

A blue banner with a metallic, reflective texture. The text "Annual Report 1999" is centered in a dark blue, serif font. The banner has a slight 3D effect with highlights and shadows.

## Annual Report 1999

### **Preface**

The Institute of Occupational Safety and Health (IOSH) is a research institute under the jurisdiction of the Council of Labor Affairs (CLA), Executive Yuan. Its important mission include application of scientific technology, surveys and analyses of various risk factors in the working environment, as well as development of countermeasures.

This annual report is a general report of the various activities of the IOSH, commencing on January 1, 1999 and ending on December 31, 1999. It is divided into four chapters: "Introduction", "Focus of Research", "Research and Results", and "Related Activities". In addition to providing a general overview of the various businesses and activities of the IOSH for the fiscal year 1999, we hope that this annual report could provide the community with an understanding of IOSH. A summary of the contents for each chapter is provided below:

1. Introduction: provides a summary of this annual report, organization and personnel of IOSH and their respective responsibilities, research expenditures, and research laboratory building construction projects.
2. Focus of Research: provides a brief introduction of research orientation of each division of the IOSH.
3. Research and Results: provides research results of each division of IOSH, as well as a description on various research

projects being implemented.

4. **Related Activities:** provide a list of academic and exchange activities held by IOSH, papers and presentations related to occupational safety and health, the publications of IOSH, computer/networking devices, promotion and exhibitions of IOSH's researches, assistance in occupational survey and other services.

The appendix includes a list of IOSH's technical book collections (published in 1999) for readers' reference.

Director of IOSH

## **Contents**

### **Preface**

## **Contents**

### **Introduction**

#### I. Overview

#### II. Organization and Personnel

#### III. Research Expenditures

#### IV. Research Laboratory Construction Project

### **FOCUS OF RESEARCH**

I. Research on Occupational Safety

II. Research on Method Development and Analysis

III. Research on Occupational Hygiene

IV. Research on Occupational Medicine

### **RESEARCH AND RESULTS**

I. Research on Occupational Safety

II. Method Development and Analysis

III. Research on Occupational Hygiene

IV. Research on Occupational Medicine

## **RELATED ACTIVITIES**

I. Academic Activities

II. Publications

III. Information Services

IV. Technology Promotion and Services

V. International Exchange and Cooperation

## **APPENDICES**

I. Technical Publications

II. Index of Accompanying Figures

III. Index of Accompanying Tables

**Introduction**

## I. Overview

The Institute of Occupational Safety and Health (IOSH) was established in August 1992, over seven years ago. From the beginning, the planning committee has clearly defined goals and directions of IOSH in its organizational regulation, which include:

1. Provide the theoretical basis for occupational safety and health strategies and administrative measures.
2. Provide solutions to important occupational health and safety problems.
3. Provide references for revisions of important occupational safety and health regulatory standards and management systems.
4. Upgrade the technological standard in occupational safety and health and inspection activities.
5. Provide necessary information for training and consultation in occupational safety and health.

In keeping with the spirit from the past, through open discussions from various parties, IOSH has developed Research Strategy 1997-2001 to guide future research, in response to changes in industrial structure and results of national survey of occupational hazardous exposures, and in accordance with administrative needs of the Department of Labor Safety and Health and Labor Inspection, and occupational safety and health standards issued by or proposed in European Union, International Standards Organization and World Trade Organization. Research Strategy focuses on serial and interdisciplinary research: it is goal-oriented and comprehensive in nature, in survey of work environment and work conditions, evaluation and prevention of occupational injuries and diseases, and technology for occupational safety and health management and personal protective equipment, in order to improve safety and health in domestic work environment, awaken workers' awareness of occupational safety and health, decrease occupational injuries and prevent occupational diseases, such that a safe, healthful, and comfortable working environment may be

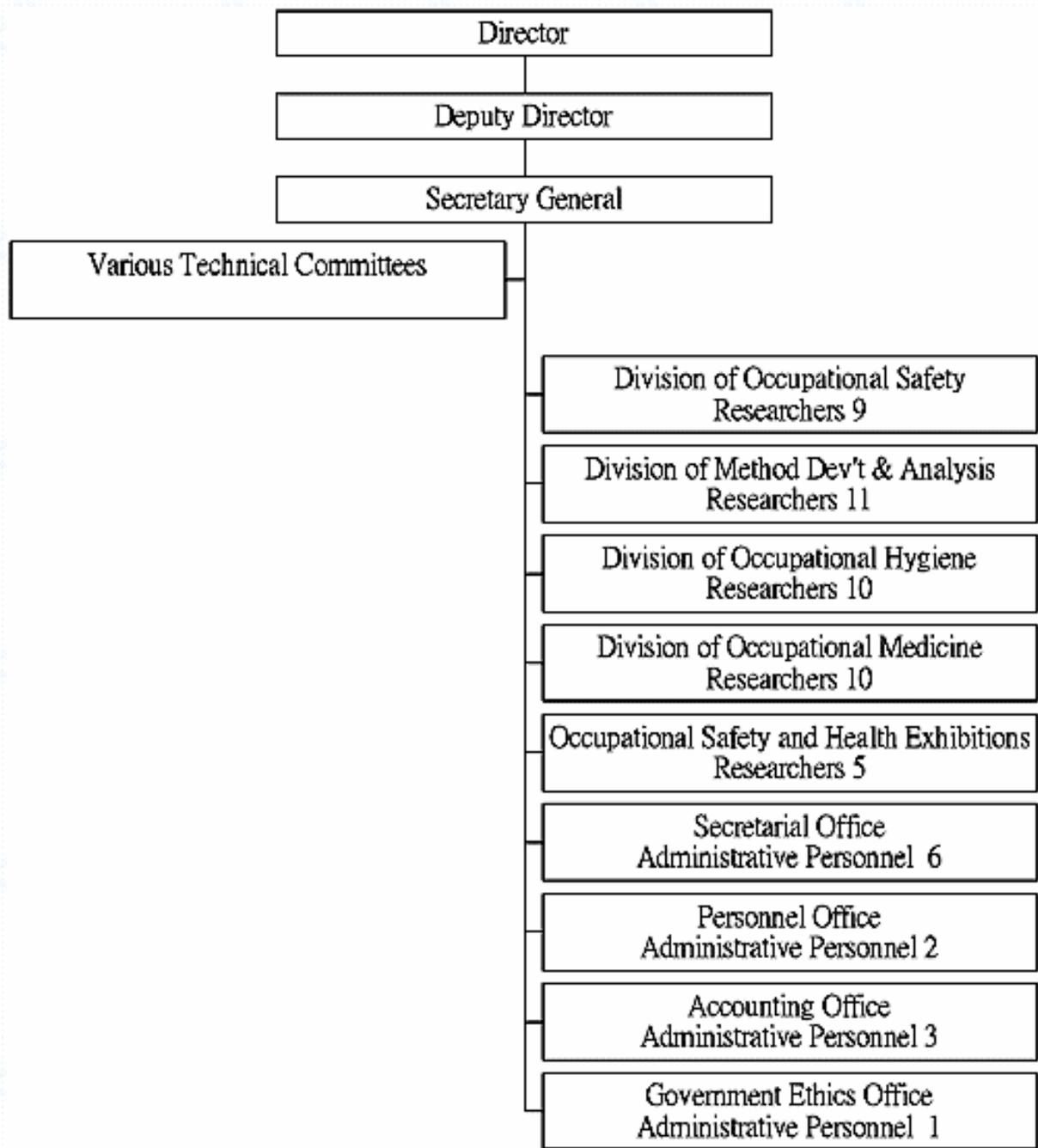
created for the nine-million-plus workers in Taiwan.

This annual report covers research activities from January 1 to December 31 of 1999, with the completion of 88 projects for fiscal year 1999, and the initiation of 108 projects for the second half of fiscal year 1999 as well as fiscal year 2000. All results are disseminated externally through presentation of research results, technology transfer, publications, theses, internet on Line searches, exhibitions, and various seminars and conferences. These include 113 publications (over 40,000 copies issued), two exhibitions, 10 academic conferences, thesis presentation in 37 local and foreign publications, 38 local and foreign academic conferences, and 13 patents obtained. IOSH also assisted with investigations in incidences of occupational injuries and diseases, as well as provided calibration services for inspection agencies.

## **II. Organization and Personnel**

IOSH is headed by a Director, a Deputy Director, and a Secretary General. It is divided into five divisions: the Division of Occupational Safety, the Division of Occupational Hygiene, the Division of Method Development and Analysis, the Division of Occupational Medicine, and Occupational Safety and Health Exhibition Branch. For administrative support, it has a Secretarial Office, an Accounting Office, a Personnel Office, and a Government Ethics Office. (Figure 1).

### **1. Organization**



Administrative Personnel 3

Government Ethics Office  
Administrative Personnel 1

Figure 1 Organizational Structure

## 2. Analysis of Research Positions

Table 1 Analysis of Research Positions

<b>Positions</b>	<b>Researcher</b>	<b>Associate Researcher</b>	<b>Assistant Researcher</b>
Number of Employees	16	22	11

## 3. Analysis of the Level of Education in Current Research Personnel

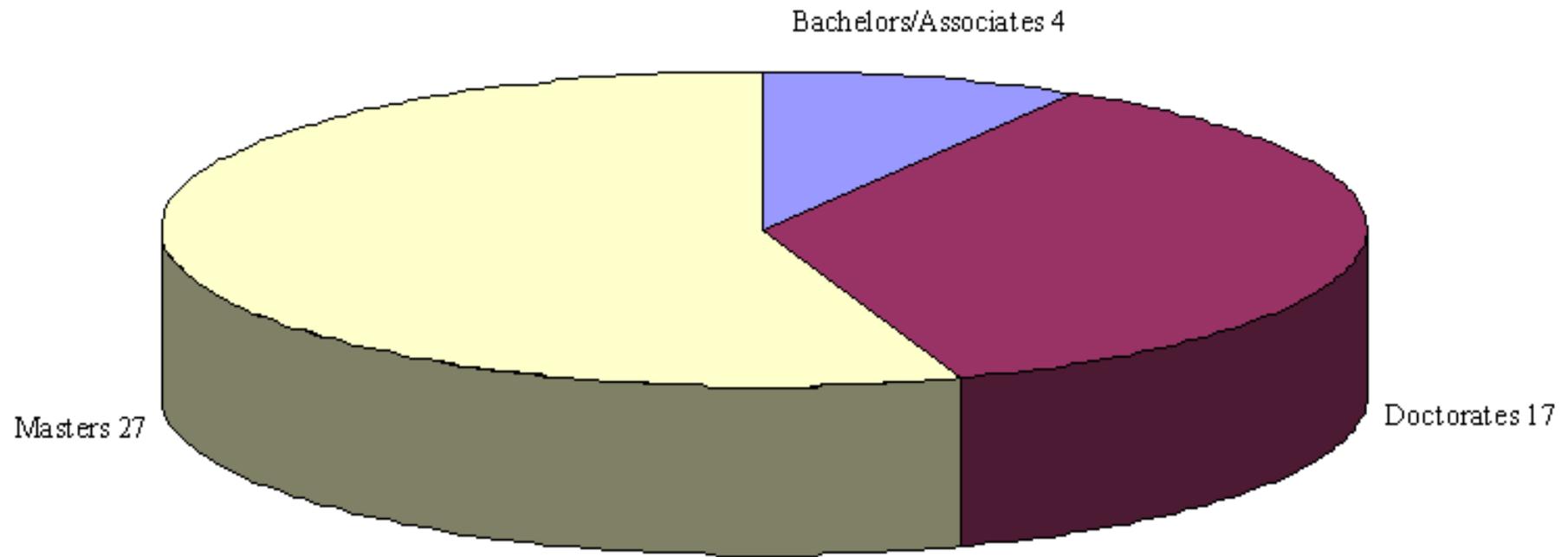


Figure 2 Analysis of the Level of Education in the Current Research Personnel

Note: Doctorate researchers include 4 that are employed; currently, 7 research personnel are undertaking doctorate studies.

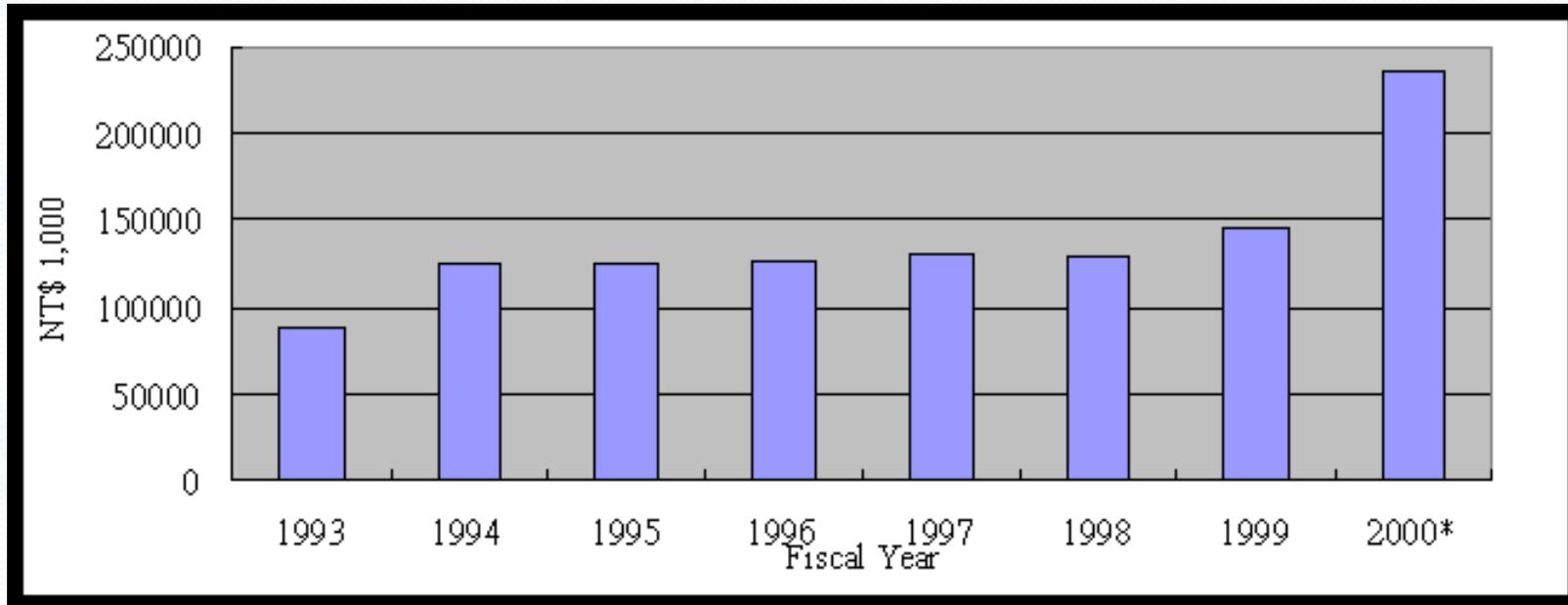
### III. Research Expenditures

1. Budget for Fiscal Years 1999, second half of Fiscal Year 1999, and Fiscal Year 2000

Table 2 Budget for Fiscal Years 1999, second half of Fiscal Year 1999, and Fiscal Year 2000

Unit: NT \$ 1,000

<b>Subject</b>	<b>Budget for FY 1999</b>	<b>Budget for second half of FY 1999 and FY 2000</b>
Occupational Safety and Health Research	145,013	236,439
Occupational Safety Survey and Research	35,404	57,829
Method Development and Analysis Technology Research	29,986	48,478
Occupational Hygiene Survey and Research	32,531	54,144
Occupational Medicine Survey and Research	32,176	52,652
Occupational Safety and Health Exhibitions	14,916	23,336



## 2. Analysis of Research Expenditures over the Years

Figure 3 Budget for Fiscal Years 1993 to 2000

Note: 2000\* includes the second half of FY 1999 and FY 2000

## IV. Research Laboratory Construction Project

### 1. Construction Plans

1. Immediately after its establishment on August 1, 1992, IOSH has embarked on a plan to construct a laboratory building. After

visiting numerous sites, IOSH requested for 8.6 hectares of land located in Hsi Chih, Taipei County, from the National Property Bureau, which was subsequently approved by the Executive Yuan.

2. Pursuant to regulations provided under the "Management Guidelines for Development and Construction on Hilly Terrain", construction and development of hilly terrain must be reviewed by the local government. Permission will be issued in three stages: first, a permit for development on hilly terrain; second, a license for miscellaneous projects (including a license for their use and an application to change the zoning in non-urban areas), and third, a building license (including a building permit).
3. An engineering consulting firm was commissioned to obtain permission for development in March. All necessary documents were submitted to Taipei County Government, which issued a permit for development a year later in July 1994. Designs for miscellaneous projects were prepared three months later for the application of a license, which was obtained in April 1995. These projects were contracted immediately thereafter, and were completed in October 1996, despite a delay due to weather, moving of ancient graves, and public protest. IOSH obtained a note certifying that no public property was damaged during the construction from Hsi Chih Government, and applied for a permit to use the miscellaneous facilities and for zoning change to "land for special purpose enterprises". These administrative procedures were completed in June 1997.
4. Architectural design for the laboratory building was completed in September 1996. However, due to the lengthy process in obtaining the permission for development in the second stage while "Technical Regulations on Construction" was revised at the same time, the design was modified accordingly. IOSH applied for a building license in August 1997. Approval of the construction permit was subsequently obtained on October 27, 1998. Currently, construction works is ongoing. It is estimated

that building construction will be completed before the end of fiscal year 2000.

## 2. Contents of Construction

### 1. Miscellaneous projects:

1. Entry/exit roadways
2. Sewage pipelines
3. Conservation of soil and water (drainage, retaining walls, landscape slopes)
4. Common drainage

### 1. Main buildings: total area of 24,581.16 m<sup>2</sup> , including:

1. Research and administrative offices of 1,893.21 m<sup>2</sup>
2. Laboratories of 13,249.07 m<sup>2</sup> , including 8 labs for occupational safety, 9 for method development and analysis, 9 for occupational hygiene, and 6 for occupational medicine
3. Exhibition hall and library of 2,678.8 m<sup>2</sup>
4. Education and training center of 5,157.5 m<sup>2</sup> , including an auditorium, lecture halls, conference rooms, dormitory, and recreational areas
5. Underground parking lot of 1,602.61 m<sup>2</sup>

### 3. Expenditures

1. Miscellaneous projects: NT \$ 46 million
2. Main buildings and landscape architecture: NT \$ 590 million
3. Instruments and equipment: approved by the Executive Yuan and budgeted yearly in accordance with construction progress

## **FOCUS OF RESEARCH**

### **I. Research on Occupational Safety**

The primary goal in occupational safety research is to ensure workers' safety by minimizing occupational disasters. In order to achieve this goal and to meet the competitive production standards and development, research in occupational safety will become interdisciplinary in nature, setting the issue of safety in high risks production jobs a priority. In addition, it will follow the guidelines of the "Development of Technology in Occupational Safety and Hygiene" from Executive Yuan's technology consulting conference, using the objectives of the 1999 technology projects as a base, as well as the advice given from the industrial and academic fields. Six research areas are assigned: mechanical safety, chemical engineering safety, electrical safety, construction safety, protection gear, and safety management policy. Occupational safety research is primarily oriented towards development of technologies for safety equipment, development of hazard monitoring and warning systems, development of hazard control and intrinsic safety technologies, formulation of regulations, standards, criteria for inspection, modification and recommendation for functions of personal safety equipment, with design for comfort, safety evaluation and management.

The focus of the various research projects of occupational safety is as follows:

### 1. Research on Construction Safety

The frequency of occurrence and the severity of occupational disasters in the construction business have always been highest among the industries. For this reason, the Council of Labor Affairs considers construction safety as one of the main issues in terms of prevention of occupational injuries. Emphasis of research in construction safety is not only focused on surveys of current conditions, safety management, and evaluation of construction safety, it is also focused on technologies of construction safety equipment and construction methods, prevention of construction hazards, and minimizing occupational hazards in the construction industries. Research in 1999 included temporary scaffolding and the development of safe anchoring device, research and development of "Protective Device for Form Inspectors" and "The Protective Device for Soil Collapse in Excavation Soil Retaining Columns", concrete methods to be incorporated in the planning of safety considerations in bridge building and construction engineering, evaluation system for setting temporary scaffolding structures, and procuring of the construction safety technology handout and construction safety technology databank.

### 2. Research on Mechanical Safety

Analysis of the results showed that struck by object, caught in or compressed by equipment, cuts and abrasions were the major types of occupational injuries, which for the most part were due to unsafe machinery. Research therefore focuses on cranes, lifts,

boilers, and pressurized containers that often result in serious injuries and construction machinery and process machinery that often result in caught in or compressed by equipment and cuts and abrasions. In particular, equipment setup and safety monitoring of technology were given priority in research. This year, research emphasized on creating safety devices for ensuring stable movement and preventing falls of crates or lifts, safety coupling devices, hazards and safety analysis system of injection molding machines, data of technology in machinery safety, applicability assessment of brake alarming device for construction site vehicles and machineries, guidelines for hoist technology safety, techniques in machinery safety and prevention, establishing erosion detecting techniques for supporting pipelines, warning technology for robots, process machinery and construction machinery; inspection of dangerous machinery and equipment, modeling and training system for operating dangerous machinery and equipment.

### 3. Research on Electrical Safety

Occupational electrocution incidents are the second leading cause of serious occupational injuries. Technical guidelines for explosion-proof electrical apparatus are also lacking. Short-term objectives for prevention of electrocution include developing and improving warning and protective devices, and establishing technical guidelines for choosing the appropriate protective devices. Short-term objectives for explosion-proof electrical apparatus research include technologies for classification of hazardous areas with combustible gases and vapors, research and analysis of structural specifications, standards and maintenance technologies for explosion-proof electrical apparatus and appropriate choice of apparatus, so that plants will install suitable explosion-proof electrical apparatus and decrease the occurrence of fires and explosions.

#### 4. Research on Chemical Safety

Focus of research includes safety and risk assessment of chemical production processes, storage and transport of hazardous and volatile chemicals, chemical hazard identification, and safety in semiconductor and chemical manufacturing plants. Research included surveys of hazards in semiconductor manufacturing and chemical industries, control of run-away reactions, fire prevention in semiconductor manufacturing, development of risk assessment technology, models and characterization of explosive properties of chemical substances and related control technologies.

#### 5. Research on Safety Protection Equipment

The provision of appropriate safety protection equipment is the last means to prevent injuries. Emphasis of research is focused on functional evaluations, methods of setting safety standards and ability, comfort design and development of new safety protection equipment. A new type of helmet suitable for using both in construction sites and while riding a motorcycle was developed, in order to provide adequate protection for workers. In addition, comparison of standards for functions and fitness of safety goggles was conducted, with the development of a computerized system to support the choice of appropriate eye protection for workers, to combat the current lack of understanding in personal protection gear.

#### 6. Occupational Safety Management and Policies

Focus of research is primarily on analysis of trends of occupational hazards, comparison and incorporation of intra- and

international management systems, review of related regulations, evaluation of organizational functions, preventive measures to respond to potential occupational hazards. New indicators for occupational hazards, and new management technologies were developed, in order to elevate safety consciousness of both employers and employees. Trends of types of occupational injuries, geographical distribution, and personal factors were reported to effectively support the enactment of policies. Feasibility of regulations (amendments), evaluation of safety management policies and organizations, and studies of the effectiveness of labor inspection were conducted in order to strengthen functions of safety management.

The primary purpose of research on occupational safety lies in the study and development of technologies to prevent occupational hazard and improve work environment and application of scientific technology. Model for research lies in: analyzing hazard factors related to safety of work environment of workers, proposing recommendations and measures to prevent occupational hazards, upgrading work environment of local workers to protect their safety, reduce rate and frequency of occupational hazards, providing a scientific theory for decisions and administrative measures for occupational safety, providing a reference for revision of regulations on occupational safety regulations and management system, and upgrading technological standards of occupational safety and inspection activities.

To unify research in the Division, meet current demands for occupational safety, and satisfy expectations of the public, research focuses on multi-disciplinary, high risk, future-oriented project series, which include fire prevention in semiconductor manufacturing, explosion prevention of mobile pressurized containers, monitoring and warning technologies for collapses during construction, overturn of construction machinery and incidences of electrocution, and comfortable design of safety protection equipment while

ensuring protective functions of the equipment. The effectiveness of safety research is maximized through optimization of research resources and integration of various academic fields.

## **II. Research on Method Development and Analysis**

Researches on Method Development and Analysis are focused on the development of monitoring methods for chemical hazards in the work environment, quality assurance and quality control programs in laboratories, development of certification for laboratories, and study of evaluation technologies for occupational exposures and health hazards. Orientation of research is as follows:

1. Develop easy-to-promote and practical sampling and analytical techniques for the workplace.
2. Develop sampling media and sampling equipment applicable to local work environment
3. Investigate actual exposure conditions for workers in high risk industries
4. Establish a database for the sampling and analytical methods and provide services to interested parties
5. Conduct technology transfer of sampling and analytical methods

According to the operational guidelines of IOSH, the functions of the Division of Method Development and Analysis are to establish sampling and analytical methods for environmental monitoring and biological monitoring methods, to assist in identifying occupational diseases through exposure assessment, and to evaluate the performance of the commercially available sampling equipment with the goals of improvement and development. Currently, emphases of research are as follows:

## 1. Survey on chemical exposure

There are still cases of occupational diseases caused by different hazardous chemicals present in the working environment today. The government has adopted various positive strategies to seek improvement measures to express its concern on this matter. However, there is no way to understand actual occupational exposures, since no comprehensive survey on exposures to various highly dangerous chemicals in the work environment has been undertaken. The lack of reference information has created difficulties in the formulation of labor policies and the amendment of regulatory standards. To solve this shortcoming, there is a need to design and implement a series of organized researchers on occupational exposures, and to integrate these results with other exposure monitoring data and the surveillance systems for occupational diseases. These will allow for the formulation of more thorough and feasible policies and regulations. IOSH shall continue to conduct in-depth studies of highly hazardous substances used in large quantities in industries, with large numbers of exposed workers or high incidence of occupational diseases, which are also focus of labor inspection and subjects for the setting of regulatory standards.

## 2. Development of sampling and analysis techniques for hazardous substances in the work environment

The Council of Labor Affairs amended the "Permissible Exposure Limits of Hazardous Substances in the Work Environment" in 1995. More than 200 different kinds of hazardous materials were included and permissible exposure limits were substantially lowered. In conjunction with these amendments, IOSH is actively developing standards for sampling and analysis of the newly included hazardous materials. Taking into account the special environmental conditions, and analytical techniques employed in developed foreign countries, methods for local sampling and analysis have already been established over the years. An

Environmental Monitoring Technical Committee was also convened to review various validated analytical methods, before submission to the Council of Labor Affairs for promulgation. Emphasis of research for this fiscal year shall continue to focus on the establishment of techniques for sampling and analysis of various hazardous materials, as well as further studies on newly developed sampling and analysis technology such as passive sampling and thermal desorption. The establishment of a database for method development and analysis will provide inquiry services to governmental agencies, academic research institutes, and enterprises to conduct various hazard surveys, and to obtain information on local occupational exposures and health hazards.

### 3. Development and evaluation of samplers and sampling media

Currently, most of the sampling equipment used in environmental monitoring is imported from foreign countries. Not only are these equipment expensive, but they are also not necessarily suitable for the working environment in Taiwan, which is characterized by high temperature and high humidity. Developing local samplers and sampling media that are more economical, more convenient, and more accurate is needed. A personal sampler for acidic mist and small diameter aerosol and fiber sampler are being developed this year to better evaluate sampler precision and the unbalanced concentrations of particles on sampling filters.

### 4. Development of biological monitoring techniques

It is essential to develop biological monitoring techniques to supplement environmental monitoring, since environmental monitoring only considers inhalation exposures. Many industrial raw materials or process intermediates may also enter the human body through dermal contact and ingestion. In addition, differences in personal hygiene and inter-individual variability in skin absorption

also increase the need for biological monitoring. Biological monitoring is the direct acquisition of a biological specimen, such as blood or urine, to test for the internal dose of hazardous substances or their metabolites. It also takes into account factors such as skin absorption, ingestion, work load, physical conditions, personal hygiene habits, and use of protection equipment to evaluate occupational health hazards. In recent years, research on occupational health technologies has caught the attention of developed countries in the world. In light of the above, IOSH invited scholars from various disciplines to form a Biological Monitoring Technical Committee, which determined that priority should be given to blood lead required in current occupational health examination regulations, and biological monitoring of eight organic solvents required by the Japanese government. This year, research on biological monitoring focuses on the development of biological monitoring technologies for arsenic speciation and methyl isobutyl ketone in urine.

#### 5. Development of real time gas monitors

Due to difficulties in using current sampling and analytical methods for certain substances in certain industries, the Division of Method Development and Analysis conducted a study on the functions of direct reading monitors. Recently, Fourier transform infrared spectroscopy (FTIR) has become common for real Time gas monitoring. The Division of Method Development and Analysis conducted an evaluation on the application of this particular instrument in industrial hygiene, and has found that it is very effective in monitoring hazard exposure in semiconductor manufacturing. For fiscal year 1999, this instrument has been effectively applied in the evaluation and survey of occupational exposure in semiconductor industries and maintenance operations.

### **III. Research on Occupational Hygiene**

Occupational hygiene studies means for understanding and controlling risk factors in the work environment. According to operation guidelines of IOSH, the Division of Occupational Hygiene is responsible for research relating to occupational health issues, such as occupational health management policies, surveys and prevention of chemical, physical, biological, and ergonomic hazards, and measuring instruments and protection equipment related. At this stage, the Division of Occupational Hygiene is oriented toward prevention of occupational diseases. In line with these guidelines, it has formulated four basic concepts and research objectives:

1. Understand occupational exposure levels in the work environment
2. Study control measures to resolve occupational health problems in enterprises
3. Obtain important localized data on occupational hygiene
4. Cooperate in establishing regulations and policies in occupational hygiene

Research is directed to:

1. Study the work environment in which occupational diseases have occurred, in order to understand the occupational exposure levels of various risk factors, and to develop control measures;
2. Support and promote systems necessary for the establishment of occupational safety and health regulatory system, and assist enterprises in finding solutions to difficulties encountered;
3. Obtain important localized data in occupational hygiene, to provide references for regulatory amendments and improvements in the work environment;

4. Introduce technologies to prevent possible occurrence of major occupational diseases;
5. Provide research results to the Council of Labor Affairs, to serve as a reference for amendment of regulations.

Due to limited manpower and funding, the Division of Occupational Hygiene, combining domestic and Institute research resources, focuses on exposure assessment, risk prevention and management policies of important occupational hazards.

In line with available research personnel and local resources, and to establish research characteristics for this Division, focuses of research are as follows:

1. Survey of exposure to occupational hazards
2. Prediction models and control of hazardous substances and noise
3. Occupational health protection equipment and measuring apparatus
4. Evaluation and control of ergonomic hazards
5. Control of occupational musculoskeletal injuries

The objectives and methods are described as follows:

1. Survey of exposure to occupational hazards

With rapid economic development and diversification of industrial operations, risk factors in the work environment are more complex and difficult to understand than ever. In order to reduce occupational injuries and to protect the health of the workers, there is a

need to study the hazardous exposure conditions and levels, and the numbers of workers exposed, so that regulatory priority for chemical substances and industries can be determined for the formulation of strategies in occupational safety and health and in labor inspections.

In addition, research will be conducted to further understand issues in occupational safety and health, the condition of airborne biological exposure in biological industries, potential health hazards in rehabilitation institutes, and industrial hazards associated with environmentally prevalent high temperature and high humidity. Furthermore, results of the related data collected will be compiled and organized into a database, establishing a system to monitor various industrial environmental exposure levels.

## 2. Prediction models and control of hazardous substances and noise

Results from a study on the status of safety and health conditions in the work environment among workers in Taiwan, conducted by IOSH in 1998 showed that workers believed that improvement was most needed for pollution of hazardous substances and noise in the work environment. To lessen air pollution in the work environment, ventilation equipment is commonly adopted. However, with the complicated nature of airflow, improper ventilation design may at times produce exactly the opposite effect. Noise has a very significant effect on health and work efficiency of the workers, therefore, a noise control in work environment becomes an important subject as well.

Emphasis of research lies in the development of control technologies for airborne hazardous substances and noise in order to improve the work environment. It also emphasized the development of relevant estimation models, in order to understand possible

effects of engineering control measures, so as to avoid making mistakes in installation, and to increase incentives to enterprises to improve the work environment. Research results can also be applied on controlling airborne contaminants and noise in specific industries.

### 3. Occupational health protection equipment and measuring apparatus

Occupational health protection equipment is the last line of defense in a workplace. Deficient or inappropriate use of health protection equipment will harm the health and the lives of the workers. Environmental assessment and control of conditions and hazardous factors in the work environment are dependent on the accuracy and the quality of the measuring apparatus. This study joins with the occupational health management system in the Council of Labor Affairs to focus on the standards and technologies for testing protection equipment, as well as their selection criteria, appropriate use and necessary education, and calibration of measuring apparatus (including photometers, noise meters, and anemometers).

### 4. Evaluation and control of ergonomic hazards

Ergonomics is an applied science aimed at understanding the interaction between human capabilities and environmental factors. Its objectives lie in the promotion of safety and health, efficiency and comfort at work. The lack of proper safety and man-machine interface design in the machinery and equipment, and poor work environment can easily cause occupational injuries, even occupational hazards. Studies on causes of occupational injuries showed the lack of overall coordination between work methods, equipment, environment, and "the worker". At the present stage, ergonomic research emphasizes the applications of

anthropometric data, assessment of manual material handling, introduction and dissemination of international ergonomic checklists, prevention of ergonomic injuries in the workplace, and adaptation of heat environmental models to local conditions. Hopefully, through the application of ergonomic principles, occupational safety and health problems may be resolved, as well as elevating work efficiency and comfort of the work environment.

#### 5. Control of occupational musculoskeletal injuries

Occupational musculoskeletal injuries are becoming more serious in recent years, along with changing industrial structure, increasing repetitiveness of work, and using machineries not suitable to the physical dimensions of local workers. According to a survey on safety and health conditions in the work environment in 1998, 45.5 % of the workers complained of awkward work posture. The fact that 52 out of 100 workers reported muscular pain and soreness, of which 40 % believed it was work-related, reveals that preventing musculoskeletal injuries is an important research topic.

At this stage, research emphasizes safety and health guidelines for designing man-machine interface, preventive strategy for repetitive injuries, physiological measurements related to biomechanics and support devices to prevent musculoskeletal injuries, so that occurrence of occupational musculoskeletal injuries will decrease.

#### **IV. Research on Occupational Medicine**

Research on Occupational Medicine is related to the study of various occupational factors and health hazards, as well as the

prevention of occupational diseases, to further protect and promote the health of the workers. In accordance with guidelines provided by IOSH, the responsibility of the Division of Occupational Medicine includes epidemiological study on occupational diseases, prevention of occupational diseases, health management, labor health promotion, and research on occupational psychology and physiology. Primary research orientation is focused on monitoring occupational diseases and analyzing health data, epidemiological study on occupational diseases, prevention of occupational diseases, labor health promotion, and occupational biological monitoring. Emphases of research are as follows:

#### 1. Monitoring of occupational diseases and analyzing health data

The monitoring of occupational diseases and the analysis of health records are ways of understanding the onset of occupational diseases. By joining efforts of a reporting system of occupational diseases and the collection of data from various channels (i.e. insurance data such as Labor or National Health Insurance), more accurate occurrence rate of occupational diseases may be documented, and more effective preventive methods for occupational diseases may be developed.

In fiscal year 1999, data on compensation for labor and health insurance for both in- and outpatients, prevention of occupational diseases and health inspection, inpatient data from labor insurance due to occupational injuries and illnesses, health inspection for taxicab drivers, and physical fitness for middle- and older-aging workers have been collected. Based on these data, a standard for epidemiological study was compiled and used for comparison with population information. In addition, these data will serve as a base for setting a monitoring system through the Internet. A diversified analysis and study can also be conducted, based on these data, to provide a basis for amendment of policies and laws, and serve as a preliminary study for epidemiological research.

A joint effort was established with the Department of Health to create an occupational monitoring system for occupational hearing loss, medical surveillance on acute occupational injuries in emergency rooms, monitor occupational burn injuries, and monitor occupational decompression sickness for compressed air workers. It was found that through this monitoring system that highest suspected occurrence of occupational injuries took place in the form of occupational decompression sickness. A labor-hearing threshold level was also established through this occupational monitoring system.

## 2. Survey on Occupational Diseases and Occupational Epidemiology Research

Due to rapid industrial and commercial development in Taiwan in recent years, complex production technologies and various new chemical substances have continually been applied in the work place. Workers are exposed to more and more complex working environment, leading to the emergence of various occupational diseases. Thus, the purposes of this research lie in the surveying of occupational diseases to gain an understanding on the current situation of occupational diseases, establishing various epidemiological data on occupational diseases, studying hazardous factors derived from epidemiology research to formulate measures to prevent occupational diseases, and to investigate and further fulfill the needs of policies and regulatory requirements. In addition to chemical hazardous factors, research emphasis is also focused on new emerging occupational diseases and physical hazardous factors.

For fiscal year 1999, primary research include vinyl chloride exposure, sulfuric acid exposure, isocyanate exposure, foamed resin industry, pneumoconiosis, noise exposure (textile industry), fishing industry, semiconductor industry, transport industry, exposure to

1,3-butadiene, animal husbandry, medical health promotion service industries, operations of dental technicians, epidemiological study among former RCA employees and pesticide manufacturing industry. In addition, there were hazardous assessment on occupational bladder cancer and survey on sudden death syndrome among foreign workers. The scope of research also included new emerging topics on musculoskeletal diseases such as pains on the neck and shoulders, and psychedelic and occupational cancer.

### 3. Research on Labor Health Promotion

Not only does occupational hygiene concern with the prevention of occupational diseases and hazards, it is also involved in the active promotion of a healthy, safe, and comfortable working environment. Other objectives of occupational hygiene include maintaining workers' physical fitness and productivity, developing human resources through reshuffling of work assignment and improving the production environment, delaying the actual age at which workers retire, and appropriately introducing potential workers into the job market. This way, productivity may increase through hiring workers that are highly experienced as well as those who will stay on the job, and the health of the workers may be maintained through the prevention of occupational diseases and hazards and the promotion of and assessment of physical fitness in the work environment.

The research includes assessment of work fatigue and physiological conditions of indoor workers in the telecommunication operation, studies on basic information on metabolism and suicide among workers, developing strategies to promote and maintain physical fitness among middle- and older-aging workers in the service, manufacturing and construction industries, assessment of the physical fitness of workers from different age cohorts, establishing a table of "five stages of health and physical fitness", and

standardizing physical fitness for various industries.

#### 4. Occupational Biological Monitoring

Hazardous substances enter the human body through various routes. Thus, there is a need to monitor the hazardous materials inside the human body through biological medicine technology to serve as workers' health hazard biological monitor index.

Biomedical technologies are employed in epidemiological studies of hazardous factors and metabolic mechanism to achieve early detection and early prevention, and serve as a reference for permissible exposure limit.

This year, research emphasized on immunopathogenesis and analysis of HLA genes in TDI sensitive workers, widespread epidemic of viral zoonoses such as Japanese Encephalitic Virus and Swine Influenza among animal husbandry workers, and studies on biological indicators for heavy metals such as chromium and cadmium.

## **RESEARCH AND RESULTS**

### **I. Research on Occupational Safety**

Since the establishment of IOSH on August 1, 1992, the research work in occupational safety has been highly looked upon and the results have been well received. Amendments of research direction and objectives are made each year at presentations of results and academic research conferences to effectively achieve the goal of minimizing occupational hazards, so that the results of

research will be applicable in various industries. Significant methods and research results for fiscal year 1999 are as follows:

## 1. Mechanical Safety

Research is primarily focused on the development of surveillance mechanism and analysis on hazards of dangerous machinery and equipment.

Research and development of the dangerous machinery virtual reality training system in manufacturing and popularizing the VR training system and multimedia education system of crane was completed by continuing the research and analysis of the three-degree-of-freedom motion platform (hydraulic platform) technology from the virtual reality mobile crane system developed from the previous year, such that the six-degree-of-freedom motion platform may reach six free rotations. The control system became compatible with a personal computer, so it is no longer limited to be used at the workstation alone. The system was designed in separable and integrative style. The new simulation system can be used to create different scenario to accompany varying training objectives. Thus, the system has low cost with wide applicability, and it may be used repeatedly with low maintenance. This versatile system can also be optimized further through the analysis of relative data and error detection.

The three-degree-of-freedom motion platform of the virtual reality mobile crane system captures the real time scenario; it is able to grade objectively the overall stability of the operator in operating the crane as well as increasing the sensitivity of the crane. The language, background music, figure presentation as well as material used were improved in the education of crane operation via multimedia technology. The system can be operated smoothly and integratively, as research progressed from design to production, assembly, and testing; it is an excellent simulation system.

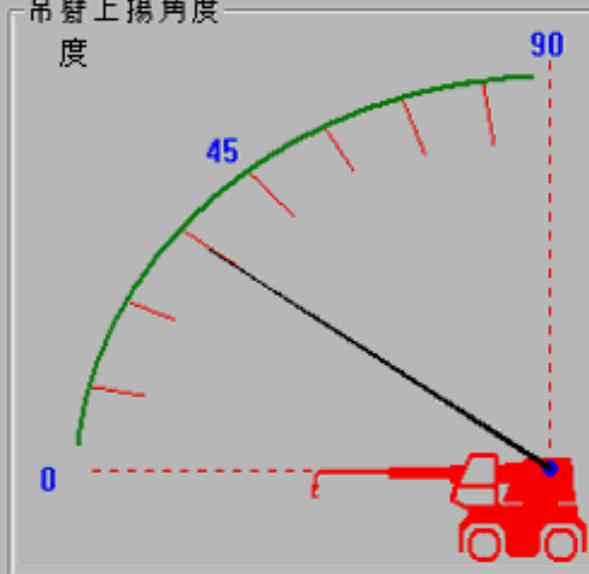


監控台 | 操控台

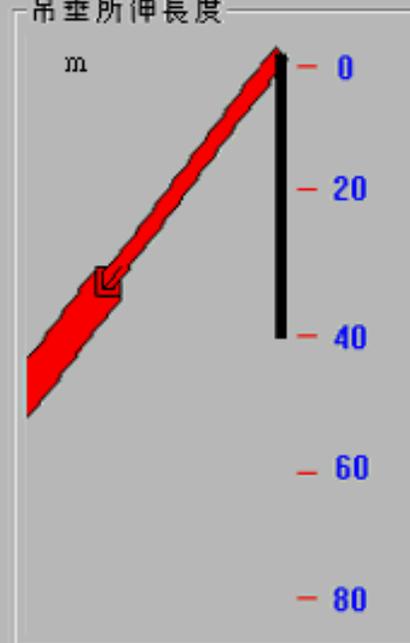
吊臂旋轉角度



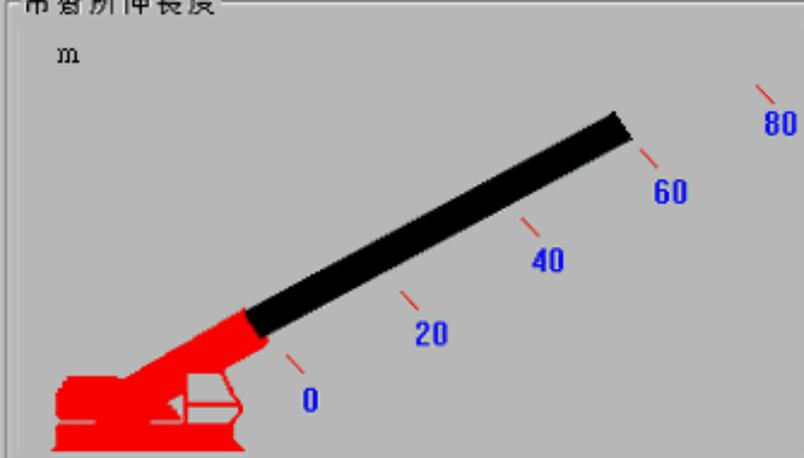
吊臂上揚角度  
度



吊垂所伸長度



吊臂所伸長度



系統資訊

吊臂旋轉角度：	67.5 度
吊臂上揚角度：	34 度
吊臂所伸長度：	60 m
吊垂所伸長度：	40 m
目前荷重：	400 Kg
安全度：	38%

吊垂過捲警告：



超過安全度警告：



吊臂碰撞警告：



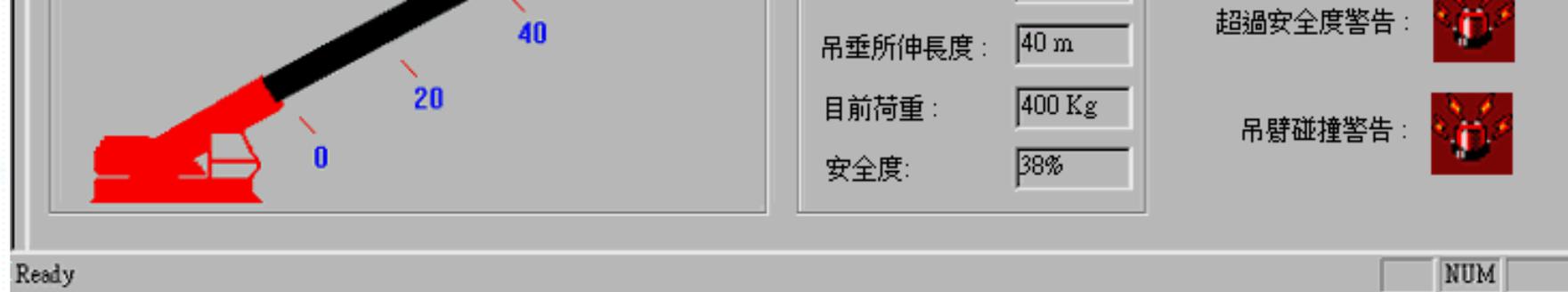


Figure 4 Control Dialog Box for Mobile Cranes

The investigation in “Fail safe for hydraulic power systems of machinery crane” was completed. The research is focused on the hydraulic power system of the machines used at construction sites. The failure of the system was analyzed using the influence of the process failure mode and effect analysis, or the fault tree analysis to regress the sources of failure and breakdown. The mobile crane and hydraulic power system were investigated according to the structure of hazard prevention and safety confirmation. Based on this information, a design theory of safety confirmation and applicable technology were established. As a result, a design for a safety-confirmed mobile crane hydraulic power system and its parts was created.

The research entitled “The study of climbing operation safety for tower crane” was completed. Tower cranes are commonly used in construction sites. The PFMEA (Process Failure Mode & Effect Analysis) and FTA (Fault Tree Analysis) techniques were used to assess the causes of accidents and propose improvement suggestions. The effects of some key safety mechanism and components on the risk of malfunctioning lifting operation were examined. A theory on the design of standard operation procedures and applied technology as well as hazard prevention methods were developed based on research on the safety of lift operations.

“The study of safety coupling device for LPG (Liquefied Petroleum Gas) pipe” was completed. A prototype of a safety coupling

device for LPG refilling was designed and produced. The quality and performance of this low-cost prototype are within the safety standard and regulations of the safety of LPG refilling. It is also low-cost, thus may increase the desire of the operators to use them over imported products. Through the introduction of this safety coupling device, the level of local design and production ability has been raised, and suggestions for amendments to the existing regulation and standards have also been submitted.

A device monitoring and controlling the lift operation was developed in the study entitled "Vibration Suppression of Tower Crane Maneuvers & Altitude Control of its Payload". The vibration of the lifted object is minimized during transport. An actuator system was developed in which the rotation and tilting of the object lifted may be remotely controlled, making loading and unloading easier as well as reducing the risk of being struck by fallen objects for the operators and workers.

A compilation of the "Mechanical safety technology databank", which included safety protection equipment, operating procedure, assessment of occupational safety, and preventative methods for potential hazards was established. This databank is localized; it will provide a basis for improvement for both the manufacturers and operators both alike, raising the level of occupational operating safety and minimizing occupational injuries.

The "Development of the inspection technique for corrosion under the support of petroleum pipeline" study was completed. One of the purposes of this study was to provide convenience for operators in the petroleum industry. An ultrasound inspection technology was hand-operated. The slanted ultrasound waves entered the wall of the pipelines from different angles, reaching the ultrasound wave receiving end directly, or indirectly by allowing the ultrasound waves to bounce repeatedly off the walls. The inspection was performed in both naturally corroded petroleum pipelines and artificial simulated corroded petroleum pipelines. This inspection using

ultrasound method was able to detect whether the support or the wall of the petroleum pipeline had been corroded.

The study on the "Corrosion of tubular and plate heat exchangers in petroleum industries" was completed. Following on-site survey and investigation, the heat exchangers have been found to be uniformly reduced in thickness, which was of the main erosion type. It was found that 23 % of the erosion occurred on the tube sides of the heat exchangers and 10 % on the shell side. Of the tubes, 40 % of corrosion occurred in the tube walls, 32 % occurred at the ends of the tubes, and 24 % occurred on the supports of the tubes. Other findings: 47 % of the heat exchangers had not been inspected regularly; eye inspection had been the most common method of inspection; most of the petroleum factories did not keep a log of maintenance work on heat exchangers. An operating and maintenance guideline was established for the industry.

The "Fail-to-safe study on safety valve device for steam boiler" was completed. A prototype of a fail-to-safe safety valve device which was to be used with steam boilers was designed and produced. This prototype was developed based on the fail-to-safe theory and a basic structural design, with the expectation of fulfilling all the relevant regulations and standards. It is hoped that, in the future, the development of this technology can be applied on other potentially dangerous devices such as the pressure releasing valve of the boilers and pressurized containers. It is also hoped that the result of the development of this safety feature may provide some useful reference and guideline for amending in relevant regulations, standards, and safety inspections in the future.

The study of "Trends of international standards in crane (II)" was completed. The trends of the international standards in cranes were analyzed. An amendment to the current standards in cranes was drafted. The draft included amendments to the standards in the inspection of cranes, safety operation of cranes, the procedure for testing cranes, installation of safety devices, and the level of

stability of cranes. The current standard in crane is under revision regarding its principles and order of priority in order to follow international trends and raise the various standards regarding cranes in Taiwan. The revised standards will act as a basis for amendments for future standards in crane. It will also serve as a reference guide for the future amendments to the standards in crane as well as a future inspection standards in crane for Central Standard Bureau and the Council of Labor Affairs.

## 2. Chemical Safety

The study entitled "Research of physical explosion investigation methods; steam-related explosions & high pressure vessel-related explosions" was completed. The research is composed of 1) investigative reports of actual explosions and/or accidents; 2) a set of formalized procedures for consistent official explosion-related investigations; and 3) methods and tools of evidence collection such as videotaping. This research will help in investigating the type of explosion, center of explosion, fuel and source of explosion as well as the reason behind the explosion, so that future explosions may be avoided.

The study on the "Control strategy for prevention of explosion in labor's workplace; safety on LPG tank lorry" was completed. The purpose of this study was foremost, to investigate and analyze the theories regarding the safety of the liquid petroleum gas tank lorry. The second purpose was to use a table of safety inspection to evaluate the safety standards of operation in the LPG tank wagon and at the gas stations. The safety device attached to the body of the LPG tank wagon was then assessed. Next, the safety in the transportation of the LPG tank wagon was discussed. Finally, a reaction plan for hazards regarding LPG accidents was proposed.

The research on "Evaluation of pyrophoric substance -- FeS" was completed. Due to the oxidation of pyrophoric FeS, it is possible that fire can break out at an oil refinery factory. If an effective extinguish system were unavailable, the consequence may be a disastrous. The adiabatic calorimeter was used to research the chemical reaction data of pyrophoric FeS in this study. The data obtained may be used to prevent accident occurrences. Data showed that, under adiabatic conditions, the starting temperature was 133 °C in the runaway reaction of pyrophoric FeS. The duration of reaction was 87.5 minutes. The following methods were recommended for preventing future accidents: 1) that factories set up temperature alarms and automatic sprinkler system; 2) that a oxidation prevention procedure for pyrophoric FeS be established in the cleaning tank; 3) that the recognition of runaway chemical reactions be strengthened in the chemical engineering department; and 4) that an emergency procedure be set up with regular practice drills.

The compilation of "Safety data sheets for the chemical industry" was completed. Items included in the compilation are the apparatus setup and safety protective operation equipment commonly used in chemical factories, operating procedures, assessment of occupational safety, and policies on preventing potential hazards. The goals of this compilation were to establish a technological data on chemical engineering safety specific for Taiwan, provide a basis of improvement in safety and related matters for workers in the chemical industries, to raise the occupational safety levels in operation, and to minimize occupational injury incidence.

The project entitled "The survey of facility safety in semiconductor FABs (vacuum pressure facilities)" was completed. The purpose of this research was to evaluate the current status of semiconductor FABs regarding four vacuum pressure facilities: fume

exhaust system, smoke control system, scrubber, and wet bench. The mechanism and features of these facilities were studied in order to identify their potential hazards. The safety information results of this report were given to the purchaser and field operators for reference purposes.

### 3. Construction Safety

Research in construction safety examined occupational hazard and its prevention strategies from the perspective of the management levels. Focus is also placed on the composing of a manual for the technologies in construction safety.

The study entitled “Safety considerations to be included in bridge engineering planning and design” was completed. Occupational hazards in the construction industry occur as a result of a combination of factors in both construction and in environment, thus the responsibility of managing construction safety falls on both construction operating unit and the design and zoning unit. Therefore, based on the principles of holistic safety management, it is necessary to regulate and consider issues of construction safety at the designing and zoning stages of construction planning. The purposes of this project were to analyze the content of the items considered during the planning and design stages in current bridge engineering. In addition, the influence of these items on construction safety was assessed. As a result, feasible safety related issues, which should be taken into consideration during the planning and designing stages were proposed. Finally, amendment of construction safety related regulations were recommended.

The research on the “Inspection system for primary temporary structures in ROC” was completed. The research purpose was aimed at establishing an inspection system and certifying technologies for frame-type scaffolding, the most commonly used

temporary structure in the construction sites in R.O.C. The R.O.C. regulation with respect to strength specifications of temporary structure was stated as “According to Chinese National Standards”, which is vague, and lacked calculation specifications and a standardized certifying procedure. Under this ambiguous regulation, workers had been facing potential dangers of collapse due to the questionable safety and strength the scaffolding system set up. Consequently, it was truly necessary to set up a standardized inspection system and its associated certifying procedures for the scaffolding systems used in R.O.C. to promote and ensure a safe environment in construction sites.

The three volumes of “Technical manual for construction safety” was completed. Although numerous construction engineering projects are currently underway and ongoing, the risk of potential worksite hazards have often been ignored. There has always been a lack of safety-related material to provide training for those who need it most, leading to constant reports of accidents and hazards occurring at various construction sites. According to the regulation of occupational safety and health No. 23, employers are to educate and train workers to practice occupationally safe and healthy as well as hazard preventative working habits. The three volumes of this manual are “Retained Excavations”, “Concrete Bridges”, and “Special Bridges and Foundations”. This manual will serve as a reference for designing a training manual for both construction managers as well as construction workers. The goal of this manual is to protect the workers from potential hazards through raising the awareness of all involved in the construction industry of protection methods available.

The project entitled “Research and development of form inspector protecting device” was completed. Form collapse is one of the most serious accidents in the construction industry. The collapse of the form, caused by lateral force conducted from the vibration

force of concrete pumping pipe during concrete pouring work often resulted in enormous catastrophes. The purpose of this study was therefore to design a device to protect form inspectors against such catastrophic harm from form collapse. The design criteria were: 1) the structural strength of the device would be enough to withstand the force resulted from the form collapse; 2) the profile of the device can completely isolate contact between the inspector and the form or the concrete; 3) the device would not interfere with the inspection practice; 4) the device would be easy to manufacture, install, and use; and 5) the manufacturing cost and the weight of the device would be as low as possible. A prototype of this innovative device was proposed based on concepts and methods from ergonomics, mechanical analysis, and construction field surveys. The prototype was tested and found that it was able to withstand the collapse of a concrete form of the dimension of 5 m x 5 m x 25 cm from a height of 7.2 meters. In addition, the device was equipped with a venting channel and the inspector was able to easily enter and exit out of the device.

The project entitled "The study and development of the anchorage systems applied to the temporary structures and safety devices under construction" was completed. In the past, occupational disasters were often created by the caving and falling of structures due to improper location of anchorage system selection and set up, and failure to install safety devices for temporary structures under construction. Therefore, the results of this project would be used to provide the construction industry with guidelines on anchorage system selection, as well as in setting up regulation standards for inspection by the relevant government agencies.

The project entitled "The protective device for soil collapse in excavation soil retaining columns" was completed. The purpose of developing this device was to protect workers from soil collapse. Large, heavy machineries are unsuitable for the excavation work site since the region is full of gravel and pebble. Hence, workers often work freehand, which directly exposes them to the immediate

danger of soil collapse. Therefore, a protective device for the workers was needed to ensure their safety. This protective device was designed such that it will be capable of withstanding a force of 50 kg gravel falling from a height of 10 meters, which will provide sufficient protection for the workers in almost all cases.

#### 4. Research on Electrical Safety

The research was focused on the compilation of a technical manual on electrical safety, and techniques in selection, maintenance, and inspection for explosion-proof electrical apparatus.

The compilation of "The electrical safety data sheet" was completed. The items in this data sheet included insulating protective equipment, live line tool, testing equipment, construction site temporary electricity distribution, factory substation, electrical interlock switch, electric plug and receptacle, cable and pipe, emergency lighting, battery and charger, portable drill, electric equipment grounding, motor maintenance, electric switch, and electrostatic mitigation equipment. The main content of the data sheet was the specifications, inspection, testing, setting, usage, repair, storage, and maintenance of the aforementioned equipments. It was hoped that through this data sheet, electric shock accidents may be more effectively prevented, so that the operators can work in a safer environment.

"Maintenance and inspection technique research for flameproof electrical apparatus" was completed. The analysis of failure mode of flameproof motor, switch, instrument enclosure, wiring box enclosure, plug and socket set, wiring conduit, lighting, warning fixture and broadcast communication device was established. The checklist and maintenance guideline was proposed to the users to

prevent occupational injuries. The safety of the people working in the area of production equipment can therefore be secured. It was hoped that the guideline can provide individual industries with a better understanding of the causes of failure, extent of hazard due to the failure, regular maintenance and inspection of flameproof electrical apparatus.

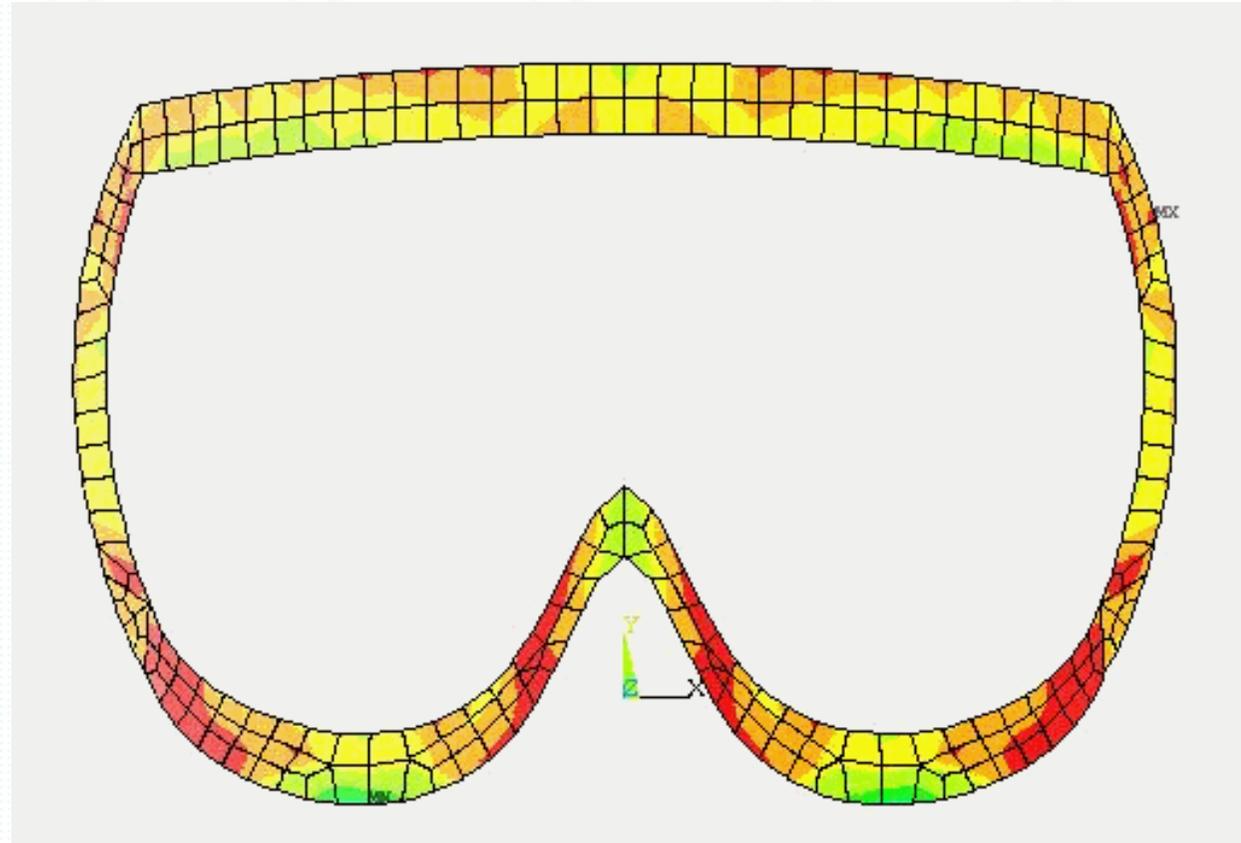
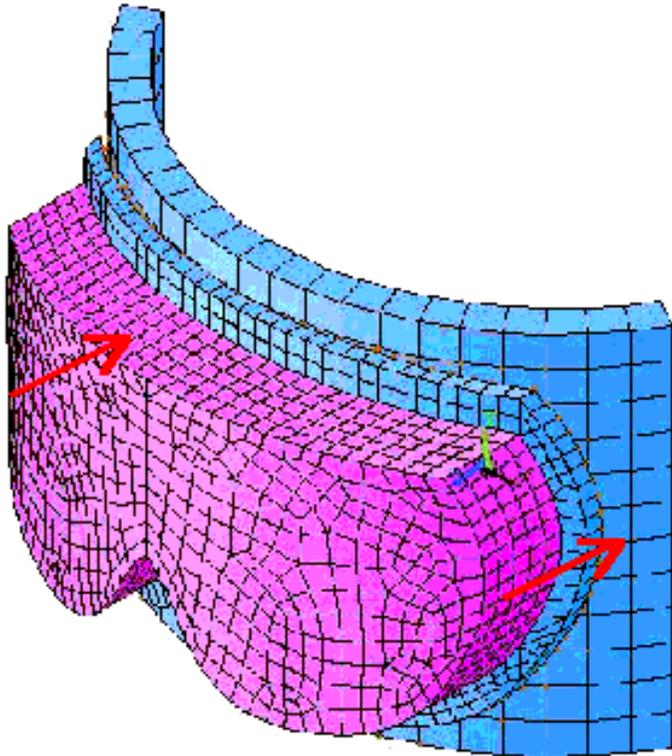
“The selection and installation of intrinsically safe explosion-proof electrical apparatus for explosive gas atmospheres” was completed. The selection criteria, locations of use, temperature levels, environmental considerations, installation, items to inspect, maintenance, etc. were topics included in this research project. Primary focus was emphasized on the installation techniques and selection of intrinsically safe explosion-proof electrical apparatus. The results of this project will serve as a guideline for the selection of intrinsically safe explosion-proof electrical apparatus for labor inspection agencies as well as relevant industries. The results will also be useful in preventing future incidence fire break outs and explosions.

## 5. Research on Personal Protection Equipment

This research area focused on function tests, comfortable designs, and the development and improvement of personal protection equipment.

The “Detail design and technology transfer of a new eye protector model” was completed. This was a continuation of the project of the same name from last year. The experiment had been re-designed and new sets of comfort index and evaluation procedure were established for safety goggles. The concept of self-adjustable facial pressure relieving design for safety goggles was investigated further in depth. A prototype was developed and optimized for highest level of comfort based on the computer analysis

of the data obtained as a result of facial pressure evaluation from clinical tests. The final step was to transfer the concepts, findings, and the testing apparatus to manufacturers, so that this new protection eyewear may be available in the market.



## Figure 5 Computer-Aided Design for the Comfort of Protective Goggles

### 6. Research on Safety Management and Policies

The research is focused on a system, which will immediately display the losses from occupational disasters.

The survey of "Current safety status of large size (employees numbered over 100) industrial enterprises" was completed. This project employed the method of spot checks to understand the safety status of large size (those with 100 or more employees) industrial enterprises. Advice were then sent to relevant government agencies for promotion of safety and health management and future inspections on worker safety as well as for future research on occupational safety.

"The comparison of safety and health management systems between Taiwan and developed countries" was completed. The promotion of the occupational health and safety management systems in Britain, U.S., Japan, New Zealand, and Australia was compared and discussed. Questionnaire and visits were conducted to obtain the perspectives of various enterprises toward safety and health management. Based on the above comparison and analysis of the questionnaire, suggestions are provided for managing agencies, business agencies, and safety and health management enforcement agencies regarding the promotion of safety and health management.

The project on "The contract management practice and management regulations in current construction industry" was completed. The purpose of this project was to provide a reference guide of policy and contract set up for construction companies and

contractors. It was hoped that problems in terms of safety and health due to inappropriate contract management may be reduced.

In general, special features of the research projects in fiscal year 1999 are as follows: active development of hazard monitoring and warning technologies, proposal of new studies to respond to safety problems brought by automation and changes in industrial structure; study of safety management systems for temporary structures, and emphasis on the development of safety protection equipment. In addition to these projects, other activities regarding occupational safety carried in fiscal year 1999 included: participating in investigations of major occupational incidents with inspection agencies, cooperating and communicating with local and foreign academic organizations, convening conferences on research results and other safety issues, calibrating safety measurement instruments used by labor inspection agencies, and planning for the laboratory building.

## **II. Method Development and Analysis**

The objectives of research in method development and analysis are to establish assessment methods for hazardous substances found in the work environment, to develop laboratory quality assurance/control program and laboratory certification system, and to assess hazardous exposures among workers.

Researches for method development and analysis for fiscal year 1999 included 1. Chemical exposures assessment; 2. Sampling and analytical techniques for hazardous substances in the work environment; 3. Development and evaluation of samplers and sampling media; 4. Development of biological monitoring techniques; 5. Development of infrared real-time gas monitoring technology. In summary, projects for fiscal year 1999 were conducted in accordance with the Institute's short-term, medium-term

and long-term plans and policy directives, in coordination with the Institute's research personnel and facilities. Chemical exposure in highly dangerous industries and operations among workers were studied, as well as more economical, convenient, sensitive, fast, automated, easy to promote, and practical sampling and analytical techniques. Sampling and analytical equipment and sampling media suitable for local conditions were developed to upgrade the technical level of industrial hygiene.

Significant methods and research results for fiscal year 1999 are as follows:

### 1. Chemical Exposure Assessment

The project entitled "Chemical exposure survey for workplace workers (II)" was completed. In order to obtain an overall idea of the degree of occupational exposure to various chemical compounds, an assessment in work places such as resin manufacturing, paint manufacturing and surface coating of motor industries was performed. The policies and standards of the environmental assessment and sampling of the above three industries were drafted. Thirteen resin manufacturing plants, 11 paint manufacturing plants, and six automobile surface coating plants were visited and surveyed in this study. Samples analyzed included toluene, xylene, ethyl acetate, butyl acetate, dimethyl formamide, methyl ethyl ketone, styrene, acetone, and methyl isobutyl ketone. A total of 580 air samples were collected and 2,100 analytical data obtained. In terms of resin manufacturing, the most severe chemical compound used in the polyurethane manufacturing industry is dimethyl formamide. The result of the survey showed that the level of dimethyl formamide was over the permissible exposure limit in 5 % of the resin manufacturers. In addition, 10 % of resin manufacturers had a dimethyl formamide level of over half of the permissible exposure limit. In terms of paint manufacturing and automobile surface coating, the exposure level of one single chemical compound had not exceeded half of the permissible exposure limit. In terms of all

the various industries combined, there was not one single outstanding chemical compound of which the exposure level severely exceeded the permissible exposure level. A draft for sampling strategy recommendations of work place sampling assessment was provided to the environmental monitoring institute and industries in the resin manufacturing, paint manufacturing, and automobile surface coating industries.

The study on the "Status of occupational exposure in domestic workers in ABS plastic manufacturing industries" was completed. This study was focused on 1,3-butadiene (BD) tank cleaners of the seven ABS plastic manufacturing plants in Taiwan. The sample size was 29 for the high exposure group of the tank cleaners and 32 for the low exposure or non-exposed workers in the control group. Personal sampling was divided into active pumps, passive badges, and real time monitors. Blood samples were obtained for examining possible biomarkers in the blood. Results revealed that the exposure level fluctuated dramatically, even up to a maximum value of 20 ppm during high exposure periods. The mean exposure concentration for the high exposure workers was 6.1 ppm, which was significantly higher than the 0.3 ppm for the low/non-exposed workers, although it is still below the permissible exposure limits of 1,3-butadiene which is 10 ppm.

The survey on "Health hazards of ethylene oxide" was completed. Ethylene oxide is an important low temperature gaseous sterilizer used in hospitals. It is a strong alkylating agent, and is considered to be a suspected carcinogen. Long term exposure to ethylene oxide may cause harmful health effects. A continuation of the project from last year, the current research tested sampling and analytical methods of ethylene oxide. In order to understand the actual exposure condition of the industrial workers and medical personnel, these methods were used in work place environmental measurement. The work places included manufacturing and user

of ethylene oxide in chemical process plants and the related downstream industries, hospital sterilization rooms, and manufacturers of disposable medical supplies, which use ethylene oxide for sterilization. The results of the personal exposure survey and environmental measurement will serve as future references for work improvement and labor inspection.

The study of "The effect of industrial process to the transformation of silicon dioxide composition" was completed. It is quite common that silica changes its physical structure when it is used in industrial procedures as raw material, when it has been heated upon, or through chemical processing or other treatments. Sometimes, non-crystallized silica will transform into crystallized silica, and crystallized silica will transform into non-crystallized silica, or quartz will transform into Tridymite or Cristobalite, which is an even greater hazard to workers. This study chose several industries where large amount of silica was used as raw material. Raw material and processed material samples were collected and analyzed, in order to compare the percentage content of crystallized free silica in these materials before and after processing. In addition, the percentage content of each isomer of quartz, Tridymite and Cristobalite were also analyzed. Study results showed one of the casting sand samples contained 9.3 % Tridymite, and firebrick contained Cristobalite and Tridymite. Therefore, not only should workers of the production factories be aware of the potential hazards of silica, workers in casting operation and furnace maintenance should also be aware of the risk involved. Since quartz content in tile ranged between 5 to 21 %, construction workers should take special care when cutting and grinding tiles. Sand used in processed peanut also contained 27 to 43 % quartz. Results showed that many industries might have under estimated their hazards to workers. In the future, related hazardous information of crystallized free silica, quartz, Tridymite and Cristobalite should be included in promotional documents.

The investigation in the "Organic solvent composition in the detergent used in restaurants" was completed. Due to requirements of sanitation and hygiene in the business, a large quantity of various cleaning agents is used in restaurants. For effective cleaning, some of these detergents contain non-ionic surfactant organic solvents (such as glycol ethers) to enhance cleaning power. When using detergent containing glycol ether without proper personal protection equipment or wear, workers may be exposed to these hazardous organic solvents through the air they breathe or from skin contact. Over exposure of these organic solvents, especially ethylene glycol ethers, may cause chronic health effect. Related reports and documents had shown that these solvents might cause reproductive system and hematological toxicity, therefore causing worldwide concern. The purpose of this study was to analyze the organic solvent composition and concentration in detergents. The source of detergents may be local retail stores and supermarkets, or detergent manufacturers and directly from restaurants for those unavailable in local stores. The results can serve as reference and guideline for protective equipment for cleaning workers in the restaurant and relevant industries.

## 2. Development of Sampling and Analytical Techniques for Hazardous Substances in the Work Environment

The project on "Analytical method validation" was completed. Methylal, allyl glycidyl ether, nitroethane, n-butyl glycidyl ether, trifluorobromomethane, terphenyls, dibutyl phthalate, furfuryl alcohol, 1,1,2-trichloro-1,2,2-trifluoroethane, and isophorone were recently listed in the Permissible Exposure Levels of Airborne Contaminants in the Workplace, promulgated by Taiwan's Council of Labor Affairs in 1995. However, the implementation of this regulation is hindered by the fact that there is no analytical method for these ten compounds recommended by the government. The current research aimed to adopt US NIOSH's methods for these compounds into a reference method that will be recommended by Taiwan's Council of Labor Affairs. The NIOSH's methods were re-

evaluated according to the Method Evaluation Guidelines for Airborne Contaminants in the Workplace, promulgated by Taiwan's Institute of Occupational Safety and Health, Council of Labor Affairs in 1996. The performance of the methods was evaluated for certain specified items including loading capacity, storage stability, recovery, accuracy, and precision.

The project entitled "Simultaneous method for sampling and analysis of aliphatic aldehydes commonly used in industrial sectors" was completed. In order to provide the industrial settings and the accredited laboratories of industrial hygiene a method for evaluating occupational exposure, this study was intended to develop a method that is capable of simultaneously sample and analyze formaldehyde, acetaldehyde, acrolein, and valeraldehyde. The method for the simultaneous sampling and analysis of formaldehyde, acetaldehyde, acrolein and valeraldehyde by using 2,4-dinitrophenylhydrazine (2,4-DNPH) was further validated. The recovery in the case of single component spiking (or in multicomponent spiking) was 97.92 % (103.99 %) for formaldehyde; 63.75 % (58.59 %) for acetaldehyde; 12.27 % (37.80 %) for acrolein, and 80.75 % (81.08 %) for valeraldehyde. Testing the stability by spiking the four kinds of aldehyde together into 2,4-DNPH tubes and keeping the tubes at 4°C, the result showed that formaldehyde-2,4-DNPH can be kept for six days without causing  $\pm 10$  % fluctuation in comparison to the initial recovery; acetaldehyde for 16 days; acrolein for five days; and valeraldehyde for 11 days. The acrolein derivatives were quite unstable at room temperature; it reached 27.95 % of its initial recovery by seven days. The breakthrough time of sampling aldehyde in a sampling tube was 240 minutes at 0.1 L/min for formaldehyde, 74 minutes at 0.01 L/min for acetaldehyde, 201.2 minutes at 0.1 L/min for acrolein, 114.6 minutes at 0.05 L/min for valeraldehyde. With respect to the sampling and analysis of acrolein, it was better to use the 2-(hydroxymethyl) piperidine method as indicated in the literature, since the instability of acrolein-DNPH derivatives resulted in low recovery. With the completion of this study, the standard operation procedure for sampling and analyzing

formaldehyde, acetaldehyde and valeraldehyde by utilizing the derivative technique of 2,4-dinitrophenylhydrazine is finally developed.

The study of the "Development of sampling and analytical method for airborne amines" was completed. Volatile amines (particularly methylamine, dimethylamine, and trimethylamine) are commonly used in various industries, therefore the potential for exposure is great. The major health effects associated with inhalation exposures to these amines include irritation of the upper respiratory tract, coughing, difficult in breathing, and even death in some severe cases. Contact with gaseous or liquid amines causes eye and skin irritations. Prolonged exposures may produce dermatitis and conjunctivitis. Presently, there is no analytical method for these three compounds recommended by the government of Taiwan. The purpose of the current research was to develop suitable methods for monitoring these amines. The US OSHA's method # 34 and 40, which utilize solid sorbent, derivatization and HPLC were adopted and evaluated for methylamine and dimethylamine. A new approach, which utilizes acidified filter, solid-phase microextraction (SPME) and GC/FID was developed to monitor trimethylamine. The result indicated that the newly invented method for monitoring trimethylamine, besides being efficient and simple to perform it was also very precise and accurate. Therefore, these two methods can be adopted as the reference method for analyzing amines.

The "Sampling and analytical methods for pesticide regulation by the Labor Acts (I)" was established. Sampling and analytical methods for 14 organophosphorus pesticides was developed. The sampling methods included airborne and skin pads as well as biological indicator detecting techniques. The analytical methods employed the use of glass fiber filter, combined filter/XAD-2, -cellulose pad and urine sampler with gas chromatography  $\gamma$  flame photometric detector (GC-FPD). The methods were evaluated

for 14 organophosphorus pesticides suited to risk assessment of workers in the pesticide manufacturing plants. This evaluation technique of the 14 organophosphorus pesticides developed by IOSH has now been applied on local airborne and skin pad samples for biological detection and analyzing methods. The results may serve as a reference for IOSH itself and IOSH administrative purposes as well as other related agencies and laboratories.

The project entitled "Sampling and analytical method for airborne hydrogen-containing chlorofluorocarbons (HCFCs)-field validation and survey" was completed. The effects of CFCs on the ozone layer may be the single greatest threat to the global atmosphere. The most likely substitutes for these halocarbons in industries are hydrogen containing chlorofluorocarbons (HCFCs). The most commonly used compound includes 1,1-dichloro-1-fluoroethane (HCFC-141b), substituting for CFC-11 in plastic foam-blowing and cleaning solvents. However, limited studies in animals indicate potential hepatotoxicity of some of this type of compounds. The object of this study was to develop a reference sampling method of HCFC-141b in the workplace atmosphere. The trace airborne HCFC-141b was sampled with charcoal tube, desorbed with methanol, and analyzed by gas chromatography with flame ionization detector (GC/FID). For sampling media capacity testing, when sample flow is at 30 ml/min, the average time of break through was 82.8 min. The average desorption rate was 97.11 % and the coefficient variation of analysis was 2.10 %. After storing at room temperature for seven days, the average recovery amount of samples was less than 90 %; after storing at 30°C for 28 days, it was 90.26 %. Field studies will be conducted in future research, and advice will be given to the employers for improving the work place environment and protecting the health of the workers based on the results of the field studies.

The project entitled "Multicomponent analytical method in PU artificial leather factory" was completed. The sampling and analytical

method was developed for actual field test of sampling for airborne multi organic compound found in three PU artificial leather manufacturing plants. Results indicated that 20 % (v/v) n-pantanol /CS 2 was found to be a good desorption solvent to simultaneously measure organic compounds such as dimethyl formamide (DMF), toluene, butylacetate (BAC), methyl ethyl ketone (MEK), acetone, and ethyl acetate (EAC) were easily found in the PU artificial leather production line. The three most common compounds found through the field tests at the plants were MEK, toluene, and DMF. It was hoped that this newly established operation procedure for the sampling and analysis for multi compounds in PU artificial leather factory may be standardized by the Council of Labor Affairs in the near future.

The evaluation of "Tenax-TA passive sampler with thermal desorption" was completed. Diffusive sampler and thermal desorption technique are widely used in environmental analysis. This study evaluated diffusive sampling tube in the industrial hygiene field. PE Tenax-TA sorbent tube with diffusion cap was validated in the field. Testing compounds included xylene, ethyl acetate, styrene, and n-butyl acetate. In four factories, 20 pair side-by-side personal samplings and two grouped area samplings were taken to compare Tenax-TA tube diffusive sampling/thermal desorption method with pumped charcoal tube/solvent desorption method. In comparison to personal sampling, these two methods have consistent results for ethyl acetate. However, for xylene, n-butyl acetate and styrene, these two methods have a positive or negative deviation. For xylene area sampling, some data showed no significant difference in these two methods. The grouped area data of the other three compounds showed significantly lower concentration by Tenax-TA tubes. The absolutes of relative biases between these two methods distributed from 9.7 % to 74.8 % in area samples.

The project entitled "Computer-assisted information management system for industrial hygiene accredited laboratories (I)" was

completed. One of the most important aspect of automating industrial-hygiene accredited laboratories is the establishment of the Laboratory Information Management System (LIMS). Data on staff organizing management, sample management, reagent management, equipment management, statistical analysis and analytical reports may all be simplified with the use of computer. Thus, efficiency and accuracy of research may be improved in the laboratories. Following the regulations on laboratory management outlined by the Council of Labor Affairs, LIMS was established to assist laboratories to raise the efficiency and accuracy of data handling. Once LIMS is installed, it will exceedingly reduce the amount of paper work and human resource and provide online data reduction and transfer as well as audit the quality of analytical data, reduce human error. LIMS can be used in sample management, data analysis, auditing, quality control, analytical report, staff training, and reagent, equipment, document, methods and other standard operation procedure organization. This system employs the concept of rational database. Data tables are linked by an index, avoiding redundancy in data entries while improving data tracking and auditing. MS SQL 7.0 was used for database management, which is located in MS NT4 operating system. The Windows-based client users were connected to the server via local area networks.

### 3. Evaluation and Development of Samplers and Sampling Media

The study on "Simultaneous sampling of acid gas and aerosol (II)" was completed. The purpose of this project was to continue testing and improving the personal denuder sampler (flow rate of 2 lpm) that was designed last year. Based on the drawback of the impactor, a new impactor with porous metal impaction surface had been designed and tested. The new impactor has a larger internal space between the nozzle and the impactor surface than the previous design, to prevent particle wall loss. Experimental

data suggested that the wall loss of the new cascade impactor was negligible, and overloading of collected particles on the impactor had been overcome. The cutoff aerodynamic diameters of the cascade impactor are 9.5  $\mu\text{m}$ , 6.7  $\mu\text{m}$ , 4.8  $\mu\text{m}$ , 3.2  $\mu\text{m}$ , and 2.0  $\mu\text{m}$  for stages 1 to 5, respectively. Wall loss for each stage was less than 10 %. The porous metal disc in the personal denuder sampler was used to sample acidic and alkaline gases. According to the study in the first year, the disc of 100  $\mu\text{m}$  in nominal pore size and 0.317 cm in thickness was suitable for sampling acidic gases. In addition to the porous metal disc, two different media, silica gel tube and impinger, were tested for comparing the gas collection efficiency and the collection capacity. The testing condition was 80 % relative humidity at 30°C at a gas concentration of 2 PEL. The data indicated that the gas collection efficiency was between 90 % and 100 % for the three sampling media for a four-hour sampling period. The adsorbing capacity was sufficient for the gas sampling in the workplace. The gas collection efficiency of porous metal disc was the highest compared to the first section of the silica gel and the first impinger. Using 5 % sodium carbonate/glycerin coating on the porous metal disc, the collection efficiency for  $\text{HNO}_3$ , HCl, HF were 91  $\pm$  0.9 %, 95  $\pm$  1.5 %, and 100  $\pm$  0.4 %, respectively. In summary, the personal denuder sampler outperformed the traditional samplers for acidic gas sampling in the workplace. With its compact size and capability of sampling gases and particles simultaneously in the workplace, it is worthwhile to promote its use both domestically and internationally.

The project entitled "Development of fibrous aerosol sampler" was completed. In order to perform the aerosol penetration test on the aerosol size selective devices and study the uniformity of the aerosol deposit on the filter, an ultrasonic atomizing nozzle was used to generate challenge aerosol particles (methylene blue). An Aerodynamic Particle Sizer was used to measure the number concentrations and size distributions upstream and downstream of the size selective devices. Both the precision and accuracy of

the samplers were analyzed and revealed as a function of particle size. In addition to the fit to the internationally defined respirable or thoracic convention, the filter deposit, after exposed to water vapor, was examined visually for uniformity. All the currently commercially available aerosol samplers and the devices developed in the present study were evaluated for not only the fit to the international standards but also whether the devices delivered a uniform distribution across the filter, which was critical to the fiber measurement method.

#### 4. Development of Biological Monitoring Techniques for Workers

The study on the "Method development for the biological monitoring of methyl isobutyl ketone exposure" was completed. Methyl isobutyl ketone is widely used as organic solvent in various industries in Taiwan. Urinary methyl isobutyl ketone has been recommended as a good biomarker of exposure to methyl isobutyl ketone. In this study, urine samples containing methyl isobutyl ketone was treated by the head-space technique, then analyzed by gas chromatography combined with a flame ionization detector. The optimal results were obtained when the heating temperature was 80°C, at a heating time of 15 minutes, and when 2.5 gm of potassium carbonate was added in the head-space sample pretreatment procedure. The correlation coefficients of 6 inter-day and 6 intra-day calibration curves of methyl isobutyl ketone were greater than 0.999 and the pooled coefficients of variance were less than 9.10 % over the concentration range of 0.16 to 25.60 mg/ml. Urinary methyl isobutyl ketone was stable for at least 22 days at 22°C. The limit of detection and quantitation was 0.024 and 0.082 mg/ml, respectively. The recovery of methyl isobutyl ketone was 95.80 ± 3.87 %. Urine samples from exposed workers demonstrated that the proposed method is applicable to real samples for field studies. It was therefore concluded that the proposed new method can provide a sensitive, simple and reliable method for

the biological monitoring of occupational exposure to methyl isobutyl ketone.

The study on the "Extent of absorption of and exposure to ethylene glycol monomethyl ether on human skin" was completed. Ethylene glycol monomethyl ether is one of the main solvents among the ingredients used in the semi-conductor manufacturing industry. However, the health risks ethylene glycol monomethyl ether pose on blood, reproduction system and growth have caused a great deal of concern in the international community. A technique that is able to assess the amount of ethylene glycol monomethyl ether vapor absorbed in the skin and present internally in the body was successfully developed in this study. This technique is direct, instantaneous, non-invasive, efficient, and totally automatic. The data from clinical tests on human indicated that the amount of ethylene glycol monomethyl ether absorbed through skin exposure is the main contributor to the total amount of ethylene glycol monomethyl ether absorbed in the body. The vapor of ethylene glycol monomethyl ether absorbed in the skin is much higher compared to the skin absorbency index of other commonly used organic solvents in the form of vapor in the industry. The technique developed and the experimental data obtained from this study may be used by the government as a way of enhancing the prevention of occupational diseases. The technique and the data can also be used to amend and improve the regulations and standards in the level of occupational exposure threshold to ethylene glycol monomethyl ether. Moreover, the data from this study can be used as a reliable and accurate source of comparison for future comparative studies on the assessment of workers exposed to ethylene glycol monomethyl ether.

The "Study on arsenic speciation with glutathione" was completed. In this study, high pressure liquid chromatography (HPLC) was used to separate arsenic species, namely As (III), As (V), MMAA, and DMAA in human urine samples. Glutathione (GSH) was used

to reduce arsenic compounds to trivalent species collected at the end of separation by a fraction collector. The determination of reduced arsenic compounds was then carried out by flow injection hydride generation atomic absorption spectrophotometry (HGAAS). GSH, composed of glutamate, cysteine, and glycine was found reducing arsenic species more completely, compared with previously used reagents such as KI or L-cysteine. The analysis could be conducted under low acid and low NaBH<sub>4</sub> conditions, thus low signal background and detection limits were obtained. The detection limits for As (III), As (V), MMAA and DMAA were 15, 45, 24, and 15 ng/l, respectively. This report demonstrated that optimization for analytical condition of arsenic speciation with GSH and the evaluation for method performance was possible.

#### 5. Development of Real Time Gas Surveillance Technology

The project entitled "Development of a new continuous monitor for workers exposed to hazardous gases" was completed. After 11 months of research, a multi functional personal organic gas and vapor continuous monitor for workers exposed to hazardous gases were developed. This monitor is equipped with semiconductor gas sensors, card size microcomputer and flash memory, among others. The monitor is capable of performing statistical analysis and real time display gas or vapor concentration, calculating mean concentrations in 15 minute intervals, and other commonly indicators used in environmental industries such as taking peak concentration measurements and average concentration measurements. In addition, the data obtained from this monitor may be saved on the microcomputer and then connected to a PC for continuing monitoring as well as for graphing purposes. Initial results indicated very little background electrical signal from the display monitor. If combined with a sensitive sensor, more precise concentration measurements may be taken. The monitor uses a rechargeable lead battery, and can be used continuously for four

hours straight. Future research is dedicated to prolonging the battery life. This monitor contains 11 signal input docks although only three had been used so far. The remaining eight may be connected to more sensors. Therefore this monitor has great expanding potentials. The monitor employed a flash memory, which can save 60 days of experimental data. The monitor is also compatible with a personal computer. All of these advantages make this monitor a better solution to exploring occupational exposures.

The research on "Fourier transfer infrared (FTIR) monitoring technique" was completed. Extractive FTIR, a computerized technology with the advantages of real time in situ detection, great sensitivity, and identification power has been widely used in gas monitoring. The USA EPA had officially recognized the technology of extractive FTIR as Test Method 320 in 1997. However, this document was not well developed and some important procedures were not given. Therefore, another standard method known as TO-16, which was much more specific but was designed for open-path FTIR users was also brought in to develop ROC standard methods of extractive FTIR technology. To have a better understanding of this technique, an extractive FTIR system was tested with a gas stream containing methane, methanol, chloroform, ethylene, acetone, ethyl acetate and perfluoroethane. The FTIR spectrometer used throughout this study was equipped with an 11-m gas cell, ZnSe windows and an MCT detector. Generally, the instrument was operated using 32 co-added scans at 1 cm<sup>-1</sup> nominal resolution and cosine apodization. The characteristics of FTIR such as resolution, RMS noise, detection limits, response time, precision, accuracy, calibration curve and sample spike were studied. According to the results, the detection limits of six compounds were below 1 ppm except 3.5 ppm for methane. Precision was less than 2 %, accuracy was among 85 % to 110 %, R square of calibration curve reached 0.997, and recovery of spike samples were between 85 % and 115 %. Toxic gases such as acids and bases were not included in this project. Furthermore, other FTIR quantitative programs such as PLS and ILS was not included either. To broaden the application of extractive FTIR, these

areas should be considered in future developments.

The project on the "Evaluation of gaseous chemical hazard in preventive maintenance process of ion implantation" was completed. A measurement on the hazardous gaseous environment created during the preventive maintenance of ion sampler used in wafer fabricators was conducted by using closed-cell FTIR and electrochemical gaseous hazard detecting system. The maintenance personnel tends to clean them by applying hydrogen peroxide and isopropyl alcohol that stirs up the adhered materials and creates hazardous gases. These transiently (30 seconds) maximum evaporated gases included 17 ppm of hydrogen peroxide, 325 ppm of isopropyl alcohol, 160 ppm of ethanol, 57 ppb of carbon tetrafluoride and unknown materials. The research showed that the exposure concentration of preventive maintenance is directly impacted by the tools or materials used in cleansing and by the use of ventilation equipment. Following are some recommendations: (1) Enhance ventilation system for ion source head chamber. (2) Use machines covered by ventilation hood in the ion source head chamber. (3) Perform preventive maintenance according to the operational standards.

### **III. Research on Occupational Hygiene**

Plans for occupational health research were aimed at protecting workers' health through recognition, evaluation, and control of the work environment, concentrating on surveying, preventing and controlling chemical, physical, biological, and ergonomic hazards, as well as at establishing research strengths. Besides joint efforts with inspection agencies such as the Department of Occupational Safety and Health, Institute and Department of Occupational Inspection for administrative needs, research projects for occupational hygiene for fiscal year 1999 expanded on those that were conducted in fiscal year 1998. In addition, issues that arise from

occupational hygiene, the status of occupational environment, and difficulties in improving occupational hygiene were examined both locally and in other countries. Furthermore, information on risk factors and biomechanical data, applying anthropometry and engineering control methods in the work environment was also gathered, with emphasis placed on the recognition, control, and protection in specific operations. The following are categories of research in Occupational Hygiene:

1. Survey of Exposure to Occupational Hazards
2. Prediction Models and Control of Hazardous Substances and Noise in the Work Environment
3. Study of Occupational Hygiene Protection Equipment and Measuring Instruments
4. Evaluation and Control of Ergonomic Hazards
5. Control of Occupational Musculoskeletal Diseases

Significant methods and research results for fiscal year 1999 are as follows:

1. Survey of Exposure to Occupational Hazards

The goals in this category include 1) controlling the severity of chemical hazards; 2) controlling the exposure population; 3) understanding the status of occupational hygiene in each industry, based on the newly implemented regulations on occupational hygiene; 4) establishing current status on various exposures to hazards in the work environment in Taiwan; and 5) understanding the actual awareness to occupational hygiene of the workers themselves. The results of these studies may be used as a reference in the future for amending policies in occupational hygiene and regulations in the inspection of occupational hygiene.

The "Occupational chemical hazard survey (III)" was completed. The focus of this research was on exposure to hazardous chemical risk factors. The chemicals investigated were ones listed according to the permissible concentration standards for airborne hazardous chemicals in the occupational environment set by the Council of Labor Affairs. The industries investigated were among the ones included within the regulations of industrial occupational safety and health. In this study, only chemical exposure agents were investigated. All investigated data were further analyzed to obtain the Exposure Hazard Index (EHI) and Exposure Hazard Rating (EHR) to evaluate the exposure hazard potentials and exposure hazard situations for individual industries. This survey program was designed as a three-year project. The first year (1997) of research focused on the development of an appropriate methodology and was dedicated to preparation work and small-scale trial survey (~ 19 % of total investigated companies). Large-scale field surveys were conducted during the second (1998) and third year (1999) of research (~ 43 % and 38 %, respectively). In addition, in the third year, the supplementation and organization of data was further analyzed, especially for the calculating of EHI and EHR values for each investigated industry. Some of the more concrete results of this project include 1) compilation of an occupational exposure risk investigation form and its handbook; 2) training of participating investigators; 3) establishing a regression model for EHI and EHR; and 4) investigation of 119 occupations in 2,962 business enterprises. According to the results, there were 2,402 types of raw material used in the industries investigated. Among them were 842 products containing raw materials with toxic substances. Within these 842 products, there were 105 species of hazardous chemicals and 134 dangerous substances in total. With regard to workers' exposure conditions, the overall EHI and EHR were 12.12 and 96, respectively. The top three industries with the highest EHI were the data processing and storing equipment industry, oil refinery industry, and paints and relative products manufacturing industry, of which the EHI were 51.36, 41.79, and 34.25, respectively. The high EHI value was significantly

related to the unique quality of the industry itself, the complicated nature of production, and the types of hazardous substances used. Therefore, due to the high EHI values for the three aforementioned industries, the inherent potential for danger is also large. Based on the EHR regression, the oil refinery industry had the highest EHR (EHR = 854), followed by cotton / textile industry (EHR = 745), followed by battery manufacturing industry (EHR = 496). The EHR values were significantly associated with EHI values, although they were not exactly the same, mainly because the number of exposed were taken into consideration in calculating EHR. The three industries with the highest EHR were ones with a greater number of exposed workers. After making adjustments for EHI and EHR for all the industries investigated, the top ten industries in order of the severity of chemical exposure hazards were: 1) oil refinery industry; 2) data processing and storing equipment industry; 3) paints and relative products manufacturing industry; 4) telecommunication equipment manufacturing industry; 5) battery manufacturing industry; 7) cotton / textile industry; 8) electronic component manufacturing industry; 9) home appliance manufacturing industry; and 10) artificial fiber, synthetic resin, plastic and rubber manufacturing industry. The results of this study may be used to establish a more complete nation wide workers' chemical exposure data bank. The results may also support the related governmental agencies to enact the National Labor Inspection Guideline and direct future researches in the field of occupational hygiene.

The survey of "Employees' perceptions of safety and health in the work environment" was completed. This project collaborated with the survey of "Human Resources" in the Department of Statistics of the Executive Yuan in September of 1998, gathering data from 85.11 % of the subjects in a sample population of 18,120. The following results are shown in terms of extrapolation to the sample population.

1. Source of knowledge in occupational safety and hygiene: advertisement agencies in the category of "education and training centers at work" ranked highest (41.52 %); television (50.39 %) and newspaper (40.56 %) were the highest in the category of telecommunication media.
2. Education and training in occupational safety and hygiene: 46.75 % of the employees had employers who had arranged education and training courses in occupational safety and hygiene when they started to work; 58.40 % of the employees had been notified prior to starting work of the potential occupational hazards.
3. Physical examination: Of the 37.26 % employees who had a physical examination prior to working, 42.29 % of the employers had paid for the physical examination. Thirty-three per cent of employees have had regular physical examinations during their work term. Among these, 50.98 % reported "very satisfied" and "satisfied" with the physical examinations provided by the individual industries, whereas 10.28 % reported "not satisfied" and "very unsatisfied" with the physical examinations. The main reason for the dissatisfaction was that the examination was too sloppy, and items examined were too few.
4. Hazards in the work environment: the percentages of the employees perceived the ensuing conditions existed in the work environment were as follows: 19.83% "cuts and abrasions"; 19.49 % "slips and slides resulting in falls" in the work environment; 26.61 % of the employees felt that the work environment was very dusty; 6.89 % believed that lead was used at the work environment; 19.48 % reported chemical compounds were used at work; 25.38 % thought the work environment was very loud; 6.30 % felt that there was inadequate (natural) air circulation space in the work environment; 36.19 % felt that there was a need for safety or health protection equipment. Of these, 56.04 % felt that respiratory equipments were needed.

Just the percentages of the manufacturing industries' employees perceived the ensuing conditions existed in the environment were

as follows, 29 % "cuts and abrasions"; 19.40 % "compressed or rolled" (by machinery); 33.58 % felt that the work environment was very dusty (mostly due to metallic dusts); 12.79 % believed that lead was used in the work environment (mostly from solder); 30.31 % believed that chemical compounds were used in the work environment (mostly chemical solvents), in which 24.30 % knew that there was no MSDS at work; 26.02 % knew that there was MSDS at work, and 49.68 % were not sure if there was or was no MSDS at work; 40.37 % reported of very loud work environment (mostly of continuous nature) as for whether the volume of the noise would deteriorate hearing, 34.90 % believed that hearing would be deteriorated from the loud noise; 6.18 % felt that the (natural) air circulation space was inadequate (mostly due to enclosed basement and ovens); 48.04 % believed that safety or health protection equipment was needed; of which 61.12 % felt that breathing masks were needed.

1. Feeling of illness and its treatment within the past year: 11.96 % of employees believed that they have some kind of skin disease; of which 31.5 % thought it was work related. 17.9 % of employees felt ill with their eyes; of which 39.26 % thought the illness was work related. 7 % of employees felt ill with their ears; of which 35.25 % thought the illness were work related. 13.21 % of employees felt ill with respiration; of which 24.93 % thought the illness was work related. 6.51 % of employees felt ill with their heart; of which 23.62 % thought the illness was work related. 9.9 % of employees felt ill with their digestion system; of which 22.34 % thought the illness was work related. 11.34 % of employees felt ill with their nerves; of which 27.73 % thought the illness was work related. In general, 51.61 % of employees felt soreness and pain in their body, mostly in the shoulders and the neck; of which 39.78 % thought the illness was work related. 41.93 % of the employees who had reported any of the above illnesses had sought treatment from western and/or Chinese doctors.
2. Experience of work pressure and its treatment: 9.25 % of the employees felt pressured by work which resulted in anxiety.

50.72 % of the employees felt pressured by work without feeling anxiety. The main sources of pressure or anxiety include problems with benefits, salary, future development at work, or work itself. Treatment to relieve anxiety included resting, sleeping/napping, walking, and exercising.

3. Knowledge about the company:

1. 24.71 % of the employees thought that the company is well prepared in hazard prevention. 6.27 % of the employees perceived that the company is ill prepared, of which 14.6 % of the employees came from the construction industry.
2. 48.71 % of the employees perceived that the company has policies which state that the company should be actively preventing the employees from getting into a traffic accident. The most common action taken by the company is verbally cautioning the employees to watch out for their safety, and urging them to not drink and drive.
3. 44.46 % of the employees believed that the company performs self-inspections regarding occupational safety and health, of which 77.91 % are employees from the power/energy/fuel-gas suppliers.
4. 79.05 % of the employees believed that the work place is set up with fire extinguishing system, of which 97.33 % are from power/energy/fuel-gas suppliers. Also, 57.14 % of these employees believed that fire extinguishing system would be used at one time or another.
5. Responding to the question on occupational safety and health, 39.67 % of the employees felt that there are no problems in occupational safety and health, or that the problems are not major; 8.09 % felt that they have no one to respond to even if they had a problem with occupational safety and health, or that if they did have someone to respond to regarding problems in occupational safety and health, that nothing would be done. If response to problems regarding occupational safety and health

is needed, the most likely person the employees turn to is the firstline supervisor.

6. 47.58 % of the employees believed that the company cared a great deal and did care (two choices) for the prevention of occupational hazard.

#### 8). General thoughts

1. Concerning the comfort level of the work environment, the ratio of very comfortable to comfortable is 43.9 %.
  2. Concerning the satisfaction level of occupational safety and health, the ratio of very satisfied to satisfied is 42.99 %.
  3. Who should be responsible for occupational safety and health? 55.06 % of the employees felt that the employers should be responsible for occupational safety and health. Government agencies were the next choice at 19.31 %.
  4. Concerning necessary improvements in occupational safety and health in the work environment, 46.61 % of the employees believed that there is a need to improve the problems in safety and hygiene. The main problems that needed improvement are in the following order: pollution, noise, temperature (too cold or too hot).
- 
1. Compared to similar surveys in the past, regular physical examinations have increased in the work place. But compared to companies with a staff of 10 or more in Japan, the frequency of regular physical examinations is 84.4 %. Therefore, although the promotion of physical examination in workers is effective, there is still room for improvement.
  2. Compared to similar surveys in the past, the satisfaction level of the employees regarding occupational safety and health in the work place, it is obvious that the work place has improved a great deal with respect to occupational safety and health. Also, workers are becoming more demanding for occupational safety and health in the work place. Therefore, in addition to

focusing on issues of hazard prevention, other issues such as the temperature in the work place, ergonomics and other issues involving comfortable levels should not be overlooked, so that the employees' satisfaction levels regarding the work environment may increase.

The study on the "Reporting system for surveillance and management of needle stick injury in health care workers" was completed. In order to effectively protect health care workers from accidental needle stick injuries and the lack of post injury treatments, it was necessary to establish a reporting system for needle stick injuries in Taiwan. Based on the five years of treating needle stick injuries and reporting experience of EPINet, the Office of Public Safety at Chong-He Memorial Hospital and the Center for Prevention of Occupational Diseases of the Kao Hsiung Medical College, a reporting form and system called "Needlestick Injury Surveillance Program" was designed and computerized. Besides the content in EPINet, several other pieces of information were added: 1) must knows in needlestick injury prevention and treatment (based on the handbook of occupational needlestick injury prevention by the Council of Labor Affairs); 2) procedure for treating general injury caused by sharp objects; 3) follow-up timetable for the injured patient in the injury report; and 4) the source and occurrence of injury as well as the general personal data of health care workers who were injured. Assessment results from the field test of this reporting system showed that, based on occupation, that interns were most likely to fall victim to needlestick injury (0.9 person times on average). The next work categories were laundry room workers (0.56 person times), followed by clinical nursing attendants (0.54 person times), and cleaning staff (0.38 person times). The six-month reporting rate for these workers was 30.8 %, 0 %, 23.6 %, and 20.0 %. Therefore, special education on prevention and protection practices and reporting should be provided for laundry room workers, as they may be the least likely to know the importance of reporting and treatment and the severity of the injury. Interns were the most likely to suffer from needlestick

injuries and they lack the assurance of having medical insurance. The U.S. would have been the best choice for demonstrating the needlestick reporting system; however, of all the health care workers they had the lowest reporting rate. Therefore, it is obvious that not only are the reporting system itself and the procedure of treatment important, continuing the hygiene education and promotion are also vital. Unnecessary occurrence of diseases may be avoided when the reporting system is effective, allowing the injured workers to receive a complete follow-up treatment. Through the data gathered in the reporting system, ways of improvement may be developed to eliminate future injuries. It is recommended that the management, education and promotion of the reporting system be listed as one of the agenda of inspection when occupational inspection agents inspect teaching hospitals. The 29th regulation of the occupational safety and hygiene act may be considered to be applied on reporting needlestick injury as non-disabling occupational incident in order to effectively improve the situation. It is also recommended that at each health or rehabilitation clinic that at least one physician with expertise may be responsible for treating and reporting needlestick injuries. With the involvement of physician, the treatment and reporting of needlestick injuries may be more effective. The basic common sense should be published in nursing or medical publications, and occasionally posting domestic and international special cases to raise public awareness for needlestick injury prevention, so that the health care workers may protect their own health and rights.

The study on the "Application of extreme temperature exposure hazard assessment predictive models" was completed. The aim of this study was set out to use the empirical heat hazard assessment model, which was developed on the basis of worker's physiological measurement results, to assess the feasibility of current standards as regulated in Taiwan and recommended by ACGIH. The measurement of WBGT values was conducted at three workplaces of two textile dyeing plants, and two workplaces of two steel casting plants. In addition, a total of 79 workers selected from the above four plants were involved to measure their heart

rates simultaneously, which were further used to estimate the metabolic rates ( $M_{HR}$ ) of each selected worker. The result showed that the allowable exposure times ( $AET_{HR}$ ), which were estimated by applying  $M_{HR}$  to the empirical heat hazard assessment model, were inconsistent with the allowable exposure times ( $AET_{PEL}$ ) which were regulated by the current standards in Taiwan. On the other hand, the allowable exposure times ( $AET_{TLV}$ ) as suggested by ACGIH showed a consistent pattern with the corresponding  $AET_{HR}$ , which indicated that the ACGIH standard recommended might be more feasible to protect workers from thermal hazard than the current Taiwan standard. It should be noted here that the empirical heat hazard assessment model was developed based on experimental data obtained from workers at dry heat workplaces. However, the consistent finding in this study suggested that the above model can also be applied to workers at wet heat workplaces (i.e., textile dyeing plant).

To support the above finding, it was suggested that the empirical heat hazard assessment model for workers at wet heat workplaces should be conducted in the future. Since as suggested by ISO-8996 that the metabolic rate ( $M_{table}$ ) obtained by referring to tables based on worker's work pattern, posture and work speed can be used to replace  $M_{HR}$  with the equivalent accuracy on measuring workers' metabolic rate, the difference between  $M_{HR}$  and  $M_{table}$  was also examined in this study. The results showed that  $M_{table}$  values were found to be consistently higher than  $M_{HR}$  for workers selected in this study, which indicated that the use of  $M_{table}$  might lead to over-protections for workers exposed to heat stresses. To put worker's metabolic rate estimation on a more reasonable basis, this study suggested that the estimation based on heart rate measurements could be used to replace the current table referring method in the future.

The evaluation of "Fungal exposure among onion workers in southern Taiwan" was completed. This project started as a result of

seven onion workers in the region of Monsoon were affected with a corneal fungal infection. The purpose of the study was to investigate the relationship between onion harvesting and corneal fungal infection. The samples were divided into two onion-growing exposure groups: Kao-Hsiung Lin Yuan as the non-Monsoon region, and Pin Tong Feng Kang, Che-Cheng, Heng Chuan as the Monsoon area, representing the onion-growing land, and Fang Liao (county) market and Fang Liao ring-apple farm as the control groups. Before, during, and after the harvesting season, fungi in the air were collected ~80 cm above the ground at the chosen sampling sites, using the Andersen Single Stage Fungal Sampler. Fungi in the air were collected in Sabouraud dextrose agar (SDA) and in SDA with 40 mg/ml of chloramphenicol (SDAC). The surface soil, onion peel, as well as onion leaves at the sampling site were also collected. Samples were quantified at the laboratory and transferred on top of Malt extract agar (MEA), incubated at 25 °C for 4 to 7 days. The number of fungal colonies and type of genus were recorded. The temperature, relative humidity, and wind speed were also recorded at the time of sampling. Samples in both SDA and SDAC showed that regardless of the time of sampling (i.e. before, during, or after the harvesting of onions), highest concentration of fungi was found in the non-Monsoon region, followed by Monsoon region, and the control groups. Furthermore, microbe concentrations significantly increased during harvesting season. There was no significant difference in microbe concentration whether the fungi were collected on SDA (n=325) or SDAC (n=353) ( $p = 0.46$ ). Cladosporium was the major microbe in the air collected before and after the onion harvesting season in all regions. During the onion harvesting season, the concentrations of Aspergillus, Fusarium, Acremonium, Alternaria, Penicillium, Monilia, Mycelia, and Rhizopus increased significantly, and Aspergillus was the major microbe in the Monsoon region.

The major microbe in the soil from onion farms and on onion peel was Aspergillus, while the major microbe on onion leaves was Alternaria. It has been documented that the fungi whose concentration increased significantly, such as Aspergillus, Fusarium,

Acremonium, Alternaria and Penicillium, can cause fungal corneal infection. Based on the results of this study, the reported cases of onion workers infected with corneal infection were concentrated in the Monsoon region. Although the concentration of fungi in the air in those regions was not as high as that of non-Monsoon regions, the strong wind specific for the Monsoon region had caused the fungal spores and the onion peels to disseminate everywhere, resulting in the workers cornea being scratched by onion peels or other objects. As the cornea were injured, the likelihood of highly contagious microbial spores entering the eyes increased. Therefore, cases of fungal corneal infection were centralized in the Monsoon region.

< the in fungi of amount great a was there season, harvesting onion during that demonstrating sites, re-packing outdoor and site gathering Chun Heng region obvious most This region. regardless air, increased concentration >

In addition to the increase of the overall concentration of the fungi, aerial fungi that may lead to fungal corneal infection include: Aspergillus, Fusarium, Acremonium, Alternaria, and Penicillium. The increased levels of these fungi pose a potential threat to the outdoor onion workers. Medical resources are usually limited in the Monsoon region of onion farms, therefore workers infected do not always receive proper treatment in time. Since the air contains severely contagious fungi, such as Fusarium, it is highly advised that during the onion harvesting season, that in order to prevent fungal corneal infection, that onion farmers and hired hands when working on the farm and gathering and packing sites to wear protective goggles. It is also suggested that the workers be aware of personal hygiene, that they try not to rub their eyes while working, in order to prevent corneal injury. Medical attention should be sought immediately once the workers felt something wrong with their eyes, notifying the physician of the possibility of contracting occupational fungal infection. Finally, the regional medical personnel should be educated on fungal corneal infection to avoid

delayed medical attention, leading to loss of sight, which could have been prevented.

## 2. Prediction Models and Control of Hazardous Substances and Noise in the Work Environment.

Research is focused on the proposal of prediction models and control technologies for environmental hazards using theories on industrial hygiene and practical experiences. Theoretical and practical studies on local ventilation, general ventilation, and noise control were conducted in this area. In addition, special topics and proposed control measures on dangerous operations in industries were studied.

The study on "Effect of cross draft on the capture zone of a flanged circular hood" was completed. The cross draft is a deterministic factor to the performance of a hood in an open atmosphere. To study the extent of influence of a cross draft on a hood, a flanged circular hood was placed in a wind-tunnel-generated cross draft. Both the smoke-streak flow visualization and laser Doppler anemometer measuring techniques were employed to probe the details of the flow field. The focus of study emphasized on the capture zone, dividing streamline, and parameters for hood design. An eye-viewed smoke-streak technique was developed and proven to be appropriate for in-situ diagnostics. The measurements of laser Doppler anemometer resulted in a series of formula which were definitely convenient for the design of the hood size, suction capacity, and position of the contaminants. The study also offered a corner stone for the applicability of the finite opening potential flow theory to the computation of the flow field of an exhaust hood.

The project on "Safety and health improvement in lead work place" was completed. According to the data from literature in the

most recent seven years, 54 % of personal lead exposure were higher than the permissible limit of the Council of Labor Affairs in lead battery (LB) factories. By means of walk through survey, monitoring and ventilation control, this project intended to identify and control lead hazard sources in the work place. LB manufacturing has front-end and assembly processes. Front-end process includes tasks of lead powder grinding, lead-acid paste mixing, grid paste-up, plate drying/collecting, casting, plate cutting, plate brushing and formation. Assembly process includes tasks of plate insulation, electrode connection and cell-in.

Six factories were assisted on-site, four of them had completed the manufacturing processes. One factory had only front-end process excluding lead powder grinding, and the other one had only the assembly process. There were 242 samples collected using personal exposure and area sampling. Results indicated that personal exposures were lower for more enclosed machines as compared to similar production quantity and processes. Nine designs of local ventilation were recommended for the tasks of lead-acid paste mixing, plate drying/collecting, plate cutting, plate brushing, plate insulation, electrode connection and cell-in, which emitted relatively concentrated lead and its compounds. Engineering improvement designs included enclosure guarding, hood modification, machine enclosure enhancement and machine automation. All recommendations for local ventilation were closed or enclosure related.

After six months of assistance, 34 % of worker's exposure reduction was achieved for the cell-in task if slot hood was implemented. Auto plate cutting machine also reduced 66 % of average personal exposure, from 0.715 to 0.26 mg/m<sup>3</sup>. However, exposure was still higher than the permissible limit, 0.1 mg/m<sup>3</sup>. Free-welding formation task reduced 88 % of exposure, from 0.273 to 0.032 mg/m<sup>3</sup>. For management practice, frequent filter cleaning would reduce airborne lead from 0.037 to 0.026 mg/m<sup>3</sup> at the outlet of

air conditioner.

In summary, those six factories invested \$ 5.6 million NT for engineering improvement so as to reduce worker's lead exposure concentration by 55 % in this project. The percentage of worker's TWA exposure exceeding the permissible limit was also reduced from 62.5 % to 25 %. It was concluded that on-site safety and health assistance scheme should be set-up for medium and small size enterprises. Interaction simulation of large- scale ventilation design and workers' movement/operation should be carried out to demonstrate the effectiveness of engineering control. Control for secondary pollution and fugitive emissions of automation machine as well as surveillance for secondary abnormal health workers should also be further studied.

The study on "Particle size in refractory brick manufacturing" was completed. Products of refractory brick manufactories in Taiwan are generally molded refractory bricks and non-molding refractory slurry. Manufacturing processes of molded refractory bricks include crushing and pouring of raw materials, mixing, molding, drying, burning, cooling, and packaging. Manufacturing processes of non-molding refractory slurry included crushing and pouring of raw materials, mixing, and packaging. The highest source of dust was pouring, mixing, and crushing; in particular, the material pouring stage. According to the IOSH 1998 study of seven refractory brick manufactories, the concentration of respirable particulate in the area sampling was between N.D. and 1 mg/m<sup>3</sup>. As for exposure to free silica, the primary worker free silica exposure area was raw material area, then the mixing and crushing area, then the molding area. In order to understand the worker exposure levels to particulates, particulate diameter distribution, and to provide suggestion for the use of personal protection equipment, this study focused on inhalable particulate sampling, personal sampling of respirable particulate, and Anderson sampler in a refractory brick manufactory in Taiwan. For the Anderson sampler, results showed

that MMAD was between 7.78 and 15.01  $\mu\text{m}$ , most of them being thoracic particulate. Diameter of the particulate was in the order of crushing > packaging > molding > mixing. After the study on the particulate diameter distribution, it was recommended that workers use N95 series single filter / quarter facial or double filters / half facial dust protection mask. For inhalable particulate, the worker's personal exposure was in the order of packaging > mixing > weighing > molding > forklift drivers; the particulate concentration was 50.98, 32.74, 12.76, 4.78, and 4.08  $\text{mg}/\text{m}^3$ , respectively. These results far exceeded the regulation set by the US NIOSH. For respirable particulate, the workers' personal exposure level was in the order of mixing > packaging > forklift drivers > molding > weighing; the concentrations were 5.84, 2.5, 1.5, 1.41, and 1.14  $\text{mg}/\text{m}^3$ . If these levels were assessed under the fourth category of nuisance dust compared to the working environment airborne hazardous material PEL of Taiwan labor regulations, then most of the levels met the regulation limit of 5  $\text{mg}/\text{m}^3$ . However, if these levels were assessed under the second category of silica containing dust, then the levels would have far exceeded the regulation limit of 1  $\text{mg}/\text{m}^3$ .

The study of "Local ventilation system in semiconductor factories" was completed. After an investigation on semiconductor fabs, it was clear that there would be a high concentration of hazardous chemicals in the preventive maintenance (PM) procedure of metal etching machine. According to the former result, it was discovered that there would be a high concentration of hydrogen chloride when the operator wiped the reaction chamber with isopropanol or DI water, of which the concentration was above the C-value (5 ppm). If the gas containing nitrogen atom was used as a processing gas, it would generate hydrogen cyanide during the procedure of PM, which would result in a C-value of more than 10 ppm. Therefore, this project was intended to study the effect of using a high speed, low volume local ventilation system to control for the hazardous substances in the semiconductor work place. The advantages of this kind of local ventilation system were cost efficiency, good control of velocity, relatively small size of the system,

and low makeup air requirement. It was especially suitable in the semiconductor manufacturing factory. The ideal local ventilation system was based on the concept of low volume and high speed. The efficacy of this system was evaluated, and the data showed that good control can be obtained with low energy consumption.

The study on "Noise status in semiconductor factories" was completed. The purpose of this study was to establish a database for noise levels in semi-conductor plants. In order to understand the occupational working environment in each division of the manufacturing process, sampling and analysis were performed at the semi-conductor manufacturing factories. Long term exposure to noise not only lead to hearing loss, it also negatively effects the cardiovascular circulation system, digestive system, and the endocrine system. Long term exposure to noise can also lead to high anxiety and irritability.

Noise problem is prevalent in factories everywhere, since noise ensues as soon as the machines are turned on. Semi-conductor industry is in the booming high-tech industry. A lot of human resources and technology is poured into the manufacturing of semi-conductors. Investigation on noise levels of each division of the production procedure of semi-conductors was necessary in order to understand whether the risk of noise induced hearing impairment for the workers.

Research results indicated that the noise level in all of the production procedures in the clean room of semi-conductor plants was less than 80 dBA (65.5 ~ 78.6 dBA). The noise level for the packing testing division ranged between 71.9 and 81.2 dBA.

Although the noise levels were within the regulation of occupational safety and health, and the results of physical examinations for the workers have shown that the workers' health was also within the workers' health protection regulations, still, in order to protect

workers from suffering a hearing loss due to occupational exposure, it was recommended that a hearing protection promotional plan to be carried out in industries where the noise level is greater than 76.0 dBA. It is also recommended that in areas where the noise level is above 85 dBA, such as in factory furnace rooms and places where vacuum pumps are used, warning signs of high noise level be posted. Noise preventive equipment to be used by workers and the promotion of noise-related education and training are also recommended.

There are four shifts and two rotations, with each shift being 12 hours in the semi-conductor production industry. Since the working hours differ from the traditional working hours of eight hours on which the standard hearing loss threshold was based, in order to get a better evaluation of risk factors for workers in the semi-conductor industry, a new hearing loss threshold based on 12 hours of exposure was necessary.

Some of the semi-conductor factories provide annual hearing examinations for workers in order to monitor and prevent the loss of hearing. Results indicated that most of the noise levels to which workers in the clean room (not including special hazardous working environments) were exposed were below the hearing loss threshold. Therefore, if a baseline of hearing test was established prior to the commencement of work [for workers in the clean room] to determine whether special hearing examinations are required, and found that special hearing examinations were indeed not needed, then the expenses for regular hearing examinations can be transferred to other jobs for improvement and management purposes.

### 3. Study of Occupational Hygiene Protection Equipment and Measuring Instruments

Research focused on factors which may affect the performance of labor safety and health protection equipment, formulation of a domestic test specifications and technologies. Calibration of labor safety and health measuring apparatus of inspection organizations was also included in the research.

The evaluation of "Evaluation of filter test requirements" was completed. In practice, a good filter should have high collection efficiency for aerosol particles and low mechanical air resistance allowing air to flow through it. Because of the limited capacity of the human respiratory system, one of the essential properties of the filter media to be used for respiratory protection is low air resistance. Low packing density, small filter thickness, and large fiber diameter all lead to low air resistance, but they also give rise to high aerosol penetration, which is a conflict with the filter test requirements. Hence, a search for the optimum/balance between these two needs is important and interesting.

The new certification requirements for respiratory devices (42 CFR Part 84) was promulgated by the National Institute of Occupational Safety and Health, USA, in 1995. The new rule, which is now more parallel with the European standard, EN149, aimed to enable respirator users to select from a broader range of certified respirators, and to expedite the incorporation of technological advancements. The size distributions of the challenge liquid and solid particles specified in 42 CFR is quite different from that of 30 CFR, and is slightly different from the European requirements. Therefore, the most penetrating size of the new products (certified under the new requirements) and old product (certified under the old rules) were thoroughly investigated in this project. The flow rates ranging from 10 to 100 L/min, simulating different workloads were employed to study the flow dependency.

Filter media of different properties were tested for their filtration efficiency and air resistance. The filter quality indicator was used to

judge the performance of the air-purifying respirators. The filtration mechanisms, including changes of the most penetrating size, were theoretically and experimentally examined. To conduct the filter performance test, a constant-output aerosol nebulizer was used to generate submicrometer-sized particles. An ultrasonic atomizing nozzle was used to generate micrometer-sized particles. A 10-mCi Krypton-85 radioactive source was used to neutralize the particles to Boltzmann charge equilibrium. A Scanning Mobility Particle Sizer was used to measure the aerosol penetration for particles smaller than 0.6  $\mu\text{m}$ , and an Aerosizer or Aerodynamic Particle Sizer (APS) was used for measuring aerosol penetration for particles larger than 0.6  $\mu\text{m}$ .

The results showed that the determination of the best size distribution of challenge aerosol particles was a complicated process, because many factors such as the characteristics of the penetration curves of the tested particulate respirators, the test flow rate, and even the measurement methods, all had influence over the aerosol penetration. In theory, monodisperse challenge aerosol with the size at collection minimum was ideal for it leads to the highest penetration value. The performance of the respirator filter was found slightly degraded due to long term storage. The results of loading test showed that, when challenged with solid test agent, the air resistance increased linearly after the cake formation point and the aerosol penetration decreased with loading time. The rise in pressure drop across the filter was relatively insignificant when challenged with liquid DOP aerosols, but the aerosol penetration may increase to a level that fails to meet the filter test requirement.

Regular calibration of occupational safety and health measuring apparatus for occupational inspection agency was completed. A system and technology of apparatus calibration was developed to calibrate the measuring apparatus in the occupational inspection agency. Both the accuracy and the precision of the apparatus were ensured, reflecting optimal status of the occupational

environment. The end result was used as a reference for inspection and improvement of the occupational environment. The apparatus calibrated in the fiscal year of 1999 included 70 photometers, 128 sound level meters and noise dose meters, one wind tunnel, and 36 wind speedometer.

#### 4. Evaluation and Control of Ergonomic Hazards

The research focused on review of foreign documents and current conditions in the local work environment. Application of anthropometric data of domestic workers and relevant ergonomic information, study of countermeasures to resolve ergonomic problems in the local work environment were also examined. The objective of the study was to prevent ergonomic-related hazards, increase work efficiency and improve comfort in the work environment.

The project entitled "Design and guidelines on a safe and healthy man-machine interface - a study of computer simulation on the working space" was completed. It is important and necessary to reduce the musculoskeletal injuries of workers from work sites. If the work space can be simulated in advance to evaluate the interactive relations between workers and machines, the above problems can be solved and the cost can also be saved. In this project, a computer simulation system on human modeling (Human Sim) was developed.

A 3-D 16-segment human model was constructed with the use of object function. The relation of motion of inter-segments was the characteristics or constraint of the object function. The anthropometric data were applied by IOSH anthropometric database, or input by users. In this study, three postures (erect, sitting, and kneeling) were developed in workspace simulation and the related

mathematical formula were derived. In VDT simulation, some items?the viewing distance, the motion of upper and lower limbs?were simulated.

The project entitled "An anthropometric evaluation on semiconductor manufacturing equipment" was completed. This investigation focused on the dimensions of the equipment and apparatus in the semiconductor manufacturing plants and related industries using the anthropometric database. The current standard in equipment dimensions was also assessed to see whether these standards were truly suitable for the needs of the workers. The result of the investigation showed that the majority of the height of most operating table surface is 90 cm from the ground; with the addition of the wafer box the height became 111 cm. It was found that the range of the elbow 30° above and 15° below was between 80 to 119 cm. The height of the table and the wafer box was within the working range for up to the 5th percentile of female and 95th percentile of the male workers. This means that the working height is within a suitable range for the workers.

From the results, it was clear that the main causes for musculoskeletal disorders were not due to the sizes or height of the machines, but the long hours of standing and walking. It was found that long hours of standing were more stressful for the plant workers than the office workers by 36 hours of biomechanical field tests. The average time for the standing was 7.25 hours a day for plant workers 1.0375 hours per day for office workers. The difference was significant ( $t = 16.356$ ; confidence level was 5.3533 to 6.1130) at  $\alpha = 0.05$  by using t-test. The average steps for the plant workers were 1298.942 steps per hour and 430.1172 steps per hour for the office workers. Again, the difference was significant ( $t = 7.681$ ; confidence level was 658.44 to 1079.22) at  $\alpha = 0.05$  by the t-test. The results showed that the standing time and walking frequency in plant workers were much higher than the office

workers, and the level of stress had the similar result. Therefore, with long term accumulation, plant workers will suffer musculoskeletal fatigue and injury.

The "Ergonomic study on personal lifting aids for trucking task" was completed. Lifting is one of the commonly used methods in transporting objects from one place to another in everyday life as well as at work; it is also the main leading cause of occupational lower back pain and injury to the musculoskeletal system. Since traditionally manual lifting is still the most common way of material handling, the designs to protect workers during lifting remains the primary focus in ergonomics research in occupational safety and health.

Some believe that back belt has a greater protective effect on the lower back by lessening the load on the back muscle. However, others believe that back belt does not lessen the load on the back muscle and the lower back. It may even lead to negative health consequences by restricting blood circulation and respiration. However, use of back belt can cause a rise in topical temperature leading to the feeling of discomfort. Therefore, there is still not a single convincing evidence showing that lifting with the back belt will prevent the onset of lower back pain. Although lifting belts had not been shown of their effects, industry does need a way of protecting the workers from lifting overexertion. The present study attempted to develop a new lifting belt with a different mechanism. The belt's effect on the reduction of hand and back muscle activities was investigated. The result indicated that the use of the belt reduced the erector spinae EMG activity. It was showed that such a reduction did not come from the increase of intra-abdominal pressure when wearing the belt. When using the belt, it was advantageous to free the hands for other uses. The belt can be helpful for material handling operators in situations where small carts were difficult to use due to space limitations. The study

recommended that further investigations should be conducted before the belt is advocated, including the physiological, biomechanical, and psychophysical effects.

The project entitled "The influence of back belts on lifting trajectory" was completed. Back belts are used as a personal protective equipment for preventing lower back pain, as they are much more cost efficient than using engineering controls for preventing lower back pain. Previous studies have indicated that wearing belts could change the range of motion, or the joint angles, lifting trajectory and lift angles during lifting. The present study was designed to explore the effects of different belts on lift angle and trunk muscle activity via NEMG (normalized EMG).

Eight male college students were recruited in the study. Objects weighing 10 kg and 25 kg were lifted from the ground onto a table 72 cm high. The split-plot experimental design was employed: three belt-wearing conditions of no belt, lumbar belt, and pelvic belt. Results indicated that the lifting angle changed significantly with belt wearing. The trunk and the knee angles associated with the belt wearing significantly differed from that of no belt wearing conditions. The lumbar belt restricted the trunk inclination much more than the other belt wearing condition. The pelvic belt significantly reduced the knee flexion. It seemed that the effect of belt on joint angle depended on the patterns of belt and working postures. For the erector spinae and internal oblique abdominus muscle, there was no difference between belt and no belt conditions. However, the belts significantly reduced the rectus abdominus muscle NEMG. There seemed to be a minor redistribution of muscle activity when wearing the belts. The Pearson correlation between abdominal and dorsal muscles was greater with belts, especially for the lumbar belt. Trunk muscle co-activity increased presumably to provide greater system stability. It stands to reason that belt wearing would help the trunk stability for the aging workers or those

who have been overworked. Finally, back belts did not dramatically reduce the spinal loading during lifting. However, the trunk stability, range of motion, and joint angles in lifting were affected by the belt. It is possible that belts would help the trunk stability much more for the aging workers or subjects without good stabilizing function than those young workers.

The study of "Human body measurements for access opening: EN547" was completed. The dimensions of emergency exits must be regulated to allow the body to safely pass through hallways in the work place during emergency situations. Dimensions for openings allowing access to operating panels on various machineries should also be regulated, in order to provide easy access for operating the machinery and maintenance while at the same time provide room for quick withdrawal from the machine during emergency situations.

Although such dimension standards do exist and are available in other countries, such as the European Union standard EN547, they are not suitable in Taiwan due to physical differences. This study reviewed the EN547 standard, collected anthropometric data of Taiwanese, and investigated the ergonomic factors in access opening dimensions. In addition, the motion analysis system was applied to measure the range of motion of the whole body during ladder climbing and level climbing. According to the experimental measurements and available anthropometric data of foreign nations in the literature, the corresponding national guideline for access opening of machinery was recommended. These recommendations provided the principles for determining the dimensions required for access opening into machinery.

## 5. Control of Occupational Musculoskeletal Diseases

The research was focused on the investigation of occupational musculoskeletal diseases in Taiwan, establishing the basic data for hand force exertion and physiological measurements of musculoskeletal systems. In addition, application of biomechanical principles, man-machine safety and health design and specifications were also examined. The results can be provided as a reference for controlling occupational musculoskeletal diseases in the industrial community.

The study on “Biomechanical evaluation and application study of biomechanical model of the lower back injury in field improvement” was completed. The purpose of this study was to develop a clinical assessment technique for occupational lower back injury. The technique would be used in assessing the relationship between lower back injury and on-site working posture, based on biomechanical models. The research is divided into four areas: 1) research and development of a system to capture images live; 2) investigate the extent of lower back injury via interviews and questionnaires. Questionnaires were collected from 142 workers with lower back injury who sought treatment at the osteology clinic. In order to gain a better understanding of the relationship between working posture and lower back pain, the workers were divided into two groups according to the nature of employment: service industry working in the record rooms of hospitals (n=36) and manufacturing industry manufacturing shoes (n=23); 3) videotaping of on-site work posture and the downloading the images onto the computer; and 4) measurement of relative angles and entering the data into an existing three dimensional biomechanical model, calculating force exerted on the lumbar and the cervix region.

The results of the questionnaire indicated that the work posture of the workers with lower back injury differed from that of workers whose work criteria involved lifting and unique postures particular for the job. The videotape recording of work posture showed that

changing the work posture changes the force exerted on the lumbar and the cervix region, although the force exerted was below the standard safety threshold of 3,400 Newton. However, if the torso were to rotate and incline forward for greater than 80° while the object in the arms was 20 kg or heavier, the force exerted on the lumbar and cervix region may be over the safety threshold. It is recommended that accumulative factors in work posture be analyzed for future studies and collaborating with manufacturers in related industries. The work procedures and methods of improvement should be further illustrated to assist the understanding of the factors involved in the occurrence of occupational lower back injuries. In addition, imaging education software may be produced as a audiovisual reference and teaching tool for seminars in occupational safety and health as well as for regulation and policy amendment in relevant government agencies.

The study entitled "An ergonomic development for VDT work station design and manufacture for a VDT table" was completed. The purpose of this project was to design a VDT table according to the anthropometric data and manufacture a prototype of the table. The whole design process for the table included the elaboration of the design requirement, conceptual design, preliminary design and detail design. In conceptual design, the functional structure and the morphological matrix were used to generate the concept sketches that satisfied the design requirements. Then, based on the concept sketches, the preliminary layout and the detail dimensional layout were carried out to obtain the final detail design of the table. The deflection and strength requirements of the table were also analyzed by using the Finite Element Method. Finally, a prototype of the table was manufactured and a query program was developed to provide appropriate adjusted parameters for different users.

The project involving "Improvement of wire tying of pipeline task on construction sites" was completed. When installing pipelines,

metal wires are used by plumbers to secure the plastic pipelines at the construction sites. The metal wires are secured by holding the two ends of the wire with a pincer, while repeatedly rotating the arms to twist the wires tight together. During the tying movement, the wrist is repeatedly used in an unnatural position producing a great amount of force. These movements result in injuries to the carpal tunnel tendon, sheath, and the median nerve. The objectives in this project, therefore, were to investigate in the pipe-tying industry, inventing a means to improve hand tying the pipes with metal wires. A three-way hand tool was developed based on the special features of the actions of the hand while tying the wires. Simulation of the metal wire-tying action was assessed in a laboratory setting using this newly developed three-way tool and a traditional pincer. Results showed that not only was the unnatural posture of the hand avoided when the newly developed hand tool was used to tie the wires, the force load on the muscles of the hand was also reduced. In addition, one particular way of the hand tool showed better performance than the other two.

In summary, research projects for occupational hygiene for the fiscal year 1999 focused on the evaluation and control of airborne hazards and studies on ergonomics. Local database on occupational safety and health to control for the emerging hazardous factors was established, in addition to studying countermeasures for special hazards and conducting relevant research on health protection equipment. Furthermore, research projects were promoted, and studies on occupational hygiene including the organization of other activities related to occupational hygiene were conducted. Some of the activities organized included convening presentation of research results, collaboration and exchange of information among local and foreign experts and scholars, sponsoring and participating in academic research publications, as well as actively promoting research results on occupational hygiene.

#### **IV. Research on Occupational Medicine**

The purpose of research on occupational medicine is to prevent occupational disease and to maintain and promote health among the workers. The research results are used as guidelines for setting policies on occupational medicine, promote the system of occupational health insurance, and studying relevant regulations. The research results are also made available to related departments and industries, so that the purpose of preventing occupational diseases and ensuring workers health may be achieved. Significant methods and research results for the fiscal year 1999 are as follows:

##### **1. Surveys on Occupational Injuries and Analysis of Health Data**

The primary source of data for research in occupational medicine for the fiscal year 1999 was based on data on compensation for labor insurance, health examination data of workers, and hospitalization data from workers admitted due to occupational diseases. Statistical analysis was then conducted on chronic and acute occupational diseases, occupational skin diseases, occupational musculoskeletal diseases, occupational respiratory diseases, occupational cancer and occupational psychological diseases.

The project on the "Analysis of the applied indicators of the Labor Insurance data" was completed. The number and frequency of incidences in the people insured by the Labor Insurance were analyzed, based on the cash payment data obtained from the Labor Insurance, whether the incidences were of an occupational or non-occupational nature, which resulted in injury, disability or death in the past years in Taiwan. The loss of basic costs due to these occupational incidences was also included in the analysis. The statistical analysis was further divided into age, gender and occupation. Next, incidences such as accidental deaths were also taken

into account according to occupation- (and type of occupation) and non-occupation-related deaths in the calculation of death rates and potential life lost.. The results were digitized and made available on the IOSH website of "Statistical Analysis of Injury, Disability, and Death in the Insured of Labor Insurance in Taiwan".

The database of "Occupational epidemiology standardized reference population" was established. The purpose of establishing this database was to understand the specific features of occupational exposure, so that a standardized reference population in occupational epidemiology may be available in Taiwan. The information collected included personal data, health status, history of requests for medical attention and use of medical resources, health habits, quality of life, leisure activities, and work environment. In order to provide an alternative population for comparative study purposes in occupational epidemiology, the difference in the basic features of workers in different industries was also examined. Follow-up of changes in basic information for individuals may also be conducted using this database.

The data obtained from the "Surveillance of workers hearing threshold in noise work sites" were analyzed. The purposes of this project were 1) to understand the trends of hearing loss in workers of the noise work sites; and 2) to provide a guideline for the hearing protection program for workers in the noise work sites. A database of hearing loss for this particular population of workers was established. The hearing loss examinations were conducted between July 1, 1998 and June 30, 1999. 408 business enterprises were notified by 34 clinics and hospitals; the final sample size for the hearing loss examination was 36,428. Results indicated that hearing loss varied with age, and that the degree of deterioration in males was significantly greater than that of the females. When the moderate hearing loss is defined as hearing loss > 40dB, 2.6 % of males under the age of 25 had a moderate

hearing loss, and 58.1 % of males over the age of 55 had at least moderate hearing loss. The three industries with the worst hearing loss were rubber manufacturing industry, transporting equipment manufacturing and repairing industry, and non-metallic mineral manufacturing industry. Suggestions for enhancing the hearing protection program were given according to the results of the analysis.

## 2. Surveys of Occupational Diseases and Occupational Epidemiology

Scope of research included chemical substances, pneumoconiosis, physical hazards, musculoskeletal diseases or neck and shoulder symptoms, and occupational cancer.

The study entitled “The vinyl chloride monomer (VCM) cohort study in Taiwan (IV) nested case-control study” was completed. This study was designed by nested case-control study to understand whether prolonged vinyl chloride exposure could induce higher risk of chronic liver disease. A total of 78 cases and 216 controls were matched by age ( $\pm 5$  years) and plant of work. Results showed individuals with HBsAg positive had higher odds ratio (OR = 2.77) of chronic liver disease than those with HBsAg negative. Therefore, an interaction between vinyl chloride exposure and HBV infection may exist, leading to the onset of chronic liver disease.

The study of “Long-term health effects among sulfuric acid exposed workers II” was completed. In fiscal year 1999, the fertilizer manufacturing industry was chosen for conducting an epidemiological study on workers exposed to sulfuric acid in factories in this industry. The relationship between occupational exposure to sulfuric acid and cancer in the respiratory system (in particular nasopharyngeal carcinoma) was examined. Insurance data were collected from the Bureau of Labor Insurance and the Division of

Insurance for Public Workers in the Central Trust Bureau to establish potential generation of exposure to sulfuric acid. The death registration records from the Department of Health of the Executive Yuan were obtained and computerized for easy access.

Research results indicated that no excess risk of all cancers was found when the standardized mortality ratios were analyzed. Also, results indicated that no excess risk of laryngeal cancer and nasopharyngeal carcinoma were present.

The project of "Occupational cohort for urinary bladder cancer study: dye manufacturing" was completed. Urinary bladder cancer is the most common form of cancer caused by exposure to benzidine. Several studies reported that the incidence rate of bladder tumor was positively correlated with the duration of occupational exposure. In addition, a significant dose response relationship between exposure level and risk of developing bladder tumor was observed. Studies also revealed that workers exposed to benzidine had a much higher standard mortality ratio (more than 100 folds) and a higher standard incidence ratio (exceeding 600 folds) compared to the general population. Workers in the applied industry of the dye manufacturing industry such as paper, textile, and leather manufacturing industries may have the same risk of developing urinary bladder cancer. Therefore, workers of these industries need to take heed.

The "Surveillance and research in occupational injury and occupational disease in medical insurance services" investigation in the injury of medical technicians and veterinary medical staff personnel" was completed. The purpose of this project was to understand the epidemiologic of skin disease and respiratory tract allergies and other diseases among medical technicians and veterinarians. The baseline of occupational exposure was established to provide for a databank in future research in occupational epidemiology. The results will serve as a guideline for improving occupational hygiene and prevention of occupational disease in

medical technicians and practicing veterinarians.

The study on the "Health effects among workers due to long-term exposure to 1,3-butadiene" was completed. Of the seven plants studied, the average exposure level to 1,3-butadiene in the high exposure group of workers (the tank cleaners) was 6.08 ppm. The eight hour average exposure level in the regular group of workers was 0.3 ppm. Comparing the blood samples of 1,3-butadiene tank cleaners with that of regular workers, blood glucose was significantly lower while triglyceride was significantly higher in workers of the high exposure group. There was no significant difference in other items examined, possibly in part due to the fact that the sample size and duration of exposure were small. It was also revealed in the study that phenotype polymorphism was significantly related to hemoglobin adducts in 1,3-butadiene. It is recommended that hemoglobin adducts be used to screen workers exposed to 1,3-butadiene who may be more susceptible to 1,3-butadiene.

The study on "Pain in the neck and shoulders of semiconductor manufacturing plant workers" was completed. The subjects of this study came from two semi-conductor manufacturing and one PGBA plate manufacturing factories. Questionnaires were given to the workers to evaluate the position and status of pain in the neck and shoulder. Results were gathered from 494 questionnaires; the participation rate was 81 %. The average age of the participants was 26.4 years; 43.1 % of the participants were females; 48.2 % were production workers. The average employment duration was 17.2 months. 38.1 % of the employees reported experiencing pain in the neck and shoulder. Result of analysis showed that significant high risk factors of having pains in the neck and shoulder are being a female production worker and having major crisis in everyday life. If "experiencing pain in the neck and shoulders in the past week" were the important determinants then risk factors are past experiences in working at semi-conductor manufacturing

plants in addition to gender.

The "Epidemiological study on sudden death among workers (III)" was completed. Relevant data on the sudden death of foreign workers and a control group for the fiscal year 1999 were collected and autopsy performed. The location and/or the plant of the occurrence of sudden death was visited. Blood samples from each individual were analyzed for heavy metal and toxic substance content. Analyzing the data using a logistic regression analysis model showed ingesting a large amount of food prior to death was a significant risk factor in the onset of sudden death.

The research investigation on the "An epidemiology study on health outcome among former RCA employees" was completed. The subjects included a group of RCA employees as well as a comparison group that consisted of the living descendants of the RCA employees. The PCMR (proportionate cancer morbidity ratio) and risks of developing cancer of the breast, stomach, liver, etc. in the RCA employees were assessed based on the files on the workers already diseased as well as the living and the descendants of the deceased, inpatient record from the Labor Health Insurance, and cancer registration data. In addition, 787 questionnaires and 735 physical examination data were completed.

The investigation of the "Estimate of the health effect on workers and industrial hygiene in the pesticide factories" was completed. The main job categories in the current investigation of the manufacturing plants of pesticides are re-packaging, partial work on the mixing of compounds at the factory. Most of the mixing took place in closed mixing tank. Also, most of the factories simultaneously produced various types of pesticides. Results indicated that 75.6 % of the workers in the pesticide manufacturing plants had the habit of showering before going home; that 60 % of the workers had the habit of wearing gloves while working; that 50 % of the

workers had the habit of wearing masks while at work, and that 15.6 % of the workers had experienced illness while at work. The reason for the discomfort was due to unpleasant odor. The most common symptoms making workers feeling ill were skin itch and pain; ranking at 14.3 % of all the symptoms.

### 3. Research on Labor Health Promotion

The purposes of research were to actively create a healthy, safe, and comfortable work environment, and to protect the physical and mental health of the workers. Various researches on labor health promotion had been conducted. Completed research included studies on the promotion of physical fitness of workers in manufacturing plants, evaluation of fatigue and physiological conditions of workers, rehabilitation models for occupational disability, study on health management and practice, survey on dietary pattern and nutrition status, and establishment of basic energy expenditure test in workers in Taiwan.

The investigation on "Health-related fitness examination for workers in Taiwan (service, manufacturing, and construction industries)" was completed. The purposes of this project were to promote workers' health-related fitness and to minimize occupational injury. This project has been ongoing for the past four years. The current status of workers' health-related fitness were investigated by IOSH. The industries investigated were service industry, manufacturing, and the construction industries. Items examined include: body composition, balance and reflex; muscular strength and endurance; flexibility and range of motion of the joints; and cardio-pulmonary fitness. An assessment software was developed through this project, examining the workers' health-related fitness test. A five-level grading table was established according to the results of this investigation. The table analyzes the health and fitness problems associated with workers from various sectors and industries. The table also outlines some health-

related fitness promotion plans and guidelines for all kinds of workers.

The project entitled "Study on work-related fatigue and physiological conditions of telecommunication workers indoor operations" was completed. One of the most common symptoms of fatigue in the telecommunication industry is the fatigue of the eyes. The prevalence of eye fatigue after work was as high as 88 % among customer service personnel and 62 % in the information service personnel. Other symptoms include dry mouth (70 % and 56 % in customer service and information service personnel, respectively); and stiffness and discomfort in the neck and shoulders (66 % and 56 % in customer service and information service personnel, respectively). In the physiological parameters, items which showed significant difference ( $p < 0.05$ ) between before and after work include: blood pressure, heart rate, measurement of cervical movement, grip force, pinch-force measurement, and the near focal point of the eyes. In terms of hearing loss among customer service personnel, there was no significant difference before and after working. However, 30 % of these workers had hard of hearing; 67 % had symptoms of dizzy spells. In the area of ergonomics, the RULA assessment (Rapid Upper Limb Assessment) showed that in a majority of customer service personnel, the posture of the upper limbs was among the "improvement not necessary" category.

The project on "Investigation of substance use among workers in Taiwan substance abuse among workers in the transportation industry prevention and research" was completed. The subjects of this study involved 506 members from the Drivers Union. The results indicated 3.8 % ( $n = 19$ ) of the bus drivers had positive benzodiazepines (BZD) (from use of stabilizer) in their urine and 81.2 % ( $n = 436$ ) of the drivers consumed alcohol. Of the 505 participants interviewed at the bus management terminal, 4.1 % ( $n = 23$ ) showed positive BZD in urine and 15.3 % ( $n = 77$ ) consumed alcohol. Workers in the transportation industry were cautioned on

using substances containing BZD, as it is capable of inducing memory lapses or memory loss, deteriorating vision control and reducing focusing abilities. Through the present study, the risk factors which may involve marriage status, the level of pressure experienced, as well as frequency and work hours, and knowledge or the lack of knowledge of drugs of the workers in the transportation industry who were into substance abuse were better understood.

The study on "Energy expenditure of labor work (II)" was completed. Data on work activity energy expenditure from other countries were collected. The energy expenditure index was established for the workers in Taiwan. Industries were categorized according the energy expenditure, so that the extent of strain on the body in workers of various industries may be better understood. Once the strain on the body is better understood in workers in Taiwan, the workers will be recommended to avoid working above their physical working capacity, so that they will endanger themselves as well as the well-being of the others.

The study for the "Sample mean of labors hearing (II): the hearing test of labors and establishment of standard calibration procedure for the audiometer" was completed. Besides disturbing conversations, noise can pose as a hazard to the human physiology and psychology. The most direct impact on the human body of noise is hearing loss. A hearing test was administered to 584 males and 634 females between the age of 15 and 65 years after completing a questionnaire and a physiological inspection of the ear. Results indicated that the sensitive to hearing for the people in Taiwan deteriorated as age increased, especially in high frequency sounds. When diagnosing hearing loss in workers, the factors of age, gender should be taken into consideration. The model of the auditory threshold developed in the study may serve as an adjustment protocol for the age factor in diagnosing hearing loss in workers, so that the diagnosis would be more accurate in the future. For workers in the high noise industries, a hearing test

is a powerful tool in detecting hearing loss due to noise. A standard calibration system and procedure for the audiometers were also developed based on a research of the international standard of calibration of audiometers.

The project entitled "The assessment of hearing loss in workers of high-noise industries (textile industry)" was completed. The result of hearing tests from 2,118 workers at seven textile manufacturing plants in Taiwan was collected to understand the status of hearing loss in these workers. It was found in this 1998 investigation of the textile manufacturing plant workers that, at 4 kHz and 6 kHz, 30.2 % of the workers and 41.2 % of the workers had a hearing loss of 40 dB in the worse ear, respectively. Therefore, the textile manufacturing industry is one of the high noise industries in which noise is particularly severe in inducing hearing loss among its workers. It was advised that a "Workers' Hearing Protection Plan" be implemented to improve the situation.

#### 4. Research on Occupational Biomedicine and Monitoring

Epidemiological studies were conducted and biological indicators were studied through the use of biomedicine technologies, so that early detection and immediate prevention of occupational diseases would be possible.

The study of "The biological marker of chromium and nickel among heavy metal exposure workers (II)" was completed. The contents of chromium, nickel, and malondialdehyde in blood, urine, hair, and nail samples as well as the liver and kidney functions from workers of nine electroplating factories were evaluated. The data were correlated with results from questionnaire and health examination records. The outcome of the research on the biological marker may be provided to the Council of Labor as future reference for amending the regulations on workers health protection.

The project entitled "A Preliminary Survey of Viral Zoonoses on Pig Farm Workers (Influenza and Japanese Encephalitic Virus (JEV))" was completed. Results indicated that the frequency of workers coming in contact with pig blood, excretion, and hair were 60 %; the frequency of workers being stabbed by needles intended for injection into pigs was 40 %--of which 70 % had been injected into the pigs; and the frequency of workers wearing protective gear while entering pig pens was 50 %. It was also indicated that symptoms of relevant diseases were related to the working environment. Investigation of exposure condition showed that more than 80 of the workers come in physical contact with swine substance. Workers whose serum showed positive Swine Influenza Virus was 25 % while JEV positive workers was 40 %. Over 50 % of the workers had positive regional viral strain. The carrier status of these two kinds of viruses is uncertain for the lack of positive PCR results by using the recommended probes.

It was found through the study this year that workers are often exposed to viruses capable of infecting both humans and animals in the animal husbandry environment in which they work. It is therefore highly urged that more investigations be conducted to devise health protection strategies in order to protect the health of workers in the husbandry industry and to enhance their knowledge regarding prevention.

The study on the "Genetic analysis of human leukocyte antigens (HLA) in isocyanate-sensitive workers" was completed. The findings of this study showed that, in the workers examined (person times = 407), 21.1 % had symptoms of the respiratory tract, 16.7 % had symptoms of skin disease, and 9.6 % had symptoms of eye disease related to the work environment. The allele 0602 and 0301 of serotype DQ1 in the class II HLA genes were positively correlated and the 0502 allele negatively correlated with occupational respiratory tract symptoms with restrictive or obstructive lung function. Also, asthmatic symptoms due to isocyanate

were significantly correlated to the DQ1 0603 and 0301 genes in the patients. However, the 06011 allele of the DQ1 serotype of the HLA class II gene was positively correlated but 0201 allele was negatively correlated with symptoms of the eye. Therefore, the answer to the question of whether isocyanate would cause an allergic reaction to the alleles 0602, 0301, 06011, 0603, 0502, and 0201 in the DQ1 serotype may have extremely important health consequences. One limit of this study was that some of the sample size was too few to make the result reliable and generalizable.

In general, the current research focus effectively made use of results from health examinations and grasped the essence of prevention of occupational diseases. Furthermore, methodologies of epidemiology were utilized to complete specific tasks in the research of occupational health and health promotion. In addition, projects were conducted to reduce harms caused by various environmental factors, such as the hearing protection plan, workers' health protection and promotion, so that occupational diseases may be effectively prevented and a comfortable working environment created.

## **RELATED ACTIVITIES**

### **I. Academic Activities**

Academic activities are primarily focused on presentations of research results and local and foreign academic exchanges. For the fiscal year 1999, IOSH sponsored or jointly sponsored 10 academic conferences; presented 25 journal papers in local publications, 12 journal papers in foreign publications, 35 papers at local academic conferences, and 5 papers at foreign academic conferences.

## 1. Academic Conferences

Table 3 Academic Conferences

Name of Conference	Summary of Activities	Date
R.O.C. & Japan Education, Promotion and Management Techniques on Chemical Production Safety Conference	140 participants included industrial agencies and occupational safety personnel, relevant educators and researchers. Two Japanese experts presented followed by discussion session for seven hours while two local experts presented for three hours at each session.	99/1/26-27 99/1/28-29
1999 Conference on Application of Research Results on Industrial Ventilation	60 participants attended the conference, including technicians on industrial safety and health, labor inspectors, safety and health professionals from industries. Seven theses were presented relating to study and technologies on design concepts of industrial ventilation, hood and pipe design, and practice in computer-aided programs. Joint discussions of questions among participants were conducted and experiences were exchanged.	99/2/25-26

<p>Workers Health-Related Fitness Promotion Conference</p>	<p>The purpose is to announce study results, to popularize evaluating method of health-related fitness, and to exchange views about related strategies. There were approx. 130 participants, some including health agency personnel, safety and health management personnel, and occupational hygiene nurses.</p>	<p>99/3/31 (Taipei) 99/4/3 (Yunlin)</p>
<p>Seminars on the Use of Hand Tools and Ergonomic Engineering</p>	<p>Experts and scholars were gathered to introduce ergonomics and issues relating to skills in using hand tools. 40 industrial safety and health technicians, labor inspectors, safety and health professionals from industries participated the seminar. Ergonomics engineering concepts were promoted, and reference to industries were provided</p>	<p>99/4/7</p>
<p>Conference on Construction Safety for Fiscal Year 1998</p>	<p>270 participants included labor inspectors, safety and health professionals from industries, researchers in related fields attended. Topic speeches and 7 papers were presented.</p>	<p>99/4/8, 12, 16, 19</p>

<p>1999 Conference on Ergonomic Evaluation and Control</p>	<p>70 participants attended the conference, which included industrial safety and health technicians, labor inspectors, safety and health professionals from industries. 10 Theses on application of ergonomics in work place were presented, evaluation of ergonomic engineering and general concepts and practice on how to prevent ergonomic hazards were also presented. Participants had a joint discussion on the problems and exchanged experiences and views.</p>	<p>99/4/13-14</p>
<p>Conference on Mechanical Safety for Fiscal Year 1998</p>	<p>Approximately 150 participants attended the presentation, among which were labor inspectors, safety and health professionals from industries and researchers in related fields. Topic speeches and 6 papers were presented.</p>	<p>99/4/23?30 998/5/7</p>

<p>SEMI Organization on Safety &amp; Health Policies Conference</p>	<p>Co-sponsored by IOSH and Hsin Chu Science Park Administration. The 100 participants included occupational inspectors related to semi-conductors, industrial safety personnel and plant management personnel. The SEMI policy was discussed and compared with the relevant policies and regulations in Taiwan. It was hoped that related enterprises and agencies will benefit from the conference.</p>	<p>99/5/10</p>
<p>Conference on Chemical Safety for Fiscal Year 1998</p>	<p>Approximately 150 participants attended the presentation, among which were labor inspectors, safety and health professionals from industries and researchers in related fields. Topic speeches and 7 papers were presented.</p>	<p>99/6/2 &amp; 99/6/4</p>

<p>1999 International Conference on Aerosol Technology</p>	<p>Jointly sponsored by R.O.C. Association on Aerosol Research and IOSH. Approx. 200 people attended the meeting in addition to foreign experts who provided speeches. 46 papers on relevant research were presented. Topics included 1) aerosol hazard; 2) aerosol control; and 3) technology for aerosol sampling. Application and research of aerosol technologies in industrial health were promoted.</p>	<p>99/9/30-10/2</p>
--	---	---------------------

## 2. Presentation of Theses ;V Local Publications

Table 4 Presentation of Theses ;V Local Publications

<p><b>Title</b></p>	<p><b>Publication</b></p>	<p><b>Authors</b></p>
<p>Comparison study of design and regulations of the dimensions of the safety release valve</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 1</p>	<p>Chiang, Shi Cho; Hsu, Chi Ming; Chang, Cheng Ming*; Wu, Hong Jun*</p>

Sampling and analysis of airborne TDI and MDI	Institute of Occupational Safety and Health Journal, Vol. 7, No. 1	Chen, Mei Lian; Uang, Shi Nian*; Shih, Tung Sheng*; Luo, Yi Wen; Lin, Yi Zhang; Mao, Yi Fang
Assessment of an ergonomically designed butcher knife used on frozen meat products	Institute of Occupational Safety and Health Journal, Vol. 7, No. 1	Wang, Mao Jun; Wu, Sio Wei; Chang, Chi Hong; Yeh, Wen Yu *; Lee, Cheng Long*
Determination of critical facial dimensions affecting the fit factor of a half mask respirator	Institute of Occupational Safety and Health Journal, Vol. 7, No. 1	Chen, Chun Wan *; Yeh, Wen Yu*; Chen, Yo Gang*
The study on the suitability of ergonomic checklist for work site	Institute of Occupational Safety and Health Journal, Vol. 7, No. 1	Lin, Yen Huei*; Yeh, Wen Yu*; Chen, Chi Yong *
Survey on the dust exposure in masonry	Institute of Occupational Safety and Health Journal, Vol. 7, No. 1	Lin, Ming Sio *; Yeh, Wen Yu*

<p>Study on reduction of chromium (VI) content in cement by addition of ferrous sulfate</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 2</p>	<p>Hsieh, Chun Ming *; Shih, Tung Sheng*; Huang, Kai Siong; Tsai, Feng Yuan; Hong, Ming Chi</p>
<p>Using gas chromatography / mass spectrometry to detect carbon disulfide in air</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 2</p>	<p>Wu, Li Jue *; Shih, Tung Sheng*</p>
<p>Method development of urinary alkoxy acetic acid</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 2</p>	<p>Shih, Tung Sheng*; Chou, Jui-Shu *; Chen, Cheng Yau *; Smith TJ</p>
<p>Survey on tetrachloroethylene exposure in hotel dry cleaning operation</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 2</p>	<p>Chen, Chang-Yuh*; Shih, Tung Sheng*;  Chang, Chen Ping *; Chien, Yeh Chung; Kuo, Jin Tang</p>

A study on factors affecting respirator fit testing	Institute of Occupational Safety and Health Journal, Vol. 7, No. 2	Sheu, Rong Nan; Chein, Hong Min; Chen, Chun Wan *
A simulation of the flow field and particle trajectories around exterior hoods	Institute of Occupational Safety and Health Journal, Vol. 7, No. 2	Chen, Yu Kang* Yeh, Wen Yu*  Chen, Chun Wan *
The application of the sound field simulating cleaning technology	Institute of Occupational Safety and Health Journal, Vol. 7, No. 2	Yeh, Wen Yu*; Lin, Sho Siang *; Wang, Dao Jun; Chang, Wen Long
Study in modification of lattice design of a crane boom	Institute of Occupational Safety and Health Journal, Vol. 7, No. 3	Kang, Yuan; Wang, Shi Ming ; Mu, Li Siang ; Kao, Chong Yang *; Wang, Shu Long*
Masking effect on the asbestos counting	Institute of Occupational Safety and Health Journal, Vol. 7, No. 3	Yu, Tai Shan *; Chen, Chi Chieh; Huang, Jing Siang ; Shi, Tung Sheng*

A study of exposure hazard and assessment of stainless steel welding fume	Institute of Occupational Safety and Health Journal, Vol. 7, No. 3	Hsieh, Chun Ming *
Validation tests and field application considerations of the Tenax-TA thermal desorption method	Institute of Occupational Safety and Health Journal, Vol. 7, No. 3	Wu, Li Jue *; Wu, Rong Tai; Chang, Rei Chi
Developing a program on the local exhaust duct design-data structure and validation on computation	Institute of Occupational Safety and Health Journal, Vol. 7, No. 3	Chen, Yo Gang*; Chen, Chun Wan *; Huang, Jen Jang; Lin, Ching Feng; Lu, Chong Sien
Review of needle stabbing injury in medical clinics and hospitals of Taiwan	Institute of Occupational Safety and Health Journal, Vol. 7, No. 3	Chang, Jing Wen *; Huang, Yau Huei
The survey and recommendations of electric shock preventing devices for AC arc welding machines	Institute of Occupational Safety and Health Journal, Vol. 7, No. 4	Wu, Chi Rei; Su, Wen Yuan*; Yang, Cheng-Fa; Yen, Shi Siong; Lee, Sang Yi; Chang, Chi Chong

<p>Investigative study on the reasonableness of the WBGT policy standard of workers' schedule in the high temperature industry from a physiological point of view</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 4</p>	<p>Tsai, Peng Jy; Hsieh, Rong Yu; Wu, Feng Ren; Tang, Ming Je; Yeh, Wen Yu *; Lin, Sho Siang *; Chen, Wang Yi *</p>
<p>An assessment of fungi exposure and investigation of its relationship with fungal corneal infection in onion farms in southern Taiwan</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 4</p>	<p>Chang, Jing Wen *; Ho, Chi Kung; Chen, Rei Ching; Chen, Mao Yen; Chen, Mei Ju; Chang, Jen Yang ; Liu, Shao Duan; Chen, Guei Yu</p>
<p>Three types of ergonomic inspection charts in semiconductor industry and application</p>	<p>Institute of Occupational Safety and Health Journal, Vol. 7, No. 4</p>	<p>Lu, Ji Wei; Chang, Ching Chong; Lin, Yen Huei *; Yeh, Wen Yu *; Lin, Yen Huei *; Chen, Chi Yong *</p>

Production of assessment chart of lifting posture in biological ergonomics	Institute of Occupational Safety and Health Journal, Vol. 7, No. 4	Eng, Yi Sio ng *; Lu, Shi Yi *; Chen, Chi Yong *; Lee, Cheng Long *
Evaluation of safety and health hazards in the semiconductor industry;Xcomparison of SEMI safety guide and regulations in Taiwan	Institute of Occupational Safety and Health Journal, Vol. 7, No. 4	Lin, Yen Huei *; Yeh, Wen Yu *

Note: \*IOSH Staff

### 3. Presentation of Theses ;V Foreign Publications

Table 5 Presentation of Theses ;V Foreign Publications

<b>Title</b>	<b>Publications</b>	<b>Authors</b>
Correlation between urinary 2-methoxy acetic acid and exposure of 2-methoxy ethanol	Occup. Environ. Med., 56: 674-8, 1999.	Shih, T.S. *, Liou, S.H., Chen, C.Y. *, Chou, J.S. *
Improved method to measure urinary alkoxy acetic acids	Occup. Environ. Med., 56: 460-7, 1999.	Shih, T.S. *, Chou, J.S. *, Chen, C.Y. *, Smith, T.J.

Detection of methyl ethyl ketone in urine using headspace solid phase microextraction and gas chromatography	J. Occup. Environ. Med., 41: 1042-7, 1999.	Chou, J.S. *, Shih, T.S. *, Chen, C.M.
Effect of deposited particles and particle charge on the penetration of small sampling cycles	J. Aero. Sci., 30(3): 313-23, 1999.	Tsai, C.J., Shiau, H.G., Lin, K.C., Shih, T.S. *
Field study of the accuracy of two respirable sampling cyclones	Aerosol Science and Technology, 31: 463-72, 1999.	Tsai, C.J., Shiau, H.G., Shih, T.S. *
Laboratory performance comparison of respirable samplers	Am. Ind. Hyg. Assoc. J., 60: 601-11, 1999.	Chen, C.C., Lai, C.C., Shih, T.S. *, Hwang, J.S.
Belt effect on lumbar sagittal angles	Clinical Biomechanics	Lee, Y.M., Chen, C.Y. *
Lumbar vertebral angles and muscle loading with belts	Industrial Health	Lee, Y.M., Chen, C.Y. *
Plasma p53 protein and anti-p53 antibody expression in vinyl chloride monomer workers in Taiwan. J Occup.	Environ. Med., 49:1-4, 1999.	Luo, J.C., Lin, H.T., Cheng, T.J., Du, C.L., Wang, J.D.

A registry-based case-control study of risk factors for the development of multiple non-fatal injuries on the job	Occup. Med., 49:331-334, 1999.	Li, C.Y., Du, C.L., Chen, C.J., Sung, F.C.
Abnormal liver function in workers exposed to low level of EDC and VCM	J. Occup. Environ. Med., 41:1128-33, 1999.	Cheng, T.J., Huang, M.L., You, N.C., Du C.L, Chou, T.T.
Lipid peroxidation in workers exposed to hexavalent chromium	J. Toxicol. Environ. Health, 56:235-247, 1999.	Huang, Y.L., Chen, C.Y., Sheu, J.Y., Chuang, I.C., Pan, C.H. *, Lin, T.H.

Note: \*IOSH Staff

#### 4. Presentation of Theses ;V Local Academic Conferences

Table 6 Presentation of Theses ;V Local Academic Conferences

Topic	Conference	Date	Presenters

Investigative Research on Chronic Musculoskeletal Injury in Transportation Industry	1999 Presentation of Research Results on Occupational Medicine and Labor Health Promotion	99/1/21-22 99/1/28-29 99/2/4-5	Shi, Chi Ming; Wang, Zi Kang; Chen, Chiou Jong *; Pan, Chih Hong*
Investigative Research on Tetrachloroethylene Exposure in Dry Cleaning Industry	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chen, Chang-Yuh *; Shih, Tung Sheng *; Chien, Yeh Chung
Evaluation of Exposure Levels using Questionnaire and Biological Indicators in Dry Cleaning Industry	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chien, Yeh Chung; Chen, Chang-Yuh *; Shih, Tung Sheng *; Chang, Chen Ping *
Study on Reduction of Chromium (VI) Content in Cement by Addition of Ferrous Sulfate	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Hsieh, Chun Ming *; Shih, Tung Sheng *; Huang, Kai Siong; Tsai, Feng Yuan; Hong, Ming Chi
Study on Gravimetric Method for the Analysis of Nuisance Dust at Workplace	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Hsieh, Chun Ming *

Risk Assessment of Workers Exposed to Pesticides	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Lee, Hong Ping ; Wong, Su Jen; Lee, Guo Chin; Chou, Jui-Shu *; Chen, Chang-Yuh *; Shih, Tung Sheng *
Performance Characteristics of PM10 Samplers at Calm Air Condition	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Lai, Chuen Yu; Chen, Chi Chieh; Shih, Tung Sheng *
Use of Virtual Cyclone as Personal Respirable Sampler	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Huang, Sheng Sio ; Shih, Tung Sheng *; Chen, Chi Chieh
Exposure Assessment and Health Hazard Evaluation of 2-Methoxy Ethanol	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Shih, Tung Sheng *
Development of Rapid Routine Method for Mercury Speciation in Urine	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Tseng, Wei Chang; Huang, Yo Li; Chen, Chang Yu; Yi, Shun Jun; Hsieh, Chun Ming *; Shih, Tung Sheng *; Lin, Te Hsien

Assessment of Exposure to Airborne Fungi in Onion Growing Industry Workers of Southern Region	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chang, Jing Wen *; Ho, Chi Kung; Chen, Rei Ching; Chang, Jen Yang ; Liu, Shao Duan; Chen, Mei Ju; Chen, Mao Yen; Chen, Guei Yu
Survey on the Processes and Dust Exposure in Refractory Brick Manufacturing	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Lin, Ming Sio *; Yeh, Wen Yu *
Investigation of Fungi-related Corneal Ulcer-- Fungi in Soil, Onion Leave, and Onion Peel of Southern Region	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chen, Mei Ju; Chang, Jing Wen *; Chang, Jen Yang ; Liu, Shao Duan; Ho, Chi Kung; Lee, Jing Ti; Wu, Chong Neng; Yu, Sing-Si
Study of the Control of Chromium Mist with Mist Suppressant in Chromium Electroplating Tank	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chen, Chun Wan *; Yeh, Wen Yu *; Chen, Yo Gang *

<p>Application of Extreme Temperature Exposure Hazard Assessment Predictive Models;"</p>	<p>1999 Academic Conference on Industrial Hygiene</p>	<p>99/3/19-21</p>	<p>Wu, Feng Ren; Hsieh, Rong Yu; Tsai, Peng Jy; Yeh, Wen Yu *; Chen, Wang Yi *; Lin, Sho Siang *</p>
<p>Guidance and Improvement of Lead as an Environmental Hazard in Lead Battery Manufacturing Industry</p>	<p>1999 Academic Conference on Industrial Hygiene</p>	<p>99/3/19-21</p>	<p>Yu, Rong Bin; Wang, Guang Sheng; Fu, Wu Sio ng; Chen, Chun Wan *; Yeh, Wen Yu</p>
<p>Guidance and Improvement on Asbestos Brake Manufacturing Working Environment</p>	<p>1999 Academic Conference on Industrial Hygiene</p>	<p>99/3/19-21</p>	<p>Wang, Guang Sheng; Yu, Rong Bin; Yeh, Wen Yu *; Chen, Chun Wan *; Fu, Wu Sio ng</p>
<p>Determination of Critical Facial Dimensions Affecting the Fit Factor of a Half Mask Respirator</p>	<p>1999 Academic Conference on Industrial Hygiene</p>	<p>99/3/19-21</p>	<p>Chen, Chun Wan *; Yeh, Wen Yu *; Chen, Yo Gang *</p>

An Epidemiological Research on Musculoskeletal Discomfort of Workers in Taiwan	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Guo, Hao Ran; Chang, Ya Jing; Yeh, Wen Yu *; Kuo, Yu Liang
Ergonomic Safety Inspection on Semiconductor Manufacturing Apparatus Design and Evaluation	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chang, Ching Chong; Lu, Ji Wei; Yeh, Wen Yu *; Lin, Yen Huei *; Chen, Chi Yong *
Investigation of Musculoskeletal Injury in Workers of Semi-Conductor Manufacturing Industry and Ergonomical Trial and Assessment	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Lin, Yen Huei *; Yeh, Wen Yu *
Occupational Related Diseases Awareness System and Status of Unique Case Follow-up	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Yeh, Wen Yu *
Employee Awareness of Safety and Health	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Chen, Chun Wan *, Tai, Ji-Fu *; Yang, Rei-Jong *; Yeh, Wen Yu *; Chen, Yo Gang *

Computer Model of Treatment of Stabbing by Sharp Objects in Medical Staff	1999 Academic Conference on Industrial Hygiene	99/3/19-21	Ho, Chi Kung; Chang, Jen Yang ; Liu, Shao Duan; Chang, Jing Wen *; Liu, Jing Yun
Study of VCM Worker and Cohorts in Taiwan	1999 Academic Conference on Industrial Hygiene	99/3/20-21	Wong, Ruey Hong; Chen, Pao Chong; Du, Zong Li *; Cheng, Tsun Jen
Study of Genotoxicity in Workers Exposed to Dicholoro ethane and VCM	1999 Academic Conference on Industrial Hygiene	99/3/20-21	Cho, Pei Yi; Huang, Mei-Lan; Du, Zong Li *; Cheng, Tsun Jen
Analysis and Evaluation of the Occupational Disease in the Labor Insurance Data	1999 Academic Conference on Industrial Hygiene	99/3/20-21	Du, Zong Li *; Lee, Zhong Yi; Chen, Chiou Jong *
Subjective Test Technology of Sound Attenuation for Hearing Protectors	Symposium on Industrial Hygiene and Occupational Health	99/3/19-21	Pan, Chih Hong *; Chen, Chiou Jong *; Lu, Cho-hsin; Suen, Der-Shuan; Sun, Hong Chu an; Chang, Shu Ju *

Study on the Use of Gloves in the Semi-Conductor Industry	The 1999 Spring Academic Conference of the Chinese Dermatological Society	99/4/25	Pan, Chih Hong *
Study of the Biological Markers of Chromium among Electroplating Workers	Symposium on Safety and Health for Electroplating Workers	99/5/20-21	Pan, Chih Hong *
Performance of Disposable Respirator for Chromium Mist in Chromium Plating Industries	1999 International Aerosol Technology Conference	99/10/1-2	Chen, Chun Wan *; Chen, Chi Chieh; Huang, Sheng Sio ; Yeh, Wen Yu*; Chen, Yo Gang *
Modification of Pt/Nafion Electrode by Electro-Polymerization of Aniline as Chlorine Sensor	The 4 th East Asian Conference on Chemical Sensors	99/11/23-26	Ling, T.R.; Chen, N.M.; Chou, T.C.; Chang, C.M. *
Evaluation of Workers' Hearing Loss in Automobile Manufacturing High Noise Industry	1999 Taiwan Occupational Safety and Hygiene Conference Symposium	99/12/15	Chang, Shu Ju *

Research on Audiometer Calibration Procedure in Hospitals for Occupational Health Examination	The 12 th Conference of the Acoustical Society of R.O.C.	99/12	Chen, Liang Sing; Kuo, Shu Fen; Chen, Sing; Chen, Chiou Jong *; Chang, Shu Ju *
---	--	-------	---

Note: \*IOSH Staff

#### 5. Presentation of Theses ;V Foreign Academic Conferences

Table 7 Presentation of Theses ;V Foreign Academic Conferences

Topic	Conference	Date	Authors
The Development of a Temperature Alarm Device for Failure Prevention of the Automobile Hydraulic Brake System	The Engineering Society for Advancing Mobility Land Sea Air and Space	99/3/1-4	Tai, C.F. *; Wu, S.H. *; Gau, C.Y. *; Lee, S.J.; Lin, K.F.
The Development of an Alarm Device for the Moisture Content in the Hydraulic Fluid of the Automobile Brake System	The Engineering Society for Advancing Mobility Land Sea Air and Space	99/3/1-4	Gau, C.Y. *; Lee, S.J.; Lin, K.F.; Lin, B.T.

Belt and Postures on Lumbosacral Orientation	XIVth International Occupational Ergonomics and Safety Conference	99/5/19	Lee, Y.M.; Chen, C.Y. *
HSP 70 Related Epitops Are Common Allergenic Determinants for Barley and Corn Anti-gens	Meetings of the International Council of Electrophoresis Societies 1999	88/5/25-28	Chiung, Y. M.*,  Lin B. L., Yeh, C. H., Lin, C. Y.
Immunoblot Analysis of Components of Aspergillus Species Recognized by IgE Antibodies in Sera from Pig Farm Workers	Meetings of the International Council of Electrophoresis Societies 1999	88/5/25-28	Chiung, Y. M.*,  Lin B. L.,  Shen, H. D.

Note: \*IOSH Staff

## II. Publications

Primary publications of IOSH include research reports, the Institute of Occupational Safety and Health Journal, IOSH Newsletter, Annual Report, and technical books (see Table 8). Depending on the nature of the organization, appropriate publications are sent to enterprises, government agencies, research agencies and associations, in order to distribute research results and information on occupational safety and health. For fiscal year 1999, a total of 10 new publications were published, with approximately 5,000 copies

printed.

Table 8 Publications for Fiscal Year 1999

<b>Title</b>	<b>Type</b>	<b>Issues</b>	<b>Copies</b>	<b>Remarks</b>
1998 Annual Report	Yearly	103	150	To save on printing expenditure and achieve promotion purposes, starting in Fiscal Year 1997, annual report was available on the internet. A compact disc version would be sent to various libraries for filing and management.
Institute of Occupational Safety and Health Journal	Quarterly	4	1100	Vol. 7 No. 1 to 4
IOSH Newsletter	Bi-monthly	6	4600	No. 33 ~ 38
Technical Books	Irregularly	8	200	Titles as per Appendix

### III. Information Services

#### 1. Library

In conjunction with the development of the National Information Infrastructure, IOSH continues to expand its library collection and to upgrade the quality of its software and hardware, in order to support safety and health research. For the fiscal year 1999, the library had a collection of 3,360 books and 99 periodicals (see Table 9), including research reports, bulletins, conference proceedings, reports of fact-finding missions and studies. It is also open to public, providing up-to-date safety and health information services to enterprises.

Table 9 Collections in the IOSH Library

Type	1998	Addition/ Subtraction in 1999	Total
Books	3,290	+70	3,360
Subscribed Periodicals	100	-1	99
Chinese	40	-3	37
English	45	-2	43
Japanese	15	+4	19
Audio Visual Materials	257	+17	257
Video Tapes	43	+17	60

Audio Cassettes	214	0	214
-----------------	-----	---	-----

## 2. IOSH's Computer/Networking Services

The main purpose of the IOSH's computer/networking services was to support various occupational safety and health researches, and to provide useful information on occupational safety and health. In 1999, the Internet networking services were much expanded.

1. The search engine for the database in the IOSH library became available on the internet;
2. Newsletters by IOSH were became available on the internet;
3. The Institute of Occupational Safety and Health Journals were totally available on IOSH's web site;
4. Provided Audio/Video stream data by RealProducer?. One can view them with RealPlayer? installed in his/her personal computer. (RealProducer and RealPlayer are trademarks of RealNetworks, Inc.)
5. Fix the Y2k problem;
6. Established the Workers Insurance Database for statistical purposes; the Workers Physical Examination Database, and database on Hearing Monitor System for workers in the Noise Producing industries which also became available on the internet.

In order to create an automated office environment, we built a Windows NT? (which is a trademark of Microsoft) server to provide

an intranet environment in which formats for official documents can be reproduced automatically. The staff hours may now be recorded and checked, and other matters in IOSH such as registration for the use of company vehicles, use of meeting rooms may all be done by using web browser.

#### IV. Technology Promotion and Services

For the year 1999, IOSH sponsored two exhibitors, assisted in three investigations into suspected cases of occupational diseases, and offered inspection apparatus calibration services four times (see Table 10-13).

Table 10 Exhibitions

Topic	Summary of Activities	Location	Date
Results Presentation and Exhibition of Research Technologies in Safety and Health	Co-operated with the 1999 Taiwan Employment Safety Conference. Eight study results in Safety and Health were exhibited.	Commercial Times Plaza	99/9/4-16

Exhibition of Occupational Safety and Health Equipment, Exhibition of Personal Protection Equipment and Exhibition of Research Results of IOSH	Coordinated with the 1999 National Seminar on Occupational Safety and Health, exhibited 10 research results of IOSH, and attracted more than 2000 people to attend.	Student Activity Center No. 2, National Taiwan University	99/12/27-28
--	---	---	-------------

Table 11 Investigation into Suspected Cases of Occupational Diseases

Name of Organization	Items Investigated	Date
Taiwan Water Company	Trenching Collapse	99/3/30
Nan Cheng Metal Company	Vapor Explosion	99/8/23
China Oil Company, Da Lin Branch	Explosion of oil tank	99/11/25

Table 12 Inspection of Apparatus and Calibration Services

Name of Agency	Services	Date
Inspection Organizations	70 photometers	99/2-99/4

Inspection Organizations	128 Audiometer and Noise meters	99/2-99/5
Inspection Organizations	1 wind tunnel and 36 anemometers	99/2-99/5
Inspection Organizations	12 oxygen and combustible gas detectors; 24 industrial safety inspection apparatus	99/3-99/5

Significant research results of the IOSH, such as the highly mobile ergonomic chair and the newly-developed safety helmet for construction sites, have a set of regulations and procedures to follow. Patent application and technology transfer must be conducted. It is hoped that this business activity promotion could urge the further integration of research and practice and actively contribute to occupational safety and health in Taiwan.

Table 13 Patents

Patent No.	Invention	Inventors
ROC Patent No. 106800	Assessment Method and Apparatus for the Extent of Absorption on Human Skin	Shih, Tung Sheng *; Wang, Peng Yau
ROC Patent No. 115332	Construction Site Safety Helmet	Wu, Shi Siong *; Kao, Chong Yang *; Hsu, Yeh Liang; Yeh, Huei Jun

ROC Patent No. 138568	Carving Knife for Meat Products	Wang, Mao Jun; Lee, Cheng Long *; Wu, Sio Wei
ROC Patent No.139806	High Mobile Ergonomic Working Chair	Yo, Ji Yun; Lee, Cheng Long *
ROC Patent No.142652	Alarm Sensing Device for Preventing Mobile Crane to Accidentally come in contact with High Voltage Wireline	Tai, Ji-Fu*; Su, Wen Yuan *; Yang, Cheng-Fa; Wu, Chi Rei; Yen, Shi Siong
ROC Patent No.145669	Electrical interlocking safety belt	Wu, Shi Siong *; Kao, Chong Yang *
ROC Patent No.146454	Pipe riding safety device for preventing trench collapse	Wu, Shi Siong *; Lin, Jen-Jong *; Hsu, Zheng Yang
ROC Patent No.146455	Wheel Type Safety Device for Preventing Trench Collapse	Wu, Shi Siong *; Lin, Jen-Jong *; Hsu, Zheng Yang
ROC Patent No.147647	Two-way Safety Helmet	Tai, Ji-Fu *; Wu, Shi Siong *; Kao, Chong Yang *; Hsu, Yeh Liang
United State Patent Number: 5,774,900	Industrial Safety Helmet	Wu, S.H. *; Gau, C.Y. *; Hsu, Y.L.; Tsay, H.S.

United State Patent Number: 5,575,534	Highly Mobile Ergonomic Working Chair	Yo, Ji Yun; Lee, Cheng Long *
United State Patent Number: 5,984,868	Assessment Method and Apparatus for the Extent of Absorption on Human Skin	Shi, Tung Sheng * Wang, Peng Yau
European Patent No. EP 0 837 312 B1?Germany and France?	Airborne Particle Sampling Method and Apparatus using a Denuder	Chen, Chi Chieh; Shih, Tung Sheng *; Yeh, Wen Yu *; Lai, Chuen Yu

Note: \*IOSH Staff

In terms of exhibition activities, IOSH's Exhibition Vehicle began its virgin voyage since March 29, 1999. Until the end of December, it has successfully toured through 60 exhibitions. Among these were schools of all levels, industrial areas, business districts and related joint activities. It is estimated that 35,000 had attended these exhibitions. Based on the evaluation of the exhibition questionnaires, 85 % of the participants were able to understand the contents displayed and realize the importance of occupational safety and health. To raise the interest in the exhibitions, newer displays and designs were constantly created. For example, in the first half of June, an instrument for preventing electric shock from electric handling driller was added. A hazard prevention device for the press and cutting machine and a mini static electric ball were also put on display. The introduction of these new products helped the Exhibition Vehicle to become more versatile; on the one hand it reached the goal of displaying the professional needs of IOSH and on the other hand it fulfilled the lively and attractive nature of exhibition displays.

After almost a year's operation and through the resultant experience, it is apparent that there is a tremendous need for receiving

education and training in safety and health among high school and vocational school students as well as regular business enterprise workers. On the same token, it is realized that policies should be made based on the nature of the guests of the exhibitions, such that different content of display is provided. In view of available manpower, the operation of the IOSH's Exhibition Vehicle has been temporarily transferred to private occupational safety and health organizations starting in the middle of October 1999. There is still a lot of room for improvement in exhibition activities for the future. In particular, new designs and products will be displayed and created to enhance the effectiveness of the exhibition tours. Other areas of development will include accessories for the exhibition vehicle and enhancing display software in various safety and health exhibitions. It is hoped that through the promotion of the exhibition tour and activities, that the guests of the exhibition may become aware of various occupational hazards, and that they will be cautious of the occupational safety and health of themselves and those around them while working.

## V. International Exchange and Cooperation

Table 14 Oversea Research Trips

Area	Country, Organization	Topic	Name	Date
Research Trip	Japan, Chemical Hazard Prevention and Related Organizations	Management Investigation and Policy Control on Harmful Chemical Substances in Industrial Work Places	Tang, Da Toung; Chen, Chun Wan	99/3/8-17

Research Trip	Japan	Safety Managing Techniques and Education Promotion in Chemical Manufacturing Process	Chang, Cheng Ming	99/4/11-17
Research Trip	USA, OSHA; Canada	Control Technologies for Work Place Hazardous Substances and attended AIHCE annual meeting	Chang, Jing Wen	99/6/1-12
Research Trip	University of California, USA	Attended World Safety Organization's "Safety and Incident Prevention" international conference and toured ergonomics and ventilation laboratories.	Yeh, Wen Yu	99/9/25-10/6
Research Trip	US OSHA & NIOSH, University of Cincinnati	"Management System for Occupational Biological Hazards"; attended the 9 th International Conference on Respiratory Prevention and Protection; collected information on prevention and protection of biological hazards.	Chang, Jing Wen	99/10/4-11/3

Study	Germany & Great Britain	Visited & studied the German Occupational Safety and Health Exhibition and Promotion and the International Occupational Safety and Industrial Hygiene Exhibition; visited the British Occupational Hazard Prevention Association, comprehending methods of promoting occupational hygiene and preventing occupational hazard.	Chen, Eng Cho	99/10/30-11/12
Research Trip	USA	Occupational Safety and Hazard Preventing Techniques	Shen, Yu Lin	99/11/16-27

## APPENDICES

### I. Technical Publications

Serial No.	Title	Publishing Date
IOSH88-T-027	Computer work station on safety and health guide	99/1

Translation	Safety standard and guide for semiconductor equipment and material; XSEMI S1-S11 (Chinese translation)	99/1
IOSH87-S-121	Handbook on construction industry safety techniques?concrete engineering	99/4
IOSH87-S-123	Handbook on construction industry safety techniques?foundation engineering	99/4
IOSH87-S-124	Handbook on construction industry safety techniques?steel structural engineering	99/4
IOSH88-T-028	Handbook on assessment techniques for occupational pressure in workers	99/5
Handbook	Handbook on hazard prevention and health of computer operating personnel	99/6
Translation	US OSHA Ergonomics project standards (draft)	99/12