overexposures to airborne chemicals, the investigators found significant pulmonary effects among firefighters who had extinguished a large fire at one site. NIOSH is continuing medical evaluations of both the cleanup workers and the firefighters. These studies led to an agreement between NIOSH and the U.S. Environmental Protection Agency for evaluating the health and safety programs at 30 hazardous waste sites covered by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, popularly known as the "Superfund."

Lucel-7

NIOSH investigated complaints of partial paralysis, numbing, itching, and burning of the extremities in workers exposed to Lucel-7, a plastic foaming agent used in making fibrous glass-reinforced bathtubs. NIOSH's documentation of peripheral neuropathy among these workers led the manufacturer to stop production and withdraw the product from the market. Most of the affected workers are now back on the job, and their medical condition continues to be monitored by NIOSH. With the cooperation of the manufacturer, NIOSH surveyed nearly all present and past users of this chemical. NIOSH has begun additional studies to determine the possible neurotoxicity of related chemicals.

HHE Cooperative Agreements

NIOSH negotiated cooperative agreements with three universities and a State health department as part of a pilot program under which these centers will conduct HHE's assigned to them by NIOSH. Agreements were established with Harvard University's School of Public Health, the University of Utah's Rocky Mountain Center for Occupational and Environmental Health, and the University of North Carolina's School of Public Health. In addition, a cooperative agreement was awarded in March 1981 to the New Jersey State Department of Health.

Usually the worksites to be evaluated under this program are near the university or health department. Although some evaluations are conducted jointly with NIOSH personnel, most are performed entirely by personnel from the cooperating facility. These groups also have initiated programs to publicize the HHE program.

These cooperating facilities worked on 22 new HHE's and completed 21 HHE's in Fiscal Year 1981. Requests for evaluations included possible occupationally related impotence among male workers at two chemical plants (performed by Harvard), occupational biological hazards (performed by the University of North Carolina), and occupational asthma due to platinum and palladium exposure (performed by the State of New Jersey).

NATIONAL OCCUPATIONAL EXPOSURE SURVEY

The field phase of NIOSH's National Occupational Exposure Survey (NOES) began in November 1980. Formerly called the National Occupational Hazard Survey II, NOES is designed to provide current, nationwide information about potential exposures to workplace hazards, the number of workers at risk from specific chemical and physical hazards, and the industries and occupations where these workers are employed. A national projection based on a sample of about 5,000 of an estimated 5 million worksites will be surveyed over a 2-year period.

NOES was revised to reflect the knowledge and experience gained from the first National Occupational Hazard Survey, which was conducted from 1972 to 1974. The basic survey design has been retained, so that the newer data can be compared with findings from the first survey. By the end of September 1981, the NOES field team had surveyed 1,492 plants employing a total of 44,000 people. The rate of response to NOES questionnaires continues to be 99 percent of the employers at the worksites visited.

COMPUTER-GENERATED MAPS FOR HAZARD AND MORTALITY SURVEILLANCE

NIOSH developed and put into operation a computerized system that produces county-level maps of the United States, showing the types of worksites where selected chemicals are found. The maps can also depict the mortality rates from specific causes for males and females by race and can correlate county workforce populations (coded by Standard Industrial Classifications) with selected industrial establishments. Federal and State health officials should find the maps helpful in planning research and disseminating information to workers affected by potential occupational health hazards.

This system can generate maps depicting the locations and estimated numbers of workers potentially exposed to the many workplace hazards observed by NIOSH during the first National Occupational Hazard Survey. Maps generated in Fiscal Year 1981 illustrated a spectrum of potential occupational exposures, ranging from such widespread agents as isopropyl alcohol to infrequently used chemicals like diethylstilbestrol (DES). The system can also generate maps that show the county location of plants where workers may potentially be exposed to whole groups of hazardous chemicals, such as carcinogens, mutagens, or teratogens. Specific chemical agents can be displayed on a national or State level.

ESTIMATES OF OCCUPATIONAL MORTALITY AND MORBIDITY

Determining the leading causes of occupationally related diseases will enable NIOSH to direct its resources to areas of greatest need. To accomplish this goal, NIOSH statisticians are developing a system for estimating the proportion of deaths that can be attributed to occupational exposures. No existing national data base relates occupation to cause of death in registries of vital statistics or death certificates. NIOSH is examining the available data for three categories of deaths: from injuries, from cancer, and from all other causes. For this surveillance, NIOSH has adopted a modified Delphi system of iterative review. First, data will be compared among a small group of reviewers. Then these estimates will be refined and sent out for a broader review. These two steps will be repeated several times, and at each repetition the reviewers will receive feedback from the previous level of review. Through this painstaking method, a range of estimates will be derived that will represent a compilation of nationwide statistics.

"SENTINEL HEALTH EVENTS" - OCCUPATIONAL DISEASE

NIOSH is encouraging States to computerize vital statistics and other health data useful in surveillance of occupational health problems. Toward this end, NIOSH will train State health workers in applying basic

epidemiologic methods to problems in occupational health. This training program, in which 15 to 22 States will participate, is in collaboration with the Bureau of the Census and the National Center for Health Statistics.

The occurrence of a preventable disease, disability, or untimely death has been termed a "Sentinel Health Event" that justifies a carefully controlled scientific search for eradicable underlying causes. NIOSH's "Sentinel Health Events - Occupational Disease" project uses occupational information from death certificates to determine which occupational exposures are potentially hazardous. Data are now coded and computerized by most of the 13 States that currently record employment information on death certificates. The NIOSH training program will ensure compatibility of industrial and occupational coding among the States and with the 1980 census.

NIOSH expects to publish a list of Sentinel Health Events that will be useful in three ways: as an active surveillance method, as an educational resource, and as a research tool for suggesting associations between occupation and illness that may warrant further testing.

SURVEILLANCE ACTIVITIES

Surveillance Cooperative Agreements with States

Surveillance Cooperative Agreements between NIOSH and States provide a mechanism for demonstrating how statewide morbidity and mortality statistical systems can be adapted for use in occupational health surveillance. This NIOSH-funded program is designed to help States strengthen their capabilities in occupational health surveillance, encourage continued surveillance, and improve the exchange of information between NIOSH and the States. Four States (Maine, New York, Rhode Island, and Utah) now participate in this 2-year pilot project, which began in October 1980.

The surveillance project proposed for Maine will identify particular occupations, industry groups, and areas of the State that are experiencing higher-than-expected numbers of occupationally related deaths. This project will take advantage of Maine's hospital discharge data file, which is unique in that it contains virtually all hospital discharges. This information, when incorporated with available death certificate and population data, should prove an invaluable aid in investigating health problems.

In New York, an automated vital records registration system is being used for occupational health surveillance. Occupation and industry codes of the parents on birth and fetal death records and of the deceased on death certificates are being added to computer files of vital statistics. This added information, in conjunction with health data already available, provides a basis for systematic analysis and evaluation of adverse health effects in selected groups of workers.

Rhode Island's Department of Health is using its mortality and hospital discharge data systems to demonstrate how an epidemiologic approach, which is based on health outcome, can be applied to occupational health surveillance. Readily available data files will be used when the State is allocating resources for reducing occupational hazards among job groups and industries that place the largest number of workers at the greatest risk.

The Utah State Health Department has developed a standardized death certificate data computer file that now covers 25 years (1956-1980). In addition, morbidity data are available to this project from the State Industrial Commission. This file includes first reports of injuries and illnesses from all nonagricultural employers in the State, amounting to 29,000 employers and 532,000 employees.

NATIONAL ELECTRONIC INJURY SURVEILLANCE SYSTEM

NIOSH and the U.S. Consumer Product Safety Commission developed a new surveillance system to provide occupational injury statistics more timely than those provided by other injury reporting systems, both government and nongovernment. The National Electronic Injury Surveillance System, which has fewer restrictions on defining employee populations at risk, is proving most useful in estimating the frequency and severity of injuries to the American worker. This system monitors all occupational injuries treated at a representative sample of 66 hospital emergency rooms. The hospitals report injuries from 2 to 10 days after the date of treatment.

During the 8-month period beginning May 1981, there were an estimated 2,192,619 occupational injuries (both lost workday and others) treated at all U.S. hospital emergency rooms. By extrapolation from these figures, statisticians can estimate that 3.3 million occupational injuries were treated nationwide during 1981.

Detailed occupational injury information provided through this surveillance system includes part of body injured, the nature of the injury, treatment date, age, sex, disposition of case, type of accident, and source of injury. Hospital emergency room data for treated injuries show that, although the most frequent injuries are lacerations (24.5 percent), followed by contusions and abrasions (23.3 percent) and strains and sprains (18.1 percent), severe injuries such as amputations, crushings, and fractures occur at an estimated rate of 5,600 per week. From May 1981 until the end of the year, about 10,000 workers suffered amputations, and 119,500 had fractures. Almost 200,000 injuries considered severe or disabling were reported by the emergency rooms.

THE NATIONAL DIVING ACCIDENT NETWORK

NIOSH continues to explore methods to reduce ill effects among commercial divers who are exposed to hyperbaric (high pressure) conditions. This research is mandated by the Outer Continental Shelf Lands Act Amendments of 1978, which provides that NIOSH, in cooperation with the Coast Guard and the Department of Commerce, conduct studies of underwater diving for protecting human safety and improving diver performance.

NIOSH, the National Oceanic and Atmospheric Administration, and the Department of Energy jointly instituted a National Diving Accident Network (NDAN). Centered at Duke University, NDAN provides 24-hour telephone hot-line medical assistance to physicians, rescue squads, and others caring for recreational and commercial divers who require medical attention. Each of the seven NDAN regional centers has a decompression chamber facility staffed by a physician and technicians trained in diagnosis and treatment of diving accidents.

The most common diving emergencies are arterial gas embolisms and decompression sickness (commonly known as "the bends"). An embolism can occur during a dive of less than 1 minute in water as shallow as 4 feet. Decompression chambers are useful in the treatment of both these conditions; however, most hospitals do not have this equipment. In addition, physicians may mistake the symptoms for stroke, and therefore may not prescribe appropriate treatment to prevent death. There are approximately 125 deaths yearly among the Nation's 2 million commercial, scientific, and sport divers. Many of these diving fatalities are misdiagnosed as drownings.

NDAN is NIOSH's principal surveillance tool for divers. During its first 6 months of operation, 120 cases were referred to NDAN, 12 percent of which involved commercial divers. During Fiscal Year 1982, NDAN will begin accumulating morbidity data on commercial divers. NIOSH will evaluate the effectiveness of emergency treatment and assess the factors that contribute to commercial diving accidents.

LOGGING ACCIDENTS

NIOSH completed a report on accidents among 73,192 loggers to provide a baseline measure for monitoring changes in the relationship between logging and injuries. This is the first in a series of surveillance reports that will provide such baseline measures or that will identify previously unrecognized associations between industries and diseases.

Federal and State data indicate that the accident rate among loggers is 38 percent greater than the combined rate for all workers. Loggers in the West over the age of 50 incur the greatest risk of disabling injuries involving fractures of the legs, skull, spine, and trunk. Studies by the States of California and Washington have shown that blows from falling objects are the leading cause of accidental deaths among loggers. The extensive data on file enable NIOSH to monitor the high rate of severe accidents in the logging industry; to construct indexes of injury, disability, and mortality for evaluating changes in the frequency, type, and severity of logging accidents; and to identify new accident prevention and occupational health promotion activities that will reduce logging accidents.

III. EVALUATION

NIOSH evaluates occupational safety and health problems through the disciplines of epidemiology, toxicology, ergonomics, and psychology. Through laboratory research and field studies, NIOSH ascertains and measures the cause-and-effect relationships underlying occupational safety and health hazards and the significance of each hazard. As occupational safety and health problems are associated with their causes, NIOSH can recommend preventive steps to those whose actions can reduce workplace hazards. These target groups include regulatory agencies, health departments, employers, and labor unions.

ORGANIC DUSTS

NIOSH observed in two studies that agricultural dusts from cotton, grain, and wood can cause lung disease in certain workers, including chronic bronchitis distinct from smoking effects. NIOSH conducted the studies to identify potentially harmful components in organic dusts. Occupational groups who are affected by organic dusts include workers involved in grain, cotton, animal husbandry, sewage treatment, composting, and related industries.

RADIATION

Ionizing Radiation

NIOSH continued studies to assess the health implications of exposures to radon daughters and other radiation hazards among workers.

Soluble Uranium: Uranium millers are exposed to uranium, vanadium, and thorium-230. Thorium-230 is of particular concern because it concentrates in the tracheobronchial tissues and lymph nodes. An earlier NIOSH study of uranium millers had, in fact, demonstrated an excess of lymphomas. A recent cross-sectional medical study at a uranium milling facility documented probable renal tubular damage among workers exposed to soluble uranium. NIOSH researchers will attempt to confirm whether these workers suffer excess mortality due to nephritis and nephrosis, as well as lymphomas.

Radon Daughters: Since the early 1950's, NIOSH and its predecessor agencies have been studying a cohort of 4,000 uranium miners to determine the adverse health effects of radon daughters and other substances found in the mines. NIOSH will continue to study this group of uranium miners, exploring long-term effects, such as multisite carcinogenicity, that may result from interaction with cigarette smoking and exposure to radon

daughters. Another group of 2,800 uranium miners is being examined to retest a hypothesis generated in Czechoslovakia that the male-to-female ratio may be lowered in children born to radiation-exposed fathers.

Radiofrequency Radiation

NIOSH investigators demonstrated that high-intensity radiofrequency (RF) radiation at 27.12 megahertz is teratogenic to rat fetuses. These teratogenic effects were found to be due solely to an increase in maternal core temperature and not to nonthermal effects of the radiation. An average 30-minute exposure to 55 amperes per meter at any time during organogenesis resulted in an increased incidence of malformed fetuses. Depending on the gestational age at the time of exposure, as many as 67 percent of the fetuses were malformed. NIOSH determined that teratogenicity at this wave length was time-dose dependent and exhibited a threshold temperature of approximately 41°C.

To assess the association between exposure to RF radiation and adverse reproductive outcome in humans, NIOSH is locating a suitable study group of women who operate RF heat sealers. In industry, most RF heat sealers (devices that seal "blister packs" in which small items are marketed) operate at or near the frequency of 27.12 megahertz. NIOSH found in these studies that 60 percent of the RF sealers measured exceed the equivalent OSHA electric field strength limits and that 29 percent exceed the equivalent magnetic field strength limits. Data from NIOSH field studies indicate that as many as 100,000 workers, over 90 percent of whom are women, may be exposed to radiation from RF heat sealers. NIOSH is preparing a guide for installing engineering controls on RF heat sealers and for safe work practices in their use.

SEGMENTAL VIBRATION

NIOSH completed studies on 385 chipper and grinder workers exposed to segmental vibration and a control group of workers not exposed to vibration at two foundries and a shipyard. Vibration white finger disease (VWF), also known as Raynaud's phenomenon, was found among 47 percent of the chipper and grinder workers and 19 percent of the shipyard workers. VWF, an occlusion of the blood vessels of the fingers, can cause irreversible tissue damage and impairment if it is allowed to progress to its later stages. An estimated 1.2 million workers in U.S. industries are exposed to segmental vibration. The NIOSH studies controlled for age, smoking, medical conditions, and nonoccupational exposure to vibration. Findings from a Health Hazard Evaluation at a foundry also showed a 45 percent prevalence of VWF among metal foundry workers exposed to hand vibration when using air hammers and grinding tools.

A 30-minute video tape on VWF, "The Vibration Syndrome," was developed by NIOSH, with assistance from expert outside physicians and researchers, industry, and labor. NIOSH's recommendations for prevention

and control include better tool design to reduce vibration, careful maintenance of vibrating hand tools, and wearing gloves. "The Vibration Syndrome" is now available from NIOSH to inform medical and industrial professionals about the hazards of vibrating hand tools.

DIOXIN

NIOSH is compiling a registry of workers who have been associated with the manufacture of 2,4,5-trichlorophenoxyacetic acid or ester (2,4,5-T, a dioxin-contaminated herbicide) and of other dioxin-contaminated substances. The U.S. Environmental Protection Agency restricted the manufacture and distribution of 2,4,5-T in 1979, but it is still being used in some agricultural applications. Evidence from studies on laboratory animals indicates that there may be an association between exposure to dioxin-contaminated materials and cancer. This evidence prompted the NIOSH long-term study of workers known to be exposed to dioxin.

NIOSH identified ten chemical companies where exposure to dioxin has been established. Data from personnel and medical records and from industrial process information are being assessed by NIOSH to discern mortality patterns among these workers. The registry may also be evaluated for use in studies of morbidity and reproductive effects.

INDUSTRY-SPECIFIC HAZARDS

Brain Tumors in Petrochemical and Electronics Workers

Studies by NIOSH and other groups are revealing excess brain cancer risks among a number of occupational groups in the Gulf Coast, the Midwest, and the Middle Atlantic States. OSHA asked NIOSH to investigate a cluster of brain cancer cases at a petrochemical plant in Texas City, Texas. The results showed a two-fold increase in brain cancer mortality among these petrochemical workers. In a related study, NIOSH, the National Cancer Institute, a major petroleum refiner, and the Oil, Chemical, and Atomic Workers Union reviewed the causes of death among members of a Texas City local union. Excess mortality due to brain tumors was found among workers at a refinery adjacent to the petrochemical plant in Texas City.

As a direct result of the study at the petrochemical plant in Texas City, NIOSH and OSHA undertook a brain cancer study at a petrochemical plant in Freeport, Texas. Results are expected in Fiscal Year 1983. NIOSH is collaborating with the National Cancer Institute and the Oil, Chemical, and Atomic Workers Union to expand a similar mortality study, which includes deaths among union members who worked at three other Gulf Coast refineries, where an excess of brain tumors had also been observed.

An observation by the United Auto Workers of an apparent cluster of brain tumors among employees of an electronics plant in Milwaukee resulted in a mortality study by NIOSH to determine if there is an excess rate of brain cancer. NIOSH is currently evaluating the data from this study. NIOSH research dealing with brain tumors was presented in October 1980 at a conference called by the New York Academy of Sciences.

Exposures in the Electronic Components Industry

The electronics components manufacturing industry, which has grown tremendously in the last decade, uses numerous hazardous materials, including arsine, phosphine, and gallium arsenide. NIOSH conducted a walk-through survey at 15 facilities to characterize occupational exposures at plants that manufacture electronics components, such as electronic tubes, semiconductors, capacitors, and resistors. This study documented the potential for exposure and indicated areas where research is needed, including engineering controls and safe work procedures.

NIOSH is continuing its evaluation of the electronics industry through an industrial hygiene/control technology assessment of processes in the semiconductor industry. This study will gather quantitative data on exposures and controls in the industry, so that guidelines can be developed for preventing these exposures in semiconductor manufacturing. The American Electronics Association has been cooperating with NIOSH in this study and is interested in tailoring these guidelines for smaller companies. In addition, the Institute for Interconnecting and Packaging Electronic Circuits has asked NIOSH to assist in preparing a handbook for chemical hazard control for the printed wiring board industry.

Decompression for Tunnel Workers

NIOSH and the Occupational Safety and Health Administration (OSHA) worked with an engineering company in Cleveland, Ohio, to evaluate the effectiveness of new decompression tables that NIOSH developed for tunnel workers. A decompression table is a schedule of pressures and gas mixtures that allow a person to adjust from a high pressure environment to normal pressure. NIOSH expects to assess the protective value of the tables in Fiscal Year 1982.

VIDEO DISPLAY TERMINALS

NIOSH's first large-scale worksite evaluation of video display terminals (VDT's) and their possible health effects included two newspapers and a health records agency on the West Coast. NIOSH documented a pattern of fatigue, sore muscles, and eyestrain that correlated with the sustained, repetitive work inherent in VDT operation. NIOSH recommended glare shields, eye exams, redesigned office

furniture, work/rest regimens, and other measures. Similar recommendations were made to the NIOSH administration after NIOSH conducted an evaluation among its own employees.

In addition, NIOSH, after receiving complaints of headaches, eyestrain, cataracts, and musculoskeletal problems among VDT users, conducted a cross-sectional medical study of VDT operators at a Baltimore newspaper. The survey of members of the Newspaper Guild and the typographic union included questionnaires and complete ophthalmologic examinations. Data from the survey are being analyzed.

A 2-day course in the proper use of VDT's was conducted for NIOSH operators and supervisors in Morgantown and Cincinnati.

INTERMITTENT NOISE

To determine how best to measure varying intensities of noise experienced by a worker during an entire shift, NIOSH studied the hearing levels and daily noise exposures of approximately 2,500 workers in the paper industry. In this industry, workers are exposed to intermittent noise, as opposed to steady-state noise. After these workers had been screened for pathology and history of other activities that could contribute to hearing loss, 158 male workers with complete interview data and three valid audiograms remained in the sample. These workers, whose exposures ranged from 84 to 94 decibels, had a significant hearing loss when compared with persons who have minimal or no exposure to occupational noise. An estimated 700,000 paperworkers may experience similar exposure to intermittent noise.

ROOFING ASPHALTS, PITCH, AND SIMULATED SUNLIGHT

NIOSH completed a study that assessed the carcinogenic potential of condensed fumes from roofing asphalts and coal-tar pitch materials. NIOSH examined the tumor-producing effects of roofing asphalt and condensed fumes of coal-tar pitch applied to the skin of mice, with and without simulated sunlight. Data from this study indicate that both roofing asphalts and fumes are tumorigenic in mice and that simulated sunlight may inhibit the development of tumors under some conditions. These results were conveyed to OSHA.

Increased risks of developing skin cancer, leukemia, and cancer at other body sites, such as the bladder, the upper respiratory tract, and the stomach, have been demonstrated previously by NIOSH in individuals who have worked 20 or more years in roofing operations. OSHA's Advisory Committee on Construction Safety and Health estimates that 113,800 workers employed by 33,000 contractors are at risk.

LEAD

NIOSH found that lead fed to pregnant rats caused subtle changes in the red blood cell production of their offspring, even though there were no overt signs of toxicity. Specifically, the activity of an enzyme responsible, in part, for the formation of hemoglobin was inhibited. The severity and duration of this and related effects were increased when the maternal lead treatment was continued throughout lactation. However, these effects proved to be reversible after the lead treatment ended. The results augment understanding of the effects of transplacental exposure to lead, although possible subtle neurologic effects were not examined.

Many women work in industrial operations (for example, battery manufacturing, lead smelting, printing, pottery and munitions production, and rubber and paint manufacturing) that use materials containing lead. Lighter industries may also involve secondary use of lead-containing materials. Regulations have helped prevent the most severe reproductive effects of acute occupational exposure to lead among female workers, such as spontaneous abortion, stillbirth, postnatal mortality, and retarded physical and mental development. Despite the known effects of lead poisoning on the formation of blood cells and on the cardiovascular, immune, and renal systems of both children and adults, few other studies have examined the effects on offspring whose mothers had relatively low chronic exposures to lead.

IV. CONTROL

NIOSH discovers, assesses, and improves measures to control work-related injuries and illness through the disciplines of engineering, ergonomics, and industrial hygiene and safety. NIOSH recommends engineering systems, including process design, protective equipment, and work practices, so that occupational hazards can be reduced. In addition, NIOSH develops methods of environmental and medical monitoring to detect failures in these control systems.

SAMPLING AND ANALYTICAL METHODS

Environmental monitoring methods provide important information for controlling occupational health hazards. NIOSH periodically publishes new and improved methods in the NIOSH Manual of Analytical Methods. Volume 7 of the Manual, which was completed in Fiscal Year 1981, describes an additional 21 methods for monitoring toxic substances. Several of these methods have been validated under a joint NIOSH/OSHA Standards Completion Program. Others have been only partly evaluated and were presented for informational and trial use. The seven volumes of the manual are the largest set of sampling and analytical techniques available for industrial hygiene monitoring.

New and revised sampling and analytical methods completed by NIOSH during Fiscal Year 1981 include:

New Methods	Revised Methods
Lead	Selenium
1,2,4,5-Tetrachlorobenzene	Platinum
Arsenic	Tellurium
Wood dust (draft)	Nickel carbonyl
Talc (draft)	Nickel
Tungsten (draft)	Vanadium (draft)
n-Octanethiol (draft)	
Ethylene glycol	
4,4'-Methylene-bis(phenyl isocyanate)	
Toluene-2,4-diisocyanate	
Vinyl bromide	
2,4,7-Trinitro-9-fluorenone	
Polychloroterphenyl, 60 percent chlorine (draft)	

NIOSH also completed a method for analysis of 31 elements in trace concentrations by using inductively coupled plasma-atomic emission spectrometry and a method involving X-ray fluorescence to detect seven elements of welding fumes.

NIOSH developed an improved method for analyzing the concentration of 4,4'-methylene-bis(2-chloroaniline), commonly known as MOCA(R), in

urine. A human carcinogen, MOCA is used as a curing agent and plasticizer in the manufacture of polyurethane resins. OSHA had requested assistance from NIOSH to improve the sensitivity of its technique for measuring MOCA in urine from 40 parts per billion (ppb) to 4 ppb. The method NIOSH developed can detect an MOCA concentration of 1 ppb in urine. NIOSH expects to complete a study in Fiscal Year 1982 to assess the rate of absorption of MOCA through the skin.

ENGINEERING CONTROLS

NIOSH conducted field studies to evaluate the effectiveness of engineering techniques to limit health hazards. The use of these techniques was promoted by NIOSH through symposia, publications, and cooperative development and demonstration work. NIOSH also provided technical assistance recommending control measures at the request of various government agencies. Publications in Fiscal Year 1981 included reports on controls for spray painting, dry cleaning, and seals and fittings for chemical unit processes. The proceedings of a NIOSH-sponsored symposium on foundries and secondary nonferrous smelters were also published. Other publications included journal articles on controls for aluminum reduction and tire manufacturing.

NIOSH held a symposium with labor and industry groups on a pesticide control technology assessment. The proceedings of the symposium were published, and a video tape of a control technology model for use by pesticide processors was produced. NIOSH and a trade group also sponsored a joint symposium on control technology for chemical processes.

WORK PRACTICES

To develop effective work practices in reducing worker exposure to a chemical hazard, NIOSH selected styrene (vinyl benzene) as a "model" chemical. Workers exposed to styrene, which is used in the plastic and rubber industries, may experience chronic health problems, including liver damage and nervous system effects. Styrene has been shown to be mutagenic after liver microsomal activation; styrene oxide, a metabolite of styrene, is also mutagenic. Animal experiments have indicated that chronic exposure to styrene metabolites can be both hepatotoxic and carcinogenic. Because of the strength of these associations, styrene was chosen for a study of the effectiveness of behavior modification in improving work practices.

NIOSH identified 43 work practices that could reduce worker exposure to styrene at 3 plants in the laminated plastics industry. These work practices were divided into eight classes: job task requirements, training requirements, personal hygiene, personal protective equipment, hazard recognition, medical monitoring, emergency procedures, and supervisory requirements. The most effective work practices were

incorporated into a worker training program specific for each workplace, and incentives were designed to motivate workers to adopt these practices. This training program resulted in reducing worker exposure to styrene by average concentrations of 36 to 80 percent. The findings indicate that improved work practices were successful in reducing worker exposure and that this approach can be useful in NIOSH's control technology program. A training package applicable to other chemical hazards will be developed.

ERGONOMICS

Manual Lifting

During Fiscal Year 1981, NIOSH applied the principles of ergonomics --a discipline that designs jobs to match worker capabilities--to develop procedures for identifying hazardous lifting jobs and reducing risk of injury. These procedures include job design and worker selection and training. Recommendations for permissible lifting load limits that minimize risk of injury were also developed. This information was incorporated into a Work Practices Guide for Manual Lifting, which was distributed throughout industry. More than one-third of all jobs require routine lifting of loads. NIOSH is applying these recommendations in a project at the Social Security Administration to reduce work-related back injuries among its clerical and warehouse staffs.

Musculoskeletal Disorders

Several NIOSH investigations concluded that wrist disorders may have a higher-than-expected prevalence in American industry; in fact, the population at risk may number 20 million. This estimate is based on findings from three Health Hazard Evaluations and from separate studies of mail-sorting machine operators, poultry processors, and electronics components workers. In each instance, a high prevalence of wrist/arm musculoskeletal disorders, including carpal tunnel syndrome and tenosynovitis, was found among these workers. Jobs requiring repetitive motions of the hands and arms and those requiring finger and wrist forces while the worker assumes awkward hand and arm positions have historically been associated with these disorders. NIOSH has recommended changes in tool design and is currently examining other ways of preventing wrist disorders.

Both these studies demonstrate the potential of ergonomics for reducing occupational trauma. Therefore, NIOSH is incorporating the principles of ergonomics into its control technology assessments and has established a working group to discuss research in this area.

RESPIRATORS

Because Federal test procedures for respirators did not fully reflect field performance, NIOSH undertook a complete revision of the section of the Code of Federal Regulations (CFR) that contains testing procedures for approval of respirators. The draft revision of 30 CFR 11 will emphasize performance standards rather than design standards, because present testing regulations do not sufficiently indicate how respirators actually perform under workplace conditions. Both manufacturers and users of respirators support an updating of the test criteria. NIOSH is working on these revisions with expert groups from other government agencies and the private sector. These groups include the Mine Health Research Advisory Committee of the Department of Health and Human Services and the Ad Hoc Subcommittee for Respirator Test and Approval of the American National Standards Institute.

In response to an increasing number of complaints from respirator users, NIOSH expanded its field investigation program to include examining previously approved respirators offered for sale by manufacturers and distributors and conducting studies of respirators in actual use.

On June 21, 1981, a Federal regulation went into effect requiring that 1-hour self-contained, self-rescue devices be provided to underground coal miners for escape during emergencies. During Fiscal Years 1980 and 1981, NIOSH expedited performance testing of all respirators submitted for approval. Five models were approved.

V. DISSEMINATION

NIOSH disseminates findings of its research and makes recommendations in order to reduce work-related injuries and illness. NIOSH recommends governmental actions on Federal standards and informs the public about problems and their solutions. Results of NIOSH research are made available to private and public organizations through publications, education programs, conferences, and joint action with government, management, and labor groups. This promotes prevention of occupational safety and health problems on a much broader front than NIOSH alone has the resources to accomplish.

RECOMMENDATIONS TO THE DEPARTMENT OF LABOR

Occupational Hazard Assessment - Coal Liquefaction

The coal liquefaction process converts coal into hydrocarbon products. In so doing, it both uses and produces toxicants potentially hazardous to worker health. These toxicants are varied, ranging from simple chemicals to complex mixtures or organic carcinogens. The possible health effects of exposure to these toxicants also varies. Animal studies have demonstrated that some of the process chemicals have produced tumors at the site of application. Workers may be exposed by inhalation of gases, vapors, or airborne particles, skin contact with airborne material, contact with contaminated surfaces, or accidental ingestion. Some of these same chemicals have caused severe long-term effects, such as skin and lung cancer, in workers. Other potential adverse health effects may include fatal poisoning from inhalation, severe respiratory irritation, and chemical burns.

NIOSH recommended measures such as engineering controls, specific work practices, personal protective equipment, medical surveillance and exposure monitoring, recordkeeping, and emergency plans and procedures. The Institute's recommendations coal liquefaction provide information that can be used to guard against the above-mentioned potential adverse health effects.

Occupational Hazard Assessment - Criteria for Controlling Occupational Hazards in Animal Rendering Processes

In 1977, the national injury rate for workers in rendering plants was reported to be almost twice that reported for manufacturing industries. The need to identify the underlying causes of this high rate of injury and to provide recommendations to reduce the incidence of these injuries prompted NIOSH to survey rendering plants and assess the occupational hazards of the rendering process. This recommendation critically reviews the scientific and technical information concerning mechanical injury, physical agents such as noise and heat, and biological and chemical

agents in rendering plants. The guidelines contained in this document are provided so that individuals immediately responsible for hazard control in their workplace will have a basis on which to formulate an effective occupational safety and health program. The recommendation is intended to assist OSHA in its standards development and compliance activities.

A Report to OSHA on Field Sanitation

This report summarizes pertinent literature in order to answer questions presented by OSHA concerning the need for a standard for field sanitation. This request for assistance arose as a result of a legal action against OSHA to prepare a timetable for the issuance of such a standard.

The situation is unique because, in contrast with other occupational hazards, the exposure to potentially harmful agents is not limited to the workplace, but is also found in the worker's general environment. In addition, discussion of the problem must go beyond strictly occupational considerations into the broader area of general public health. Based on the literature and the other information obtained and reviewed, NIOSH supports the need for a standard for field sanitation on the basis of the well-known and long-documented sanitary requirements of public health practice and the need for equalization of working conditions with those of other occupational groups.

CURRENT INTELLIGENCE BULLETINS

Formaldehyde

In the Current Intelligence Bulletin "Formaldehyde: Evidence of Carcinogenicity," NIOSH recommended that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure. NIOSH based its recommendation on several nongovernmental studies. In a study by the Chemical Industry Institute of Toxicology, laboratory rats exposed to formaldehyde vapor developed nasal cancer. This finding was confirmed by a New York University study, in which rats exposed to a mixture of formaldehyde and hydrochloric acid vapors also developed nasal cancer. Several short-term laboratory studies showed formaldehyde to be mutagenic. The carcinogenic potential of formaldehyde to humans was confirmed by a panel of scientists from eight Federal agencies, under the auspices of the National Toxicology Program.

Improved methods for sampling and measuring formaldehyde were developed by NIOSH. Lack of long-term stability and interference from other chemicals have caused inaccuracies when older sampling methods are used. The new NIOSH method, which was presented to the American Chemical Society in August 1981, is relatively free from interferences and has improved precision and accuracy.

NIOSH also began a mortality study to evaluate the potential effects among workers occupationally exposed to formaldehyde. Workers from two shirt manufacturing plants were chosen as a study population because of the continuous low-level exposure, the quality of the records of exposure and death, the numbers of exposed workers, and the length of their exposure. Industrial hygiene surveys are also under way to provide a detailed characterization of the work environment at the plants in the study.

Ethylene Oxide

NIOSH recommended that ethylene oxide (EtO) be regarded as a potential human carcinogen and that appropriate controls be used to reduce worker exposure to the most practical extent. An inhalation study sponsored by a group of EtO manufacturers indicated increases in leukemia in female rats and malignant tumors in male rats exposed to EtO. The results of this study were shared with NIOSH, OSHA, and the National Toxicology Program. In Fiscal Year 1981, NIOSH published the data about the carcinogenicity of EtO and updated information published in 1977.

Several NIOSH studies are under way that examine the effects of occupational exposure to EtO. One study of a large chemical plant in West Virginia is reviewing the mortality of workers who have been employed in the EtO production area. Since there are data indicating that EtO may cause chromosomal damage, a cytogenetic study is being conducted by NIOSH at a Texas petrochemical plant that uses EtO. Current NIOSH toxicology studies of the effects of EtO in rats and monkeys include a chronic toxicity experiment and an inhalation teratology study.

EtO is among the 25 chemicals of highest production volume in the United States. It is widely used as a fumigant for foodstuffs and textiles, as an agricultural fungicide, and as a sterilant, especially for surgical instruments such as blood transfusion tubing. NIOSH believes that the greatest potential for worker exposure to EtO occurs when it is used as a fumigant, not in the chemical industry. Other industries and work settings where exposures may occur include health care, medical products manufacturing, libraries, museums, research laboratories, agricultural fumigation, and textile and clothing fumigation.

REVIEW OF RECENT LITERATURE

NIOSH published a review of recent literature on occupational exposure to sulfuric acid and may develop criteria for a recommendation for a new Federal standard.

New data developed since 1974, when NIOSH published recommendations for a Federal standard, indicate that low concentrations of sulfuric acid mist lead to adverse health effects, especially when combined with low concentrations of pollutants commonly found in urban atmospheres, such as sulfur dioxide, ozone, and carbon particulates. These health effects most probably occur in industries in urban areas that have great concentrations of other pollutants. The review also described improved sampling and analytical methods developed since 1974. More sulfuric acid was produced in the United States during 1979 and 1980 than any other chemical. Among the largest users of sulfuric acid are the steel industry, zinc and petroleum refineries, and manufacturers of phosphate fertilizers.

A NIOSH Health Hazard Evaluation among workers at a steel pickling operation recorded respiratory irritation caused by sulfuric acid mist in concentrations below the OSHA standard of 1 milligram per cubic meter of air. Animal data have suggested that low concentrations of sulfuric acid mist in the presence of sulfur dioxide and ozone decrease resistance to influenza infection and aggravate allergic responses.

OCCUPATIONAL HEALTH GUIDELINES

Guidelines for Chemical Hazards

NIOSH and OSHA jointly published three comprehensive volumes that summarize information on specific chemicals found in the workplace. Occupational Health Guidelines for Chemical Hazards catalogs exposure limits, chemical properties, and health hazards for chemicals with existing Federal exposure limits, in addition to the NIOSH recommendations for effective occupational health programs. The guidelines compile information assembled and evaluated under the NIOSH/OSHA Standards Completion Program.

The primary readership of the guidelines includes industrial hygienists and medical surveillance staff responsible for occupational health programs. Others may also find the summary information on specific chemicals useful. Chemical names and synonyms, permissible exposure limits, chemical and physical properties, and signs and symptoms of overexposure are included for each chemical, in addition to recommendations for environmental and medical monitoring procedures, use of respiratory and personal protective equipment, measures of controlling the chemical, and procedures for emergency treatment and conditions.

NIOSH recommendations for over 300 chemicals--from acetaldehyde to zirconium compounds--are given. Guidelines for the 100 remaining chemicals with Federal standards will be issued when they are developed. The three-volume set is bound in looseleaf form, so that additions, updates, and revisions may be inserted easily.

Guidelines for Mine Sanitation Practices

The recommendation contains a set of guidelines for a general mine sanitation program, which is intended to be used as a framework for development or modification of individual programs. It was prepared after evaluating the literature and receiving input from experts in the field. A description of each literature reference is provided, so that users of this recommendation may decide if those sources of information are useful for their needs. The recommendation contains sections on drinking water, toilet, shower, and clothes-changing facilities, and eating places. Detailed information on State offices to contact regarding drinking water regulations is included.

CURRENT RESEARCH FILE

NIOSH's Current Research File contains approximately 10,000 computerized records of current occupational safety and health research. It includes not only NIOSH projects, but also selected projects funded by foreign and domestic government agencies and nonprofit organizations. To give an overview of subjects in the file, an alphabetical list of its 6,000 index terms is available.

The file is recognized internationally as one of two primary resources on current occupational safety and health research, the other being the International Labor Organization's International Occupational Safety and Health Information Center. NIOSH conducted 357 searches for information in the file in Fiscal Year 1981, over twice the number of searches in Fiscal Year 1980.

EDUCATIONAL RESOURCE CENTERS

NIOSH continued its support of Educational Resource Centers across the Nation. The centers, which were established by NIOSH in 1977, provide continuing education to occupational health and safety professionals, combine medical disciplines with occupational safety and health disciplines, and reach out to other institutions to aid in training and other services. In Fiscal Year 1981, NIOSH provided $6.4 million in financial support to the 12 Educational Resource Centers. In addition, NIOSH staff assisted the centers by providing guidance, experienced lecturers, and equipment.

Spread throughout the United States to serve each region of the country, the centers are located at the following schools:

- University of Arizona Health Science Center, Tucson
- University of California Department of Community and Environmental Medicine, Irvine
- University of Cincinnati Institute of Environmental Health, Cincinnati
- Harvard School of Public Health, Boston
- University of Illinois School of Public Health, Chicago
- Johns Hopkins University School of Hygiene and Public Health, Baltimore
- University of Minnesota School of Public Health, Minneapolis
- Mt. Sinai School of Medicine, New York
- University of North Carolina School of Public Health, Chapel Hill
- University of Texas Health Science Center, Houston
- University of Utah Medical Center, Salt Lake City
- University of Washington Department of Environmental Health, Seattle

Enrollment has increased progressively each year, most sharply in continuing education, as indicated below.

ERC Enrollment

Student Enrollment	FY-1978	FY-1979	FY-1980	FY-1981
Full-time	485	659	782	784
Part-time	3,436	3,095	4,485	4,363
Continuing Education	1,683	6,421	8,944	9,853
Totals	5,604	10,175	14,211	15,000

SAFETY AND HEALTH IN INDUSTRIAL VOCATIONAL EDUCATION

NIOSH and OSHA jointly developed a safety and health training guide for teachers, administrators, supervisors, and maintenance personnel in vocational education. The guide includes the basic concepts of recognizing, evaluating, and controlling safety and health hazards common in vocational education. The consequences of adverse exposures, their relationship to current standards, and recognized safe practices are discussed. Also covered are the roles of professionals in a school's overall vocational safety and health program.

After taking the course, teachers and administrators should have a better appreciation of the role of safety and health, specifically the need for introducing hazard recognition and control strategies in school programs. The course introduces a broad perspective of industry's needs and requirements for safety and health.

The curriculum's text is based on the cumulative recommendations of Federal, state, and industrial safety and health professionals. More than 100 vocational educational personnel participated in pilot programs conducted in four major regions of the country. The program can be given over a 3-day period, or its 17 units can be studied individually over longer periods. Because the program's approach is so flexible, the training material is also being used by other groups, including state and local safety and health agencies, Federal and state correctional institutions, colleges, universities, and professional and trade associations.

APPENDIX

INDUSTRYWIDE STUDIES -- STARTS AND COMPLETIONS

Starts

Epidemiologic investigations of lathe injuries
Neurotoxicity evaluations of fumigators
Chronic stress in office work
Stress/trauma of non-traditional jobs
Prevalence of chronic wrist disorders
Health and safety effects of cold stress
Trauma of alternative work schedules
Mortality and industrial hygiene study of automotive wood die and model makers
Industrial hygiene study of new agents IV - extent of exposure
Mortality and industrial hygiene study of formaldehyde
Effect of polychlorinated biphenyls on reproductive outcomes
Biological hazards
Mortality and industrial hygiene study of a uranium enrichment plant
Epidemiologic support of the Toxic Substance Control Act
Mortality analysis of United Auto Workers cohorts
Control technology assessment of chemical process batch unit operations
Control technology assessment of petroleum refining industry
Electronics components industry pilot study
Control technology assessment of formaldehyde formulation
Control technology assessment of styrene emissions in the fiberglass boat industry
Control technology assessment of chemical adhesive bonding
Assessment of effective control for dry chemical bagging and filling operations
Control technology assessment of oral contraceptive tableting operations
Control technology assessment for hazardous waste from chemical processes
Control technology assessment for sampling solids processes
Control technology assessment: robot technology
Control technology assessment of lead ore benefication operations
Case-control study of gastrointestinal cancer among coal miners
Industrial hygiene characterization of fluidized bed combustion
Aerosol deposition in humans
Endotoxins in animal confinement units
Hypersensitivity pneumonitis due to humidfiers
Industrial hygiene characterization of indirect liquefaction
Industrial hygiene characterization of oil shale industries
Occupational health studies of advanced coal combustion
Morbidity and mortality among chrysotile asbestos textile workers
Early events in immune response to organic dusts
Early indicators of risk for energy industries
Evaluation of the effects of washed cotton dust

Completions

Segmental vibration: chippers and grinders
Segmental vibration and noise: miners
Retrospective cohort mortality study of workers exposed to radiation at the Portsmouth Naval Shipyard
Industrial hygiene characterization of petroleum refineries
Industrial hygiene characterization of wood preservative operations
Industrial hygiene characterization of nitrosamine exposures
Mortality and case-control studies of brain tumors in the petrochemical industry (four reports)
Industrial hygiene characterization of radiofrequency exposures in heat sealing operations
Reproductive study of female pharmaceutical workers
Industrial hygiene characterization of carbon disulfide exposures in viscose rayon operations
Retrospective cohort mortality study of perchloroethylene workers
Industrial hygiene characterization of perchloroethylene exposures in dry cleaning operations
Industrial hygiene characterization of styrene-butadiene rubber processing
Industrial hygiene characterization of pesticide applicators
Preliminary study of sex ratio in children of uranium miners
Retrospective cohort mortality study of boilermakers
Control technology assessment of pesticide formulation
Control technology assessment of spray painting and coating
Industrial hygiene characterization of resource recovery industries
Morbidity and industrial hygiene study of workers exposed to sulfur oxides and nitrogen oxides
Morbidity and industrial hygiene study of fibrous mineral industry
Morbidity/industrial hygiene study of cement workers
Industrial hygiene characterization of crushed stone industry