



## **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, 2000 and ending on December 31, 2000. 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 2000, 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 2000) for readers' reference.

Director of IOSH

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#### **Introduction**

##### **I. Overview**

The Institute of Occupational Safety and Health (IOSH) was established in August 1992. 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 2000, with the completion of 120 projects for 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 131 publications, 1 exhibition, 12 academic conferences, thesis presentation in 38 local and foreign publications, 41 local and foreign academic conferences, and 6 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

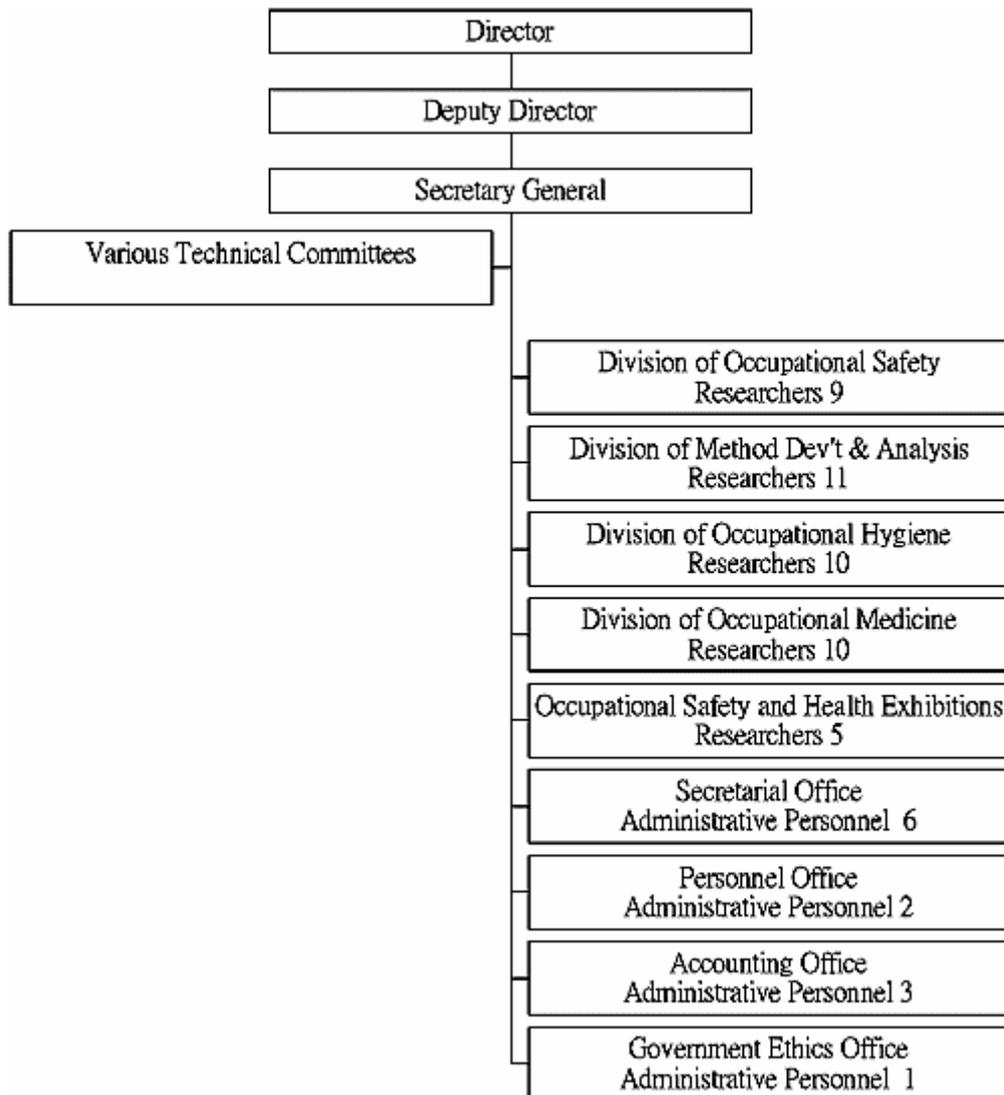


Figure 1 Organizational Structure

### 2. Analysis of Research Positions

Table 1 Analysis of Research Positions

Positions	Researcher	Associate Researcher	Assistant Researcher
Number of Employees	16	22	11

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

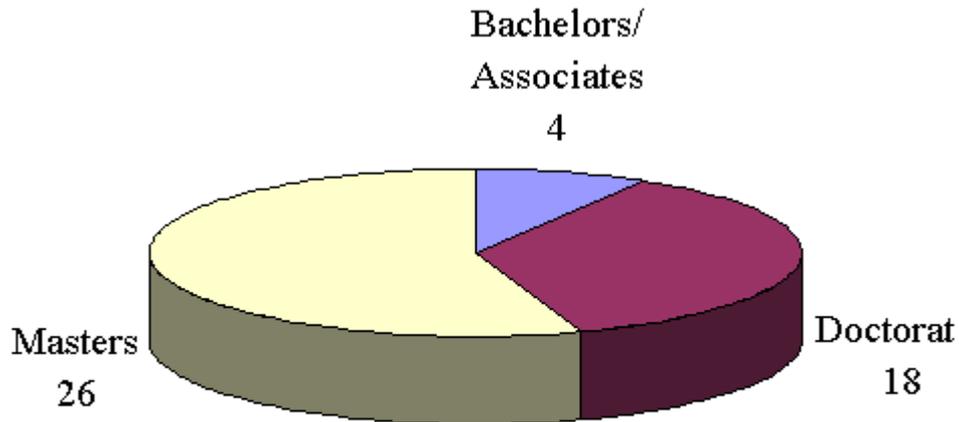


Figure 2 Analysis of the Level of Education in the Current Research Personnel

Note: 1. 1 position is open.

2. Doctorate researchers include 4 that are on fix-term contract

3. Currently, 4 research personnel are undertaking doctorate studies.

**III. Research Expenditures**

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

Table 2 Budget for Fiscal Years 2000

Unit: NT\$ 1,000

Subject	Budget for FY 2000*
Occupational Safety and Health Research	157,626
Occupational Safety Survey and Research	38,553

Method Development and Analysis Technology Research	32,319
Occupational Hygiene Survey and Research	36,096
Occupational Medicine Survey and Research	35,101
Occupational Safety and Health Exhibitions	15,557

\*Note: Fiscal year 2000 budget is calculated by dividing the budget for the second half of 1999 and the year 2000 by 1.5.

2. Analysis of Research Expenditures over the Years

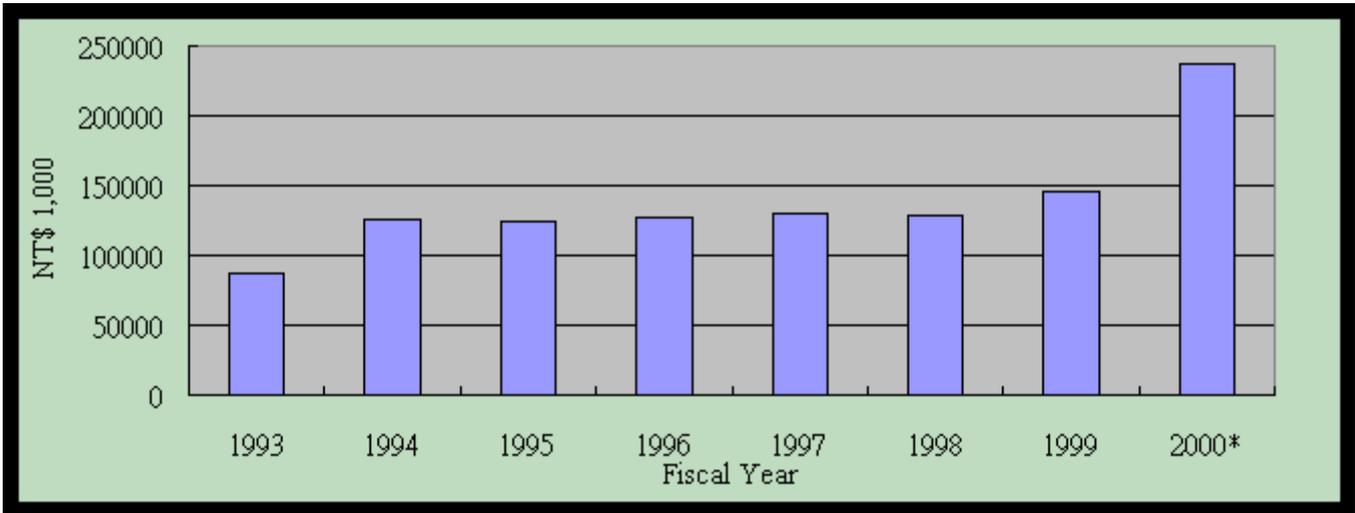


Figure 3 Budget for Fiscal Years 1993 to 2000

Note: 2000\* includes the second half of 1999 and the year 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 city 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. Building construction is completed in June, 2001.
5. The new buildings of IOSH will be located on:

No. 99, Lane 407, Hengke Rd.,

Hsi Chi, Taipei

Taiwan, R. O. C.

## 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. The Division of Occupational Safety is responsible for research on occupational safety management, on technologies for mechanical safety, chemical engineering safety, electrical safety, construction safety, on functional testing and certification of protection equipment, and for assisting the investigation of occupational injuries. Research areas include mechanical safety, chemical engineering safety, electrical safety, construction safety, protective equipment and safety management policy. Research focuses on safety equipment and technology, warning and monitoring technologies, risk control and intrinsic safety technologies, personal safety equipment with design for comfort, safety management policy, and recommendations for revisions of regulations, standards, and 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.

#### 2. Research on Mechanical Safety

Statistics of inspections of major occupational injuries shows that 130 cases have occurred in the manufacturing industry in 1999, only second to the construction industry. Struck by object, caught in or compressed by equipment, cuts and abrasions are the most common type of occupational injuries, which most of all were due to unsafe machinery. Research therefore

focuses on cranes, lifts, boilers, and pressurized vessels 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.

### 3. Research on Electrical Safety

Occupational electrocution incidents are the second leading cause of serious occupational injuries. Technical guidelines for explosion-protected electrical apparatus are also lacking. Short-term objectives for prevention of electrocution include investigating electrocution incidents, discussing safe facilities and management methods, establishing technical guidelines, and developing and improving warning and protective devices. Short-term objectives for explosion-protected electrical apparatus research include investigating apparatus installed, analysis of regulations and guidelines between domestic and overseas, appropriate choice and installation, and maintenance technologies of apparatus. We will focus on grounding safety technologies for preventing electric shocks, low-voltage line safe problems, and editing the guideline of maintenance and inspection for intrinsically safe explosion-protected electrical apparatus.

### 4. Research on Chemical Safety

Focus of research includes safety and risk assessment of chemical processes, storage and transportation 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, modeling 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, proposing safety standards and testing methods, comfort design and development of new safety protection equipment. It leads to promote the safety and willingness for labors to use these equipment.

### 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 for both employers and employees. Trends of types of occupational injuries, geographical distribution, and personal

factors were analyzed 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 improve functions of safety management.

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

Research on Method Development and Analysis aims to develop methods for detecting hazardous substances in the workplace, and for evaluating workers' exposures, as well as to promote laboratory QA/QC and the system for accrediting laboratories, in order to prevent occupational diseases, enhance productivity and the quality of the work environment. According to the operational directives 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. Chemical hazard exposure studies are a series of studies among workers in high-risk industries. Together with exposure monitoring and occupational disease surveillance, these studies will be helpful in setting comprehensive and feasible regulations and policies. 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. 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.

### 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.

### 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.

## **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. Research is directed

towards

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;

1. Support and promote systems necessary for the establishment of occupational safety and health regulatory system, and assist enterprises in finding solutions to difficulties encountered;
2. Obtain important localized data in occupational hygiene, to provide references for regulatory amendments and improvements in the work environment;
3. Introduce technologies to prevent possible occurrence of major occupational diseases;
4. Provide research results to the Council of Labor Affairs, to serve as a reference for amendment of regulations.

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. 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 occurrence 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 2000, data have been collected 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,. Based on these data, analysis of the indices is publicized periodically through the web site of the Institute for the public and the workers. 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.

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. A monitoring system for blood lead has been developed. Norms for workers' hearing threshold has been established.

##### **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 these researches 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, investigating and further fulfilling the needs for policies and regulatory requirements. In addition to chemical hazardous factors, research emphasis is also focused on new emerging occupational diseases and physical hazardous agents.

### 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.

### 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.

## Chapter III Research Results

### Section 1 Occupational Safety Research

The abstracts of occupational safety research in 2000 are as follows:

A. Mechanical Safety Research: focused on analyzing hazards posed by construction equipment and developing monitoring devices.

Researching and Developing the Dangerous Machinery Virtual Reality Training System:

Manufacturing and Popularizing the VR Training System and Multimedia Education System of Cranes: A hydraulic motion platform has been re-designed. And a computerized six-degree-of-freedom motion platform has also been developed. Problems related to noise and pollution generated from hydraulic motions has been resolved. At the same time, the modular computer system for simulation is built upon a dispersed, interactive software platform for data processing, and uses Direct 3D database for 3D graphics and sound outputs, for higher quality overall performance. It is also equipped with advanced CAVE functions, capable of simultaneous display on up to three monitors. A new 360-degree electrical walking platform has been developed, to enhance the accuracy of real-time walk analysis and assessment, the first time that such training platform has been developed locally. This simulation system is a prototype and is ready for commercialization.

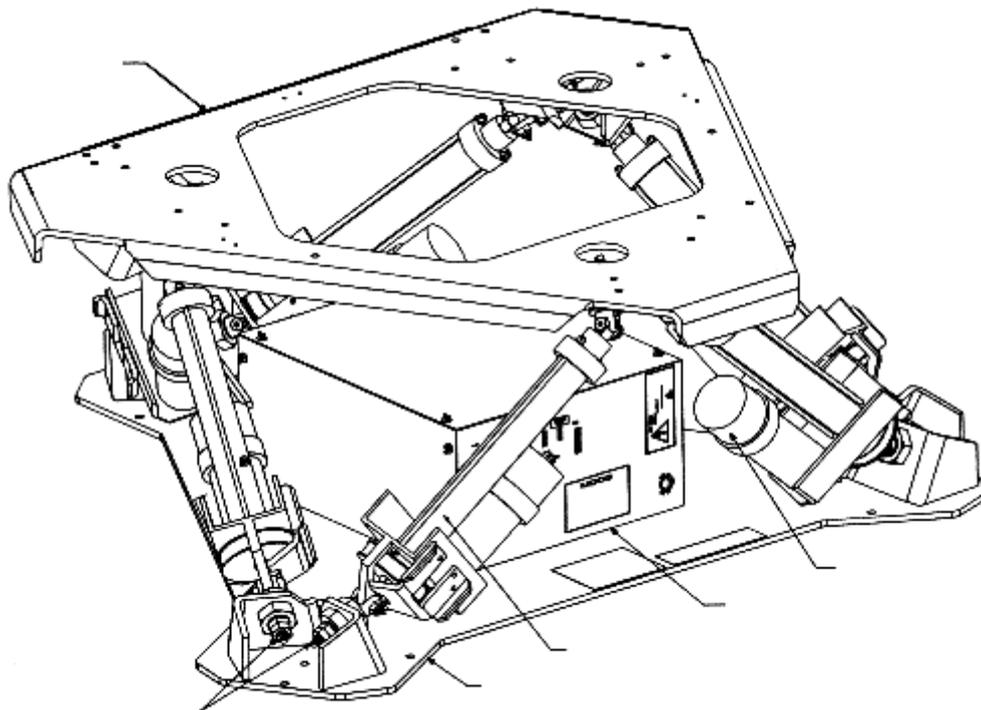


Figure 4 Motion Platform Component

Test and Technology Transfer of an Alarm Device for Failure Prevention of Automobile Hydraulic Brake System: Functions in signal detection, processing and decision-making functions of the previous developed alarm prototype have been modified, which makes the system simpler and increases sensor stability and system reliability. The device has an improved water-spray control system to cool down the heat generated by braking actions on the brake system, as an active preventive measure to decrease the possibility of malfunction. Preparatory work for the transfer of technology, including prototype improvement, system testings, installation and manufacturing processes, and compilation of technical data, was

completed.

The Study of Climbing Operation Safety for Tower Cranes: Analytical tools (PFMEA and FTA) are used in predicting failure modes and finding the causes of occupational injuries, then engineering control and other preventive measures are proposed. Through computerized 3-D motion simulation, a safety analysis model for climbing operations for tower cranes has been established, serving as a reference for preparing standard operation procedures. A safety technical handbook has been compiled for training tower crane operators and maintenance workers.

The Improvement of Secure Stabilizer of Gondola Operation: Dynamics of gondola operation platform has been analyzed. A stabilizing device is studied in design, prototype construction and environmental function testing mechanism. This device can secure the gondola against the wall or the glass and decrease the hazards created by movements of the gondola during operation.

Test Evaluation and Redesign of an Over-Winding Prevention Device for the Truck Crane: Overwinding prevention device has been tested on truck cranes, and the tracking data were collected to improve the features of the device. Specifications of this device and a technical manual for its installation have been developed. To promote and expand the use of such a device, suggestions on commercialization and mass production were also made.

Study of Improvement of Safety Devices for Preventing Fall for Aircraft Maintenance Workers: A semi-automated maintenance platform positioning system has been developed. It can help to increase overall safety and competitiveness for local aircraft maintenance industries. Two designs have been proposed for the steel wiring safety device on the maintenance platform. Evergreen Aviation Technologies Corp. has adopted these devices to improve its workplace safety.

Design of Remote Control Released Device for Crane's Payload: This system has an integrated electro-mechanical design that puts operator safety as its highest priority. With wireless remote control, the payload will be released automatically, decreasing the probability of injuring the operators, as well as simplifying operating procedure and maximizing the use of the available human resources for higher work efficiency.

Study of Safety Coupling Device for LPG Pipe (II): Continuing the study conducted in the past year, a safe connector for the flexible tubings on LPG tanker has been developed. It meets related quality and functional standards, but costs less than similar imported devices, which will increase the likelihood of its use by the industry and enhance local capability to design and manufacture such connectors. Recommendations for regulations and standards for safe connectors were also made.

Study of Hazards and Safety System of Injection Molding Machines: Safety regulations, standards, testing methods, and certification system for injection molding machine has been

proposed, with reference to those already in place in EU, USA, UK, and Japan. Local injection molding machine manufacturing industry can use it as an operating standard, to elevate its product safety and image. Those in injection molding processing industry can also use it when purchasing or using such machinery, to decrease the incidence of occupational injury.

Developing Localized Industrial Mechanical Safety Data Sheets (II): Technical information for mechanical safety, including safety guarding, operating procedures, safety evaluation, possible injuries and related preventive measures, have been compiled, as the basis for safety improvements made by manufacturers and users alike.

The Survey of Facilities and Tanks in Factories after the Ji-Ji Earthquake and the Compilation of Safety Instruction Manuals: The study provides reference standards for factories after a major earthquake, for equipment and installation, inspection, maintenance, emergency preparation and response, temporary substitutions for the integrity of machinery.

The Study of Regulations and Standards of Aerial Lift: Standards and regulations for aerial lifts from around the world are gathered to develop a proposal suitable for local conditions. It can then be used by agencies such as the Bureau of Standards, Metrology and Inspection, to set standards on par with international ones.

Technique of Non-Open Inspection Codes in Pressure Vessel: The study offers an alternative for the open inspection code. Equipment for pressurized gases should be inspected first. Information on standards and systems used in other countries should be collected, to assist inspectors in understanding how information is managed in an enterprise internally to ensure equipment safety in the workplace. Government inspection agencies should set effective and feasible inspection standards. Inspections should focus on methods for implementing OSI, risk assessment, and determination of the remaining lifespan of the equipment. Private inspection agencies can be entrusted with the authority for document review and on-site inspection.

Development of User-friendly Structural Safety Checking System for Pressure Vessels of the First Kind: A computer-assisted calculation system with user-friendly interface design has been developed for regional inspectors. The system includes a material database, testing calculations, and a digital reference database. In order to assure data security, the system includes a triple encryption security measure.

## B. Chemical Safety Research:

Automatic Fault-Tree Drawing System for the Fire, Explosion and Leaking Event of Equipment in the Chemical Factory: Simplified safety assessment software for corporate use has been developed. Through an interactive, Q&A format, it generates a text file of systematic malfunctions, along with five possible causes of chemical equipment failures.

Investigation of Physical Explosion: Basic steps to determine the cause of physical explosion and a mathematic model for physical explosion have been developed for labor inspection

agencies.

Study of Dangerous Material Amount Limitation in Dangerous Area: A proposal for regulating workplace with hazardous substances has been developed for labor inspection agencies, based on the risks after the leakage of specific dangerous substances, and the minimum amounts above which a workplace is considered hazardous and requires assessment in various countries.

Mechanical Integrity Study for Maintaining Piping & Reactors in Chemical Plants: A technical manual for mechanical integrity has been developed, focusing on what enterprises in Taiwan frequently overlook, with related literature from other countries as references.

Safety Evaluation of the Positive Pressure (Gas Supply System) in the Semiconductor Fabs: Operations and maintenance safety assessment for gas supply system in semiconductor fabs has been conducted, using failure models and impact analysis methods. A guide for operating and maintaining such systems has also been developed.

#### C. Construction Safety Research:

Study on Construction Safety and Health of Facility Standard: Excavating Ground in the Open: For this operation with high incidence of occupational injury, risks associated with construction methods and machinery have been identified from analyzing cases of occupational injury. Recommendations for protective devices and measures, as well as for regulatory revisions, have been made.

Construction Safety Data Sheets (II): Safety assessments have been conducted according to the types of construction machinery, methods and operations utilized, to identify possible causes of injuries and their preventive measures. Construction management and workers can use this local construction-safety technical database to improve occupational safety and decrease the incidence of injury.

Technology of Construction Safety for Falsework of Higher Clearance and Large Placing Concrete Area: The study has analyzed the amount of support provided by different types of falseworks for the construction of high clearance and large placing areas, including simple framed steel tubes, adjustable steel tubes, wood, steel structure, and a mix of the above. From the analysis of the cases of collapse in Taiwan, the study deduces the possible causes for the failure in support. These results can be used by labor inspection agencies when inspecting falseworks at construction sites, as well as offering recommendations for revising related regulations in the "Construction Safety and Health Facility Standard".

Safety Evaluation of Scaffolding Using in Domestic Construction: The study uses field surveys for a comprehensive record of the actual conditions of scaffolding around Taiwan. Its quantitative results are used in reviewing related articles in the current "Construction Safety

and Health Installation Standard", to see if it is appropriate and up-to-date.

**Safety of Scaffold Structures under Wind and Seismic Loading: Preliminary Study:** This is a pilot study of the safety of scaffold structures under high environmental stress such as earthquake or gusty wind, as a basis for planning future research.

**Establishing the Working Manual of Construction Safety for Bridge Design:** In order to assist construction and bridge design professionals in incorporating safety concerns into the construction design and planning process, operating procedures and standard forms during each stage have been developed, including "construction design requirement safety analysis", "safety audit of construction site", "safety audit for assignments", "construction design safety review". To ensure that safety concerns are expressed in request-for-tender documents, operating standards and record forms such as "safety considerations during construction planning", "planning and design of safety measures", "setting construction safety rules", "budget for safety and health installations", "setting reasonable construction schedule" have also been developed.

**The Survey of Labor Safety and Hygiene During the Stages of Structure Demolition and Work Resumption after the Ji-Ji Earthquake and the Compilation of Safety Instruction Manuals:** The study focuses on the safety conditions and the work environment of workers involved in demolition and rebuilding after the earthquake on September 21, 1999. This data has been used to develop several safety operating manuals, as future references for occupational safety and health in similar activities after a major earthquake, including rescue, demolition, resumption of operations, and building of temporary structures.

**Guide of Falling Protection in Construction:** The study develops fall protection technologies. Information on the causes of occupational injuries related to falls have been gathered and analyzed. Appropriate preventive measures, such as standards for fall prevention equipment, the occasions for their uses, and their operating procedures, safety management, and training materials, are included as references for implementation in the construction industry.

**D. Electrical Safety Research:** focused on grounding safety simulation and analysis, low-voltage electric line safety technologies and editing the guide of maintenance and inspection for intrinsically safe explosion-protected electrical apparatus.

**A Study on Grounding Safety Techniques for Preventing Electric Shocks:** The study explores problems associated with grounding safety of low-voltage equipment. Analyze characteristics of ground potential rise from grounding fault current and the ground potential rise on grounding metal plates and rods are analyzed by applying FLUX 3D finite element method. Regulations related to grounding in Taiwan and in other countries are compared. CDEGS program is used for failure analysis of grounding net. Field tests are performed to obtain actual data of ground potential rise on grounding rods and records the touching voltage on a simulated human body model.

Editing the Guide of Maintenance and Inspection for Explosion-Protected Electrical Apparatus: Type of Intrinsic Safety: The study focuses on major types of explosion-protected electrical apparatus. Fault tree analyses have been performed to discover risk factors. A checklist and a maintenance and inspection technical guide have been developed for such apparatus.

The Electrical Safety of Low-Voltage Lines in the Plants: Electric safety related to the use of low-voltage lines by local factories is studied. Local regulations are compared with those from more advanced countries, and a proposal for improving safety has been developed.

E. Research into the Functions of Personal Safety Protective Equipment: focused on testing the functions of personal safety protective equipment, developing personal protective equipment and improving their design and comfort.

Safety Standards and Functional Test of Personal Protective Equipment: Eye Protector: Testing equipment for three safety goggle wearing comfort indicators (field of vision, fogged light penetration, pressure on the face) are developed. Testing procedures are standardized and automated to improve the precision and the validity of testing results. Study results can be applied during design, manufacturing and selection of safety goggles.

Design and Manufacture of Safety Devices for Concrete Filling-Process Inspectors: This device can be used by concrete filling-process inspectors, to protect them from getting injuries as a result of the collapse of formworks. Designed especially for the construction sites, the portable safety device can withstand the impact of the collapse of formworks, and is easy to make, assemble and use. It also will not interfere with inspections of formworks.

F. Safety Management and Policy Research:

The Feasibility Study of Combining the Management System of Safety & Health with Quality and Environment Systems: Operational Practice: The contents and the certification processes of BS 8800, ISO 9000, ISO 14000 have been compared and analyzed. Through questionnaires, on-site visits, and expert consultations, items and ways by which these three systems can be harmonized are identified. A manual to assist enterprises in increasing management efficiency, and a proposal of corresponding government measures, have been developed.

The Survey of the Working Place for the Disabled and the Compilation of the Safety Guides: Work characteristics and hazards for various types of disability have been studied. Feasible preventive measures and safety guides have been developed for different types of disability.

The Comparison of Safety and Health Management System between R.O.C. and Developed Countries: Safety and health management system, organization and operations in Taiwan are compared with those in industrially advanced countries, to clarify whether their major components are driven by regulation or derived from the management system itself. The results show that regulations related to management are basic in nature, mostly independent

of each other and scattered in different codes. In contrast, standards, guidelines and systems are systematically arranged. Regulations focus on safety and health organization, its operations and safety and health personnel. The study includes a proposal for revising related regulations in Taiwan.

Besides research, the Division of Occupational Safety has also conducted the following in the year 2000: participating in the investigations into major occupational injury incidents with labor inspection agencies; assisting enterprises in resolving occupational safety problems; cooperation and exchanges with academics in Taiwan and in other countries; sponsoring research result seminars and occupational safety conferences; calibrating safety measurement devices used by labor inspection agencies; and planning the use of the space in the new research building.

## Section 2 Method Development and Analysis Research

The abstracts of method development and analysis research in 2000 are as follows:

### A. Chemical Hazard Exposure Survey:

Exposure Assessment Technique for Polycyclic Aromatic Hydrocarbons (PAHs) in Workplace (I): Polycyclic Aromatic Hydrocarbons, or PAHs, and their derivatives are present in fairly large quantities in petrochemical raw materials and their products. In addition, industrial processing, aluminum and steel refining, automobiles, and asphalt processing may also release these substances. Past literature showed that chimney sweepers have high incidence of the cancer of the scrotum. Further study showed that asphalt and coal tar refining produces carcinogen benzo(a)pyrene, which, along with other PAHs, became well-known environmental carcinogens. PAHs can also lead to dermatological, respiratory, and neurological disorders, which cannot be overlooked when evaluating PAH workplace exposure. This study establishes environmental and biological monitoring methods for PAH, in order to uncover potential occupational exposure for the protection of workers' health.

Exposure Assessment Program for Workers in Hazard Industries: Formaldehyde, Hydrofluoric Acid, and Toluene-2,4-diisocyanate: Occupational exposure assessment is one of the primary activities of industrial hygienists. The purpose is not only to see if the exposure levels meet regulatory limits, but also whether such levels are acceptable to workers. Cases of suspected occupational diseases have been associated with toluene-2,4-diisocyanate in PU foam, PU resin, and adhesives productions; formaldehyde in formaldehyde resin or wood and bamboo product industries; hydrofluoric acid in stainless steel cleaning or semiconductor or liquid crystal display production. The study focuses on understanding exposure conditions of workers related to the above substances.

Crystallized Free Silica Content Survey of Often Used Stone Materials in Taiwan: The study assesses crystallized free silica contents in 100 common stone materials in Taiwan by using X-ray diffraction analysis, as a reference for preventing silicosis. Crystallized free silica content is

the highest in limestone. This information should be included in the literature for related industries. Respiratory exposure in masonry and in the construction industry requires further study.

**Sampling and Analytical Method for Airborne Hydrogen-Containing Chlorofluorocarbons (HCFCs): Field Validation and Survey:** The sampling and analytical method of HCFC-141b developed in 1999 is tested in the second factory site, both in the laboratory and in the workplace. Enterprises may refer to the proposed standard operating procedures. An exposure survey has also been conducted, using the method mentioned above, providing the necessary information for setting inspection priority and future research directions.

**Workers Exposure Assessment Techniques for Mercury Vapor:** This study explores workers' exposure to mercury vapor in fluorescent lighting factories, including environmental monitoring and biological monitoring. In environmental monitoring, the difference between traditional active sampling method using tubes and pumps and newly developed passive badge-type samplers is studied in two domestic fluorescent lighting factories for at least a six-hour work shift. In biological monitoring, blood and urine specimen have been collected from workers for analyses of total mercury and inorganic mercury species.

**Survey on Workers Exposure of Ethylene Oxide (III):** In order to assess ethylene oxide concentration in the work environment, and workers' exposure to ethylene oxide in the sterilization process, samples have been taken from the following areas: workers' breathing zones, areas by sterilizers, ventilators, and ventilation systems, gas storage and supply areas, storage areas of sterilized and disposable medical instruments, and others that may have high ethylene oxide concentration. Active sampling has been conducted using activated charcoal containing hydrogen bromide as the medium, with sampling flow rate set at 50-200 mL/min. They are desorbed by using a mixture of methylene chloride and methanol, and are then analyzed directly using GC/MS. Active samplers can only take measurements for a short period of time, which may result in the underestimation of the exposure concentration because the amount of ethylene oxide sampled is too small. However, if direct-reading devices (such as infrared spectrophotometer or real-time chemical detectors) can be used in conjunction, more detailed observation of the exposure conditions can be made.

**Chemical Hazard Investigations for the Preventive Maintenance of CVD Equipment in Wafer Fab:** CVD is an important part of the process for creating thin films on semiconductor wafers. During maintenance, some strongly irritating, odorous gases are released, which may damage workers' health. However, because the concentrations of these pollutants vary greatly over time, monitoring equipment that reflects actual exposure conditions is needed to ensure a safe work environment. A continuous, direct-reading and multi-species detection method has to be developed in place of the traditional work environment monitoring method. The study uses the aspiratory Fourier transfer infrared spectrophotometer to analyze the exposure to gases for maintenance workers in wafer fab operations.

**Survey of Formaldehyde Exposure in Hospitals:** The study conducts a formaldehyde exposure

survey, using a stratified sampling methods in selecting 20-25% of medical centers and regional hospitals from the list of hospital reviewed by the Department of Health. Laboratory studies of methods for formaldehyde sampling and analysis are conducted first to determine which method will be used in the subsequent study. Questionnaires and field surveys are used to determine major areas of exposure, the tasks performed by exposed workers, and how workers' exposure concentrations are distributed.

B. Development of sampling and analysis technologies for hazardous substances in the work environment:

Development of Adsorbent Tube for VOCs Analysis in Semiconductor Industries by GC/MS: The key to the success of the Taiwan semiconductor industry is its ability to maintain low defect rate. With advances in production technologies, the prevention of environmental pollutants receives increasing attention. The rise in defect rate indicates problems in the production process. However, workers' potential exposure to volatile pollutants is often overlooked in the quest to lower defect rate. These hazardous substances may not create immediate danger, or may be fatal in an instant. In addition to the known use of hazardous substances in the production process, unknown hazardous substances may also be created, by mixing two or more substances. In addition to understand the production process, continuous work site monitoring of with appropriate monitoring and analysis method is also necessary to uncover hidden exposure problems to protect workers' health.

Evaluation of Tenax-TA Passive Sampler with Thermal Desorption: This study generates standard gases by active dilution methods, including xylene, styrene, butyl acetate, ethyl acetate, tetrachloroethylene, and methyl isobutyl ketone, to be used in assessing the validity, reliability, and passive uptake rate of Tenax-TA passive sampler analyzed by heat desorption method. Detectors and activated charcoal samplers analyzed by solvent desorption method are used to determine the concentrations of standard gases. Passive uptake rates of Tenax-TA thermal desorption tubes with dispersion covers, for 0.5, 1, 2, 4, 8 hours of sampling time, are assessed with 200ppm butyl acetate, 150ppm ethyl acetate, 50ppm styrene, 100ppm xylene, 50ppm methyl isobutyl ketone, 100ppm tetrachloroethylene vapors, under 25%FVC and 80%RH. The validity and reliability of Tenax-TA thermal desorption tubes with dispersion covers for 0.1, 0.5, 1 times the permissible exposure levels are also assessed, with 4-hour sampling time and under 25%FVC and 80%RH. The result shows that Tenax-TA passive sampling method is very reliable, with variation coefficients averaging between 1.6% and 2.4%. However, the uptake rate falls with increasing sampling time. The average uptake rates for 0.5-hour to 8-hour sampling time are as follows: 1.72 ng/ppm/min for butyl acetate, 2.13 ng/ppm/min for ethyl acetate, 3.38 ng/ppm/min for styrene, 2.61 ng/ppm/min for xylene, 1.81 ng/ppm/min methyl isobutyl ketone, and 3.08 ng/ppm/min for tetrachloroethylene. For all six organic solvents, the total uncertainty for Tenax-TA passive samplers using thermal desorption analytical method is less than 25%.

Establishing Analytical Method for Pesticide Regulated by Labor Acts (II): Carbamate Pesticides Analysis: A survey of the types and the amount of agrochemicals produced by local

factories, and the types of agrochemicals used by those providing application services, has been conducted to obtain basic exposure data on agrochemical workers. Environmental exposure levels are also monitored for agrochemical workers, in order to recommend the appropriate analytical method and exposure assessment model to enterprises. Appropriate sampling tubes are selected according to NIOSH and OSHA recommendations. Analytical method is established in accordance with the "Validation Procedure for Reference Sampling and Analytical Methods for Hazardous Substances in the Work Environment". Analysis of carbamates uses high-resolution liquid chromatography, with reactive agents at the end of the compound available for fluorescence analysis. Lowest detectable limits for the permissible levels set for agrochemicals are confirmed. Different sampling media such as XAD-2 and glass filter, detection thresholds, storage stability of samples, accuracy of analytical methods are studied. The method is then used in workplace exposure survey and assessment, according to the precedent set in 1999 for field validation of analytical method in registered organic phosphate manufacturing sites.

The Automation of FTIR Reference Method: Modern FTIR reference method has the following characteristics: on-line continuous testing, instant sampling, immediate quantification, QA/QC check by on-line standards, and setting of warning system. The key to putting these functions to full use is the automation of extractive FTIR reference method. It can be used in safety and health monitoring of the work environment and the production process, including the simultaneous monitoring of hazardous substances such as fluorine, oxygen, silicon, and hydrocarbons. The study develops a prototype for an automated FTIR system, including control valves, a FTIR chamber with instant extractive sampling capability, and three sampling lines, of which one is for the addition of the standard compound. The samples can be taken statically or dynamically, and are tested with different concentrations of the standard compounds on-line, with the implementation of QA/QC to validate and ensure accurate measurements. (1) The prototype includes vacuum pump, control software and interface, dilution system that contains solenoid valves and mass flow controller (dilution factor of 10 or more), automatic sample input system (with software to control periodic intakes from different sampling lines and standard gases). The entire sampling system (including its manufacturing and assembly) must be compatible with the analytic software. (2) Automated analysis includes automatic sampling process, automated analysis, and QA/QC procedures. (3) Laboratory testing: At least two different gases are used, automatically diluted 5 times with three repetitions, and 5 periodic inputs of standard gases for automatic analysis. Standardization and functional testing of this quantitative measurement by automated means have also been conducted. The results show that automated FTIR system has high precision, and is a good tool for occupational safety and health.

The Establishment of Simultaneous Determination of Heavy Metals in Fumes by Inductively Coupled Plasma/Atomic Emission Spectrometry (ICP/AES): To meet regulatory and enforcement needs, the Institute has developed standard methods for detecting air-borne hazards in the work environment over the past few years. This study introduces the ICP/AES method developed by the US National Institute for Occupational Safety and Health for heavy

metals in fumes. The method has been validated. Another certified laboratory has been asked to perform the same testing procedure according to the draft of the standard method. The results show that it meets the requirements of the certification process. After further review by the Council of Labor Affairs, it will be promulgated as the standard method, to enhance the effectiveness, economy, efficiency and accuracy of such tests.

Methods Validation for Compounds of Carbon Disulfide, 1,3-Butadiene, Styrene and Acrylonitrile: This study evaluates passive heat desorption by using GC/MS for analysis. For carbon disulfide samples with concentrations of 0.253, 0.505, 1.263mg/sample, the average desorption efficiency is 95%. When the concentration falls below 0.253 mg/sample, desorption efficiency falls dramatically. 1,3-butadiene is analyzed under the following conditions: 180°C for injector and detector, with highest temperature of the column at 150°C. After committee review, it will be sent to the Council for promulgation. Enterprises can use the method developed as a reference for environmental monitoring.

Method Improvement for Regulated Organic Solvents in Working Environment: Literature review of the latest development in analytical methods reveals the need to revise some existing regulations. Review and Comparison of the new and the old must consider the following: accuracy, precision, stability, specificity, convenience, the need for further reaction, sensitivity, maximum sampling quantity, desorption efficiency, and cost. Priority for revision is set by considering differentiation, toxicity, the quantity used in the country, and urgency for the new methods. As for simultaneous analysis of mixtures, the study focuses on the possibility of using the same sampling methods, the similarity of regulatory extent, the possibility of using the same column for analysis, and the probability of the existence of the mixtures in the work environment. Pilot tests of the possibility for using GC for analysis have been conducted. A list of organic solvent mixtures suitable for further development in analytical methods for mixtures has been proposed, based on experimental data that have been used to evaluate the feasibility for future implementation.

### C. Developing and Evaluating the Functions of Samplers and Sampling Media:

Improvement of Fibrous Aerosol Measurement: This study uses VOMAG (model 3450, TSI Inc., St. Paul, MN) to generate methylene blue particles, and Po-210 aerosol neutralized by 25-mCi. Aerodynamic Particle Sizer (model 3320, TSI, Inc.) is used to measure aerosol concentration and particle size distribution. The filters are used to determine the deposition gradient using image processing and statistical means. Hexagonal flow direction technique is used to validate the effect of airflow field on the deposition gradient of gases on the filters. The unevenness experiment shows that for aerosol deposition counting, equal area counting is better than equal distance counting. With a simple index transformation of cover rate variation coefficients among different counting fields, one can obtain a suitable unevenness assessment index. With the new particle separation sampler with multi-pore fiber, an integrated assessment index can be established.

Research and Development of a Personal Denuder Sampler: Field Test: This study tests the

use of the new personal denuder sampler in different work sites, including fertilizer, semiconductor, aviation electronics, lead battery, and chromic acid manufacturing. The results from using personal denuder samplers are compared with those from using silicon gel tube, filter cartridge, hexagonal denuder sampler, aspirator, and Marple personal multi-level impactor. Particle distribution and pH of chromic acid mist in lead battery and chromic acid manufacturing site are studied. Particle distribution and pH of aerosol from wastewater treatment tank in semiconductor manufacturing are also studied, along with the extent of its neutralization by  $\text{NH}_3$ . Experimental study of new personal denuder on the collection efficiency of mixed aerosol is also conducted. Mathematic models are used to study the effects of particle settlement forces and multi-pore metal plates on the collection efficiency curves of the multi-level impactor. It is then compared with the experimental results from the past year. Different design parameters are used in simulation to ensure that the impactor collection efficiency curve conforms with the efficiency standards for respirable and thoracic dusts.

**Improved Method to Measure Carbon Disulfide Exposure:** This study seeks to improve the current method used to assess carbon disulfide exposure by using ATD-400 passive sampler with heat desorption and GC/MS analysis. The method is established and validated according to the protocol set by the Institute, focusing on recovery rate, precision, linearity, detection limit, lowest quantifiable limit, sampling flow rate, recurrence when used repeatedly, storage stability, detectable quantities for analyses conducted on the same day and on the next day, effects of temperature and humidity, sampling tubes and airflow directions of the exposure to carbon disulfide, flow rates for different sampling times, method validation among different laboratories. Field test and validation are performed in a factory, to compare new and old methods in simultaneous personal and area samplings.

#### D. Development of Occupational Biological Monitoring Methods:

**Comparison in Biological Monitoring Techniques for Workers Exposed to Toluene:** The only substance requiring biological monitoring according to the current Taiwan occupational health regulations is lead (in blood). However, toluene is widely used in tape, paint, plastics, and dyestuff manufacturing. ACGIH considers lowering permissible exposure level of toluene in the work environment from 100ppm to 50ppm, but the NIOSH 8301 method is only applicable to toluene detection between 200ppm and 1000ppm. Using this method to detect toluene at lower concentrations may result in variations as great as 20% to 30%. Literature shows that exhaling breath may be used in detecting lower concentrations of toluene. The results can be used to estimate the original exposure level. It is also easy to obtain such samples. In response to future regulatory needs, workers' exposure to toluene is studied using several methods, and the results can serve as references for setting regulations.

#### E. Development of Real-time Monitoring Methods for Gaseous Substance:

**Development of a New Continuous Monitor for Workers Exposed to Hazardous Organic Vapor and Gases-Field Evaluation:** Several direct-reading instruments on the market can measure instantaneous concentrations, but for measuring workers' personal exposures, these are too

bulky and too heavy. This study develops a multi-function, real-time personal detector for gases and vapors, by combining semi-conductor detection, PDA, flash memory storage, and object-oriented software development technologies. This detector can display instantaneous concentration, TWA concentration, 15- minute TWA-STEL, and peak concentration on the monitor, has alarm functions, and can be connected to PC for graphic displays and statistical analysis.

#### F. Others:

Computer-Assist Information Management System for Industrial-Hygiene Accredited Laboratories (II): A computerized information management system for certified industrial hygiene laboratories has been established, in order to: (1) decrease the manpower required for processing; (2) elevate analytical quality of these laboratories; (3) decrease the possibility of calculation errors, mistakes when transferring and re-entering data, and forgery of data; and (4) effectively understand the use and the conditions of instruments, equipment and reagents. The computerized standard operating procedure can shorten the time required for training new employees, as well as offering a relational database for storing and analyzing data, useful for tracking and checking the data. It also provides statistics for environmental monitoring necessary for understanding the actual conditions of exposure among workers in Taiwan.

Workplace Environmental Monitoring Regulation Study: This study gathers information on environmental monitoring of chemicals from UK, USA, Japan and Singapore, including regulations, required monitoring items, qualification of sampling personnel, certification system for analytical laboratories, and review of analytical capability. This study has found that Japan is different from UK and USA in the approach to environmental monitoring: US and UK focus on workers' exposure assessment and personal sampling; Japan focuses on work environmental monitoring and area sampling. Taiwan and Japan specify the required sampling items and sampling frequency. USA and UK make employers liable to conduct workers' exposure assessment when exposure levels may exceed permissible levels (or half of the permissible levels, but monitoring frequencies vary according to the exposure level. Special high-exposure operations require additional monitoring. The proposal for revising the environmental monitoring system in Taiwan includes adding monitoring items, varying monitoring frequency according to concentration, focusing on personal sampling, and notifying workers of the monitoring results.

### Section 3 Occupational Hygiene Research

The abstracts of occupational hygiene research in 2000 are as follows:

#### A. Occupational Hazard Exposure Surveys and Studies:

Occupational Chemical Hazard Survey (IV): A search computer network has been established, providing rapid search services to different types of users, while ensuring the security of the database contents and the flexibility of modifying the database according to different statistical

needs. Data from information storage and processing manufacturing, petroleum refining, and paint manufacturing industries are tested for the reliability and validity. Different industries do have significant differences, and changes in time and space are one of the influencing factors. The results above may be used as reference indices for extrapolating current exposure conditions for different industries from the contents of the database.

A Pilot Investigation of Biological Hazard Research: Research shows that future studies of biological hazards should focus on healthcare, agriculture and biotechnology industries. To protect workers from these hazards, this study recommends the following: (1) Legislation: passing the law on preventing and controlling blood-borne pathogens should have high legislative priority. (2) Reporting system: reporting systems for occupational diseases, needle injuries, and intra-hospital infection control should be integrated. (3) Personal protective equipment: wearing personal protective equipment can effectively block the entry of microorganism into the human body, and is also cost-efficient. (4) Environmental survey: the work environment of agriculture and biotechnology industries, including aerosol, microorganism count, mold count, and endotoxins, should be studied. (5) Permissible exposure levels: International recommendations for permissible exposure levels for organic aerosol and endotoxins are already available. Upon confirmation, Taiwan may include these standards. (6) Health examinations: For appropriate employee selection and job assignment, different industries should have different health examination items, based on the health risks present in the industry. (7) education and training: Periodic education and training mandated by the Labor Safety and Health Law should be enforced, especially in disseminating information on preventive measures against blood-borne pathogens.

Assessment of Exposure to Glutaraldehyde in Hospitals: Research shows: (1) Current sampling and analytical method places certain limitation on the assessment of instantaneous peak exposure to glutaraldehyde, so 5- to 15-minute samples are taken instead, which means that the samples may reflect only the average exposure, not peak exposures. (2) The use of vacuum DNPH-silicon gel can lower the quantifiable lower limit to 0.20mg/sample. With the development of multi-set automated sampling equipment, this method can be used to reach the goal of instantaneous sampling. (3) Glutaraldemeter can take measurements one minute apart, meeting the goals of shortening sampling time and real-time reflection of instantaneous exposure. However, the resulting data is not systematic and have large variation. (4) Hospitals use glutaraldehyde for sterilization. Its concentration in the work environment rises significantly when the cover is lifted for the addition of alcohol, and at the end of the sterilization process, so the assessment and the prevention of exposure should focus on these activities. (5) To detect glutaraldehyde during endoscopy procedures in eight hospitals, vacuum DNPH method and NIOSH 2352 method are the most appropriate. The study shows that the concentration of glutaraldehyde in these areas has not exceeded the current permissible exposure level of 0.2ppm. Even so, reminding workers to maintain proper operating procedures and ventilation is recommended.

Study on Corneal Infection of Onion Workers: The results show that those working within onion

farmlands, living within 1km of onion fields, or older people, seek ophthalmologic care in significantly higher proportions. *Aspergillus spp.* is the most frequently found bacteria in the eyes. Onion pickers have the highest concentration of fungi in the eye. Healthy people living in windy areas whose eyes come in contact with foreign substances have the next highest concentration of fungi in the cornea (one-tenth that of the onion workers). The most common fungi type, as healthy workers living in non-windy areas, is *Candida spp.* and *Cryptococcus spp.* Analysis of the data on people living in windy areas whose eyes come in contact with foreign substances show that the injuries are directed related to the wind speed, but unrelated to the location of injury. The cases of corneal infection found through the field survey are all related to living in windy areas and working with onions, of which 11 have resulted in the loss of sight in one eye, between 1981 and 1999. The study clarifies the mechanism by which corneal infections of onion workers in windy areas occur. Eye injuries from contacting foreign substances are mainly affected by the local wind speed, and not significantly related to working with onions. However, because onion pickers have higher fungal counts and pathogenic fungi in their eyes, the incidence of infection is higher after eye injury. By taking protective measures (such as wearing protective glasses), the possibility of foreign substances entering the eyes will decrease. Incidence of onion workers suffering from bacterial corneal infection will decrease with health education on using protective glasses.

Application of Thermal Health-Hazard Predictive Models: A Comparison of Estimated Allowable Exposure Times Obtained from Predictive Models and Current Regulations:!  
@Workers meeting study criteria from appropriate workplace are selected for the measurements of heart rate. Environmental monitoring is accompanied by videotaping of the operations being performed. The results show the work-rest schedule set by the local standard is in accordance with the one recommended by AGCIH. Tenco experimental design is used to find major environmental factors, including Pa and Va. When work load increases, the above mentioned factors cannot reach the target conditions at AET=60 min. This shows that metabolic rate has great influence on heat response, so that under heavy loads, it is impossible to work continuously by simply controlling environmental factors.

A Preliminary Study on Airway Particulate Deposition: This study seeks to construct the following: (1) a testing system for airway particulate deposition, including test particle generation system, and particle size and concentration detection systems; (2) an airway deposition testing system, to assess methods for partitioning inhaling and exhaling air flow volumes, and for measuring and controlling breathing types; (3) the method for determining breathing type, including volume and frequency, and the method for training subjects to control their breathing types. From the measurements of inhaling and exhaling aerosol concentrations, one can find the deposition efficiency. The systems are tested for preliminary assessment of deposition efficiencies in different regions of the airway. The equipment and the method developed in this study can be used for future study of the relationship between airway particulate deposition and disease. The rapid particle size detector developed can be used to study the changes in airway deposition and aerosol concentrations.

## B. Estimation Models and Control Studies of Hazardous Substances and Noise in the Work Environment:

**Control Velocity and Capture Capability of the Exterior Hoods:** This study explores the characteristics of commonly seen rectangular hoods when affected by sidestreams. The width-to-length ratio has significant influence on capture zone efficiency, thereby increasing the complexity. Using wind tunnel to generate even sidestreams, and laser Doppler speedometer to measure the velocity field, fluid dynamic distribution can be drawn to determine capture zone and its characteristics when the rectangular hood is under the influence of sidestreams. The results show that the width-to-length ratio and the ratio of sidestream velocity to aspiration velocity are the major factors that lead to changes in capture zone. The greater the ratio of sidestream velocity to aspiration velocity, the smaller the capture zone. For hoods with different width-to-length ratios, as long as the ratios of sidestream velocity to aspiration velocity are the same, the capture zones will be the same, with the hood with shorter width having better resistance against the wind. Rectangular hoods have the same characteristics as circular ones: those with width-to-length ratio less than one have one set of characteristics, while those with width-to-length ratio greater than one have another. The equation for finding separate flows and characteristic volumes in the capture zone can be used for future design. Under the same wind velocity, the capture zone calculated by using equivalent circular area opening, is similar to the experimental result obtained. The effective wind velocity for rectangular opening is only about  $\frac{3}{4}$  that for the circular one.

**Safety and Health Improvement in Small Enterprises: Lead Exposure:** This study tracks the improvement of safety and health conditions in industries with lead operations by collecting data on implementation from enterprises. The study involves field survey and environmental testing (including lead concentration and particle size) in 5 plastic stabilizer manufacturers, 7 powder lead manufacturers, and 14 lead battery manufacturers. Regulatory requirements directly affect how safety and health measures are implemented in the workplace. Most of the enterprises studied consider hygiene habits and education and training of workers need the most improvement. The lack of cooperation and the unwillingness to wear protective equipment are the most troubling for enterprises. For the past three years, blood lead concentrations from health examination records have not seen significant decrease. For environmental monitoring, 62% of plastic stabilizer manufacturers, 15% of powder lead manufacturers, and 33% lead battery manufacturers exceeded the permissible level.



Figure 5: Determination of particle size in bagging chromic lead

Contaminant Distribution Due to Pressure Difference: This study uses gas tracing method to determine the spread of pollutants when opening the container in adjacent areas with pressure differences. Results show that under the same pressure difference, the larger the opening area, the greater the spread effect. With same opening area, the smaller the pressure difference, the more obvious the spread effect. OSHA requires that the ward for tuberculosis patients maintain a negative pressure of 0.001 inAq, but even so pollutants can still move from low pressure to high pressure area. The experiment simulates operating room in the hospital with 8 Pa pressure difference, but the results show that when opening the door, pollutants may move from the hallway!low pressure!^ to the operating room (high pressure). The results can be used in controlling pollutant spread when pressure difference exists, but the interrelationship between pressure difference and the opening area, and the effect of opening shapes on spread will need further studies.

A Study on the Dust Exposure and Hazard Prevention in Ceramics Manufacturing: The survey is conducted by random sampling from a list of member companies of the Ceramics Manufacturers' Association. Of the 40 raw material samples taken, 12 contain free silica, with concentrations ranging from 4.32% to 20.14%. For personal exposure monitoring, respirable dust concentration ranges from not detectable to 5.75 mg/m<sup>3</sup>, which are within regulatory limits. Dust concentrations are the highest for those making ceramics products for bathroom,

according to the study on respirable, thoracic, and breathable dusts using direct-reading instruments, and breathable dust samplers. In the manufacturing processes, lacquer spraying produces the highest dust concentration. The ratio of the concentration of breathable dust to total dust for building ceramics is estimated to be 0.51 to 0.82, by using the dust distribution obtained by Marple 8-stage samplers during area sampling. For this manufacturing process, area sampling is not related to personal sampling, which ranges between 0.04 to 0.36. Building ceramics breathable dust free silica content ranges from 0 to 7.64%. Total dust free silica content ranges from 0 to 11.02%. Dust in this type of workplace fall under the second and fourth categories. Particle size distribution has a geometric average of 2.53-2.85  $\mu\text{m}$ , which can serve as a reference for selecting protective equipment.

The Research of Control Combustible Aerosol in Tail Gas: Aerosol settlement of tail gas that may lead to safety and health problem in the semiconductor industry. This study explores the effects of fluid temperature on aerosol settlement, including factors such as flow volume, pressure and heating from outside the pipe. The decrease in the amount of settlement for aerosol with different particle size is calculated from different temperature gradients on the pipe wall. When the temperature of the wall increases, no matter what the flow direction is, the movement of the particle toward the center of the pipe decreases with increasing pipe length, and therefore heating the wall prevents particle settlement within a certain pipe length. The theoretical framework for the relationship among heating temperature, pipe length, particle size and other parameters can serve as a reference for the semiconductor industry.

Assistance for the reconstruction of workplace safety and health measures after the September 21, 1999 earthquake: This study focuses on assessing process and safety management of enterprise in Central Taiwan after the September 21, 1999 earthquake. Field safety auditing and the review of records are conducted in 21 enterprises, in order to offer appropriate improvement suggestions, and to build references for future responses to major earthquakes. The results show that the earthquake has brought the following damages to enterprises: walls slanting or with cracks, pipelines breaking, shelves overturning, equipment moving from its original position, and electricity outage. Preventive measures may include: strengthening of foundations and building structures, office furniture and machinery shock absorbing capabilities, centralization of important equipment, multiple communication networks for emergency use, maintenance of clear passageway and emergency lighting, ensuring functions of life-supporting pipelines, and storage of materials and tools for emergency response. In terms of management, injury prevention organization, reporting system, emergency response system, education and training can all effectively decrease the damages caused by natural disasters.

Collection of basic occupational safety and health data--with Tainan Science Industrial Park as a model: To establish a system for reporting basic safety and health data, the study has chosen the Tainan Science Industrial Park as a model. The data is useful for understanding the current conditions in enterprises, and with further analysis, can serve as a warning system. Monthly reporting of the incidence of occupational injury can be done via the Internet.

Hospitals can report health examination data directly, with enterprises providing information about which department a particular employee is working. In the initial stage, the Institute will establish the original records for enterprises. Thereafter the enterprise can add further data via the Internet.

**A Study on Noise Suppression for Airplane Engine Test Cell:** Ground testing of the functions of the aircraft or its engine is necessary at the end of production, after maintenance or after a certain period of use. The testing room is designed to control the noise during testing and prevent possible damage to workers' hearing. This study compares noise exposure and noise distribution in the room for two different testing room structures. The results reveal noise exposure characteristics, exposure dosage and feasible prevention measures for engine testing.

**C. Research on occupational hygiene personal protective equipment and measuring instruments:**

**Evaluation of Filter Performance:** Filter quality and the particle sizes that pass through the filter most easily for commonly used half-face masks are studied. Resistance is tested under three wind velocities: 3, 8.5, 9.5 cm/sec. Capture efficiency is tested for particles with diameters ranging from 0.03 to 10 $\mu$ Gm. The results show that different masks do have significant difference in capture efficiency for particles of different sizes. Particles with diameters 0.1 to 1 $\mu$ Gm penetrate most easily. The masks can be classified into three groups according to capture efficiency: the first with capture efficiency greater than 90%, the third less than 20%. Masks for non-industrial use have very limited protective effect. The responsible authority should establish a management system to enable workers to select appropriate masks. The current testing standard is rather lax in terms of testing particle sizes. For masks barely meeting the minimum requirements, disputes may arise because when different particle size ranges are used, their effects may differ significantly.

**The Study on Selection and Use of Respirators:** A handbook for the selection of respirators has been compiled based on past testing data and by consulting local experts. The contents include the basic principles of respirators, available products and company contact information. Seminars are held to review the draft of the handbook. Most enterprises have responded that they have found the information useful. The actual conditions of mask use in agricultural chemical industry have also been studied. Because agricultural chemicals are available in different forms and with different additives, it is impossible to set a standard for respirators applicable to all types of agricultural chemicals. However, all of them should offer protection against dust and particles. Depending on the vaporization condition and the dosage form, filters may also need to offer protection against gases.

**D. Ergonomic hazard evaluation and control technologies:**

**Occupational Injuries & Workplace Evaluation for Disabled Workers:** The sample of the study has been taken according to the proportion of disabled in the population. Of the 384 people

completing this questionnaire on employment and safety and health, 16.1% requires assistive devices. 52.9% has complained of minor aches. 62.6% has complained of discomfort. 100 sites in which the disabled work have also been studied. The work environment includes machinery and sharp tools that can result in occupational injury. Slippery and disorganized floor may endanger workers with crutches. The field survey has also found many assistive devices need to be developed, such as height-adjustable message chairs, special gloves, carts that can move up and down the stairs, workstation suitable for those sitting on wheelchairs, and computer desks and jewelry workstations for paraplegics.

Developing Job Assistive Devices for Persons Disabilities: Ergonomic Design in Computer Operation: The demand for information professionals are greater than the supply in the current labor market. Furthermore, because these jobs mostly involve operating computers, which is sedative in nature and does not require much physical strength, they are very suitable for those with physical disabilities. This study seeks to develop assistive devices for paraplegics for computer operations, designed systematically and humanely, taking into consideration of the special needs of the disabled and ergonomic principles. The study has completed designs and prototypes of a multi-functional wheelchair and a computer workstation for physically disabled, as well as a voice controlled computer-human interface for issuing commands for software operations, and a computer-mouse interface for the disabled for data entry.

The Demands of Employment and Occupational Safety and Health in the Disabled: Examining the Case of Physical Handicaps in Tau-Yuan County: The study seeks to understand the current employment conditions of the disabled, including physical and psychological capabilities, intents and difficulties in finding employment, and needs for vocational training. The results are used to develop recommendations for job selection, vocational training and safety and health of the disabled in the workplace. A human resource database of the disabled is also be built for job matching, so that they can enjoy the same right to work as others. In the future such database can be expanded to other counties, as an important reference for the development of social welfare policy for the disabled.

Development of Handbook for Vibration Hazard Prevention: This study explores methodology to measure and evaluate whole-body vibration. A preliminary study is conducted on the vibration characteristics of transportation machinery that cause high whole-body vibration. Feasibility of revising vibration exposure threshold in the "Regulations on Occupational Safety and Health Equipment and Installation" is also studied. A manual to decrease the incidence of vibration-related injuries is also compiled.

The Application of Worker's Typical Craniofacial Manikins' database for Respiratory Protective Equipment and Helmets Design: The study completes CAD modeling and prototyping of three typical craniofacial shapes. The model is then used in testing respirators. The results have been given to related safety and health agencies, enterprises and academic institutions, including the Department of Defense for the development of masks against poisoning. A database for manufacturers of safety helmets for the local population is built with reference to

ISO safety helmet standard.

Analysis of Risk of Low Back Injury for Camera Journalists: Through questionnaire, interview and work analysis, and biomechanical analysis, the relationship between work and lower back pain among photo journalists is studied. Results show that holding and lifting camera at or below chest level create greater stress on vertebral discs and muscles on the lower back than taking shots above chest level. Holding camera below chest level exerts the greatest amount of stress on the lower back. Holding camera at eye level or above the head create less stress on the lower back than the other positions, but will result in aches of arms, shoulders, and necks in a short time, so prolonged operation in these positions should be avoided. The results can be used as a basis for improvement and education.

Incorporated Quality Circles with Ergonomic Interventions in Workplace Improvement: For workplace improvement, management may command employees to do so unilaterally, or through employee suggestions. Many studies overseas show that with increasing sense of participation, acceptance of the improvement measures and loyalty to the company will also increase. Employee participation takes many forms, and its implementation must take the level of difficulty and the experience of employees into consideration. Most of the local firms have quality circles and a suggestion system, even holding seminars to share experiences, so management and workers are familiar with them and have positive experiences with them. Through on-site participation, the study utilizes the quality circle system for ergonomic improvement in the workplace. Of the five companies participating in the study, four have developed improvement suggestions.

E. Control technologies for occupational musculo-skeletal disorders:

Work Recommendation Guideline for Hand Wrist Work: Five subjects with wrist strength falling on the action limit, and another five falling on the maximum permissible limit, are selected for this study. The results show that the preliminary guidelines for hand and wrist work are applicable to different hand-wrist positionings and varying lengths of work time. Together with the database on the forces exerted by 18 types of grips and 40 types of wrist moments, a set of guidelines can be developed for setting standards for work design.

Biomechanical Evaluation and Application Study (II): Clinical Applications and Cases Evaluations: The study has selected workers in a shoe factory for field evaluation of lower back injury biomechanical assessment methodology. Observational records are analyzed by this methodology, to understand the impact exerted by different postures on the lower back. Educational materials for safety and health education are developed, as the basis for conducting "back pain class" in the workplace. Seminars for workers are also held to see how well the preventive measures can be applied in the workplace. The results show that this methodology is useful for screening and assessing lower back injury.

Prevention of Musculoskeletal Injury (I): Effectiveness Analysis of Back Belt and Lifting Aid: Field assessment of local workers using lower back protectors is conducted. The cost-

effectiveness for the use of back protectors is also analyzed. The study also seeks to improve existing protector, by performing comprehensive biomechanical assessment on newly developed back protectors in the laboratory. The study shows that most users think that protectors will have significant effect in lower the incidence of lower back injury. However, objective data do not support this subjective viewpoint. The experimental study shows that newly developed protectors is useful for lifting tasks, because it decrease the activity of rectus muscles in the back, but will not affect the overall stability of the body.

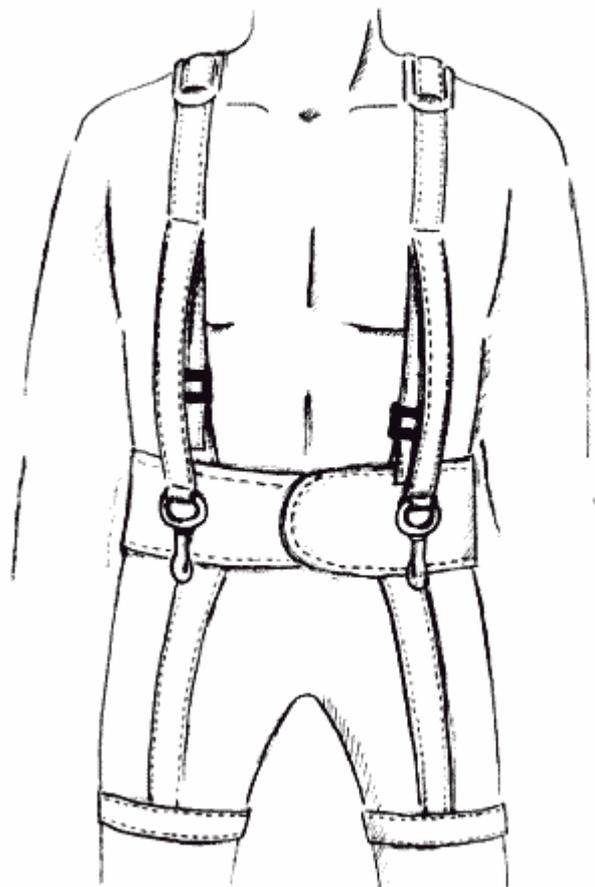


Figure 6: Newly patented protector that redistributes the impact borne by the lower back

The Study of Color Discrimination in Lithographic Area: This study uses Farnsworth-Munsell 100-Hue test to examine color discrimination ability of workers in lithographic area in semiconductor industry. The results show that under different light source, color discrimination abilities are significantly different ( $P$ -value=0.003843). Differences also exist among individuals ( $P$ -value=0.003834). Under yellow light the average error score is 263.88, far greater than that under white light (12.92). Furthermore, under yellow light, the ability to discriminate green-yellow, green, blue-green, blue, purple, and red decreases, with such decline most obvious for

green and blue. For working under yellow light, tasks and interface that are distinguished by color should be avoided to decrease the probability of error. Equipment for emergency should use other means of discrimination other than color, to enable rapid identification and response.

In conclusion, occupational hygiene research in 2000 emphasizes recognition and evaluation of risk factors, evaluation and control of airborne hazardous substances, and ergonomics, in order to build local occupational hygiene databases, understand new risk factors, develop control strategies for special hazards, including personal protective equipment. The Division of Occupational Hygiene also handles related activities, such as research result seminars, cooperation and exchanges with academics in Taiwan and in other countries, publications of research results in academic journals, in order to disseminate the information gained.

#### Section 4 Occupational Medicine Research

The abstracts of occupational medicine research in 2000 are as follows:

##### A. Surveillance and analysis of occupational injury, disease and health data:

Labor force health index from the analysis of labor and health insurance data: Labor Insurance cash compensation records from and National Health Insurance in-patient and out-patient service records are used to analyze the frequency and the incidence of injuries, disabilities, and deaths due to occupational and non-occupational causes. The losses resulting from occupational injuries are calculated. The losses in terms of the health of the labor force by country have also been analyzed. Analyses by age, sex, and industry are also completed. For accidental deaths, cumulative death rates and potential losses in person-year due to occupational and non-occupational causes are also calculated. The results are accessible from the web site of the Institute.

Fatal Occupational Injuries/Disease Surveillance in Taiwan: Integrating occupational death records from various channels shows that in the seven months between November 1999 and May 2001, there have been 1079 occupational deaths. Public service insurance reports 58 cases, labor inspection 223, questionnaire 294, labor insurance 599, and media 204. Some cases are reported more than once. Extrapolating the data to 12 months, there would have been 1850 occupational deaths. Current occupational death index is based solely on labor insurance data, reporting 1165 cases in 1999. Comparing the aforementioned two figures for yearly cases of occupational deaths, the extrapolated figure is 685 people (59%) more than the official figure. This shows that using multiple sources, the current occupational death index underestimates the actual number of occupational deaths. Future studies will explore the following: (1) Comprehensive review of systems, regulations and definitions used to determine whether a case is occupationally related, with further analysis to find in which industries the deaths are underestimated. (2) Review of regional occupational injury reporting system, modifying promotional literature. (3) Develop feasible recommendations for obtaining reliable occupational injury data.

Analysis of data from the surveillance system for hearing ability among workers in noisy operations: A database for occupational hearing loss is established as a reference for the development of hearing conservation programs. Included in the database are audiograms of 30,125 workers in 385 enterprises reported by 39 medical institutions in 1999. Results show that hearing ability decreases as age rises. Males show significantly greater hearing loss than females. 15.6% male workers and 21.5% female workers have abnormal speech frequency hearing ability (hearing threshold greater than 25 dB). For 4 kHz frequency, 41.2% of the workers have abnormal hearing ability, with 19.6% have medium or greater extent of hearing loss (hearing threshold greater than 40 dB). For 500 to 6 kHz frequencies, hearing threshold is the highest at 6 kHz. The ratio of workers with abnormal hearing ability is the highest among textile, printing, personal service, tobacco manufacturing and machinery manufacturing and repair industries. Recommendations for hearing conservation programs have been developed.

Establishment of Standard Management and Follow up Procedures for Worker Cohort Databases in Taiwan: Computerized data have been established for cohorts of workers in fertilizer, vinyl chloride (data from health examination and insurance), carbon disulfide, dyestuff, silicosis operations, miners, and reference population for occupational epidemiological studies. This study recommends the standardization of basic data, data format, storage software, coding, and original documentation that must be supplied for cohort studies. Standard forms have been developed for constructing a cohort in the future. Software for managing the eight processed files of occupational cohorts linked with labor insurance and national health insurance data has also been developed.

Analysis of Health Examinations from Labor Insurance Database: Over 88,000 health examination files have been analyzed by age, sex, the year of employment, occupational history, medical history and special examination items.

#### B. Occupational disease studies and occupational epidemiology:

A model for managing health examination data of vinyl chloride workers with liver abnormalities as an example: This study uses nested case-control method to examine whether an increase in cumulative exposure to vinyl chloride is related to higher risk of chronic liver diseases. The subjects are vinyl chloride workers who have received health examinations through the Institute or the Institute of Industrial Hygiene and Occupational Medicine of the National Taiwan University from 1988 to 1999, who also have one of the following three conditions: (1) abdominal ultrasound scan showing liver disorder, cirrhosis or enlargement of spleen; (2) ALT > 70 IU/L (two times the normal upper limit) for two or more testings; (3) HbsAg or Anti-HCV positive. Matched by age (5 years) and the work site, data for 78 cases and 216 controls are collected. The results show that those who are HbsAg positive have higher risk of chronic liver diseases, with OR=2.77, indicating that for chronic liver diseases, an interaction exists between exposure to vinyl chloride and hepatitis B infection. Among the 38 that have received liver function tests, 17 have returned to the clinic, 21 have not, for a return visit rate of 44.7%. The tests include abdominal ultrasound scan, blood tests, biochemical tests, and serum immunology tests. For the 17 that have returned, abnormalities in the past

health examinations can all be explained by the presence of HbsAg, alcoholic steatohepatitis, and fatty liver.

**Intervention Study on Vibration Hazards of Car-Manufacturing Industry (Focus on Thermal Treatment):** 60 workers in an auto plant with vibrating operations are surveyed and divided into two groups: those who are willing to receive treatment and those who are not. Treatment includes wax and water therapies at least 30 minutes every week for four months. Neural functions are evaluated after 8 months. The evaluation focuses on the functions of the peripheral nerves by measuring current perception threshold of the hand. Those showing clear symptoms, or with examination results indicating neural or vascular damages, are referred to hospitals for further neurological examinations such as NCV and EMG. Data for long-term follow-up of workers exposed to vibration hazard have been established. Neural damages due to vibration among workers in automobile manufacturing have been evaluated. The efficacy of physical therapy (wax and water therapies) on treating and preventing these damages has also been studied, with a model of developing cooperative research with enterprises. In addition to measures to decrease exposure to vibration, rehabilitative therapy such as heat treatment can also prevent white-finger syndrome or carpal tunnel syndrome. This study is a reference for diagnosing and treating disorders caused by vibration.

**Medical Surveillance of Medical Personnel Focusing on Dental Technicians:** Through structured questionnaire, lung function tests, clinical diagnosis of skin disorders, biochemical tests and heavy metal concentrations in the samples taken, occupational disease prevalence among dental technicians is studied. Together with environmental assessment of particulates and metals, the interaction between the work environment and health effects among dental technicians is confirmed. The results show that most of the dental technicians are male (200 out of 243), with average age of 32, and have been in this profession for around 10 years. Questionnaires and health examinations indicate that digestive, skin and respiratory disorders are the most prevalent. Most commonly self-reported symptoms are related to the nervous system, vision and hearing. Blood cholesterol, uric acid, and GPT values are relatively high, with corresponding higher abnormal rate. As for lung function, relatively large number of the subjects has obstructive pulmonary disorders. With the use of local dust collection system, indoor inhalable dust concentrations average below  $500 \text{ m g/m}^3$ . However, if proper ventilation is lacking during grinding, the instantaneous concentration may be over  $10000 \text{ m g/m}^3$ , showing the need for improvement of the work condition and the work environment. In addition, eating and smoking are also found in the workplace, indicating a need for forming good personal hygiene habits in the workplace.

**The Health Effects among Workers due to Long-term Exposure to 1,3-Butadiene (II): Focus on the High Exposed Workers in Petrochemical and 1,3-Butadiene Manufacturing Industries:** Highly exposed group working in sink cleaning and warehousing, transportation and maintenance operations is exposed to significantly higher level of 1,3-butadiene than other workers. Blood tests show that highly exposed group has significantly lower blood sugar level, but relatively high triglyceride level. Other items show no significant difference. For the highly

exposed in the maintenance operation, SCE and HFC show no significant difference before and after work. SCE rate and polymorphism of CYP2E1, EH, GST related genes do not show a statistically significant association. GST test results are similar to the reports of BD occupational exposure in the literature.

An Epidemiological Study on Health Outcome among Former RCA Employees (II): In addition to calculating the SMRs for breast and gastric cancers among former RCA employees, a nested control study is completed. Preliminary results show that SMRs for former RCA employees do not show statistically significant difference compared with the reference population. The relationship between breast cancer and occupational exposure cannot be proven for former RCA employees so far.

Estimate the Health Effect of the Workers and Industrial Hygiene in the Pesticide Factories (II): Questionnaires show that most workers use protective equipment, with gloves and half-face masks being the most common. However, field observation show that the percentage of workers using protective equipment is still relatively low. In terms of personal hygiene habits, the most common nutrient supplement taken is the so-called "liver protector". In conjunction with suitable equipment, implementing pre-job training on proper personal hygiene habits and the proper use of personal protective equipment is recommended. Most workers do not have a clear understanding of their current health status, so it is necessary to provide health education to enhance their understand of warnings and symptoms the body sends.

#### C. Occupational health promotion research:

Popularize Health Promotion Plan in Workplace: In order to assist workers in forming healthy lifestyle, preparation for workplace health promotion programs are completed, including: (1) compilation of workplace health promotion handbook, (2) training for workplace health promotion personnel, (3) pilot study of workplace health promotion program, (4) establishment of collegiate health promotion service network.

The Investigation on Taiwanese Workers' Hearing and Long-Term Speech Spectrum: This study focuses on the characteristics speech spectra for local workers with noise-induced hearing loss, the background of these workers, and the difference in characteristics speech spectra for workers with high, medium, and low level of hearing loss. Long-term speech spectra characteristics for Mandarin and Taiwanese are also studied, as a basis for evaluating the actual effectiveness of hearing aids for workers with hearing loss. In the past, long-term speech spectrum for English is used for such evaluation. The data from this study can be used in the future for such evaluation, more in line with the needs of local workers.

Assessment of Hearing Loss among Workers in Industries with High Noise Level: Steel Manufacturing: This study shows that 29% of the workers in noisy operations has hearing loss greater than 40 dB at 4 kHz (for the ear with worse hearing ability than the other). At 6 kHz the percentage rises to 31%. This indicates that steel manufacturing is one of the industries with serious noise problem worthy of further attention. Regardless of age, hearing loss at 4 kHz and

6 kHz is significant, as high as 14dB. For those above 50 years of age, the loss may reach 20 dB. For health management, 91.5% requires level I management. 8.5% requires level II management. Only one person requires level III management. More detailed classification standard is necessary. To prevent the worsening of hearing ability among workers, improvement of safety and health education and implementation of hearing examination are recommended.

Comfort Evaluation of Hearing Protectors: Through questionnaires, this study shows that for workers wearing plugs, 48.4% reports discomfort within an hour. For those wearing muffs, 67.0% reports discomfort within an hour. This shows that the tolerance for muffs is shorter than for plugs. For plugs, the factor that affects comfort the most is noise reduction effect, followed by the material used and its touch, and the pressure exerted during expansion. For muffs, the factor that affects comfort the most is also noise reduction effect, followed by closeness and tightness of fit, weight, heat dissipation, the material used and its touch, all with similar scores. Whether the material absorbs sweat does not affect the comfort of either plugs or muffs. Indices of evaluating the comfort of hearing protectors are developed from these questionnaires. For muffs the indices include closeness and tightness of fit, heat dissipation, the touch of the material. For plugs they should include pressure and the touch of the material. In accordance with international standards, testing procedures and machinery are developed.

A Pilot Study of Vocational Mental Health: Research on Counseling and Guidance Model: Through literature review, field observation and interview, an overview of the institutional resources for psychological counseling and assistance for employees is completed. Processes and methods for psychological counseling and assistance for employees are also studied, including the major psychological problems encountered, how to seek assistance when psychological problems or work-life adjustment problems arise, and how enterprises assist employees in overcoming these problems. Professional panel discussions are conducted to develop the ideal structure and operating procedures for psychological counseling in occupational setting in the future.

Evaluation on Work Fatigue and Physiological Effect for Postal Workers: 25% of postal workers has had gastro-intestinal disorders. In the past three years, 32% has been bitten by dogs; 27% has had traffic injuries. In terms of repetitive musculoskeletal disorders, postal workers complain of shoulder pain most frequently, followed by lower back pain. Some exhibit symptoms related to carpal tunnel diseases. In terms of self-reported fatigue after work, mail sorting and delivery personnel report mostly eye fatigue, whereas those handling packages report lower back pain most frequently. Fatigue is reported more often in the winter than in the summer.

Development of a Vocational Evaluation Instrument for Physically Handicapped People: Counseling and evaluation tools are developed, including job analysis form, counseling evaluation form, computer software and counseling handbook. The use of the handbook will be promoted through seminars.

A Preliminary Study on the Energy Expenditure of Labor (III) Work and Establishment of Software: Basic metabolic data for workers with different frequently maintained postures under different work load is collected. The partially completed database is available for on-line search.

#### D. Occupational biomedical monitoring:

Study on the Health Effect of Arsenic Workers in Semiconductor: Field observation, evaluation of arsenic air concentration in the workplace, health questionnaire, physical examinations by medical specialists, testing for arsenic and its metabolite in blood, hair, nail and urine, are completed for workers in arsenic operations in three semiconductor manufacturing plants. The results show that arsenic air concentration has not exceeded the PL-TWA standard of 0.5 mg/m<sup>3</sup> set by the Council of Labor Affairs in and out of arsenic operation areas in all three plants. However, whether PL-TWA=0.5 mg/m<sup>3</sup> is appropriate requires further investigation. Otolaryngological and dermatological consultations show that workers in these plants, whether the exposed group of workers in arsenic operation, or the reference group of administrative workers, do not exhibit any symptom of being affected by arsenic. Most workers are healthy. A few workers have relatively high concentrations of metabolites of inorganic arsenic (greater than 100 mg/g creatinine), worthy of further studies. The concentration of arsenic in the specimen may be affected by non-occupational causes. Installing direct-reading instruments in arsenic operation areas (if not already completed) is recommended. Of the three plants studied, only one has installed direct-reading instruments. However, these instruments are essential to provide warning and prevent acute injuries caused by the leakage of arsenic gas. Periodic maintenance work on these instruments is also necessary in all three plants. Enhancing health education for workers in arsenic operation is also recommended, because some workers have not worn respiratory protectors, protective clothing and gloves. Protective equipment is the last line of defense against exposure to hazardous substances. Even though the current arsenic air concentrations in the work environment in all three plants have not exceeded the regulatory limit, the health effect of long term exposure to low dose arsenic should not be neglected.

Medical Surveillance of Electroplating Workers: Field observation, evaluation of hexavalent chromium and nickel air concentration in the workplace, health questionnaire, physical examinations by medical specialists, testing for chromium and nickel and their metabolites in blood, hair, nail and urine, as well as liver and renal function testings, are completed for workers in eight electroplating plants. The results show that in a plant in northern Taiwan, a high percentage has perforation of the nasal septum, and a few has skin disorders that may be linked with exposure to chromic acid. Environmental testing for hexavalent chromium shows that area sampling concentrations are higher than personal sampling concentrations. However, the concentrations of hexavalent chromium and total nickel are all below the PL-TWA of 0.1 mg/m<sup>3</sup> and 1.0 mg/m<sup>3</sup> set by the Council. Whether the current PL-TWA is appropriate requires further study. To prevent occupational diseases caused by exposure to chromic acid, most plants need to improve the work environment around the electroplating tanks, especially

the ventilation system in one of the plants in northern Taiwan. During electroplating operations, some of the workers do not use personal protective equipment. Most do not use appropriate protective equipment, such as using cotton gloves during electroplating operations, indicating a need for improving occupational hygiene education.

Comparison of Diagnosis of Occupational Illness & Workers' Compensation between Developing Countries & ROC: Information on determining and compensating for occupational diseases in different countries are obtained by searching on the Internet. The documents are translated and an analysis of the systems in the US, Canada, UK, Germany, France, Japan and Singapore has been completed, to develop feasible measure for improving the system in Taiwan. The following is recommended: (1) Increase the number of physicians specializing in occupational medicine by changes in medical education; (2) Develop on-line occupational disease reporting system, giving employer and employees the authority to report; (3) Strengthen the authority to determine occupational diseases by the Institute and the inspection agencies, with professional support and an integrated mechanism; (4) Reasonable compensation for professional consultation; (5) Enhance the functions of the committees for occupational disease determination and for appeals review; approved cases should meet the criteria set in the "Diagnostic Standard for Listed Occupational Diseases as much as possible; (6) Objective evidences should receive greater attention, including environmental and biological monitoring; (7) Occupational diseases with clear cause and effect relationships should be listed as entitled to compensation without further review; (8) establish a no-fault insurance system for employers, to enhance the protection of workers.

Sampling from Oral Mucosa to Study HLA Alleles in the Allergic Diseases among Workers Exposed to Diisocyanates and Developing the Preventive Strategies: The study correlates 578 questionnaires returned by workers in 15 diisocyanate factories with blood samples taken, to establish a cohort of diisocyanate workers and a DQB1 genetic database, in order to understand the relationship between HLA and hypersensitivity of the respiratory tract, the skin, and the eyes. The questionnaires reveal that 28% reports hypersensitivity of the respiratory tract, followed by hypersensitivity of the skin (18.6%), and hypersensitivity of the eyes (12.6%). 2.9% has asthmatic symptoms. 79.5% of the hypersensitivity of the eyes is related to work, followed by hypersensitivity of the skin (74.1%), and hypersensitivity of the respiratory tract (51.9%). Among the 23 genes of the Type II HLA antigen DQB1, DQB1 0601 and 0503 are related to asthmatic symptoms, 0601 to skin symptoms, 0601 and 0503 to eye symptoms, 0503 and 0402 to decrease in expiratory volume. This study establishes an objective way of examining allergies to diisocyanate, including skin patch test, peak expiratory flow rate, specific TDI and MDI antibodies in the serum, and the relationship between exposure and disease. The aforementioned three variables are positively correlated with 0601 of Type II HLA DQB1.

A Survey of Zoonic Infectious Disease on Meat Processing Workers: Streptococcus: Through questionnaires, blood samples, oral swipes and skin surface swipes, the relationship between streptococcal infection and 260 meat processing workers is studied. The results show that

symptoms of streptococcal infection including inflammation, headache, fever, shivering, and body aches are related to oral streptococci. Shortness of breath, chest pain, itchy and teary eyes, itchy throat and cough are related to skin surface streptococci. Some streptococci are antibiotic-resistant, with those on the skin surface showing greater resistance than those in the oral cavity. However, antibiotic resistance of streptococci in the oral cavity is showing an increasing trend. Further study of biological hazards, antibiotic resistance and preventive measures involving the National Science Council, the Department of Health, and the Environmental Protection Administration is recommended. Educating meet processing industry on the importance of sanitation and controlling the use of antibiotics is also necessary.

In conclusion, current research focuses on using health examination data effectively, understanding how to prevent occupational diseases, and applying occupational epidemiological methods in studying health and health promotion among workers in special operations. In addition, to decrease the incidence of injury caused by environmental factors, prevent the occurrence of occupational diseases, and create comfortable work environment, the Division is actively developing hearing protection program and other health and health promotion research plans.

## 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 2000, IOSH sponsored or jointly sponsored 12 academic conferences; presented 22 journal papers in local publications, 16 journal papers in foreign publications, 38 papers at local academic conferences and 3 papers at foreign academic conferences.

#### 1. Academic Conferences

Table 3 Academic Conferences

Name of Conference	Summary of Activities	Date
Chemical Laboratory Safety Workshop	After the September 21, 1999 earthquake, 3 workshops were held in Taipei, Taichung and Tainan to discuss and promote chemical laboratory safety, approximate 100 participants had attended each workshop.	99/12/27 00/01/06,11
The 2000 Conference on Aerosol Science and Technology	Over 90 papers pertaining to workplace environmental measurement, indoor air quality and aerosol sampling and analysis technique were published in the conference.	00/09/13-16
Workshop on Measurement and Application of Anthropometry	The application of anthropometry, and the ergonomical check lists were discussed among labor inspectors and I & H specialists in field .	00/04/13-14
Seminar on ergonomic	150 I & H specialists attended. Two Japanese ergonomical	00/05/10-12

Development and Trend in Japan	professions were invited to introduce ergonomical guidelines in Japan.	
Workshop on control and Prevention of Industrial Technology	60 participants attended the workshop 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 and prevention.  Joint discussions of questions among participants were conducted and experiences were exchanged.	00/03/07-08
Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	Approximately 500 participants attended the presentation, 7 theses were presented from the Division of Occupational Medicine	00/08/16-17 (Changhua)  00/08/24-25 (Taipei)  00/08/31-09/01 (Tainan)

## 2. Presentation of Theses - Local Publications

Table 4 Presentation of Theses - Local Publications

<b>Title</b>	<b>Publication</b>	<b>Authors</b>
A preliminary Screen of Antibiotics Produced by Thermophilic Fungi Isolated from Taiwan. Diversity of Fungi in Taiwan	Fungal Science, 15 (1,2): 567-63, 2000	Chiung, Y. M.*, Chen, Q. Y.,  Chen Z. C.
The Range of Motion of the Upper Limbs Taiwanese in Machinery Safety	Institute of Occupational Safety and Health Journal, Vol. 8, No. 1	Lee, C. L.*,  Su, F. C.,  Wu, H. W.,  Lu, S. Y.*
The Development of Database and Work Recommendation Guidelines on Cylindrical and Linear Grip Strength	Institute of Occupational Safety and Health Journal, Vol. 8, No. 1	Yu, C. Y.,  Liu, Y. L.,

		Chang, C. L., Yang, Y. X., Chen, C. Y.*
Performance Comparison of Respirable Aerosol Size-Selective Samplers	Institute of Occupational Safety and Health Journal, Vol. 8, No. 1	Lai, C. Y., Chen, C. C., Hwang, J. S. Shih, T. S.* Huang, W. Y.*
Mercury Speciation in Urine and Blood of Workers	Institute of Occupational Safety and Health Journal, Vol. 8, No. 1	Tseng, W. C., Huang, Y. L., Hsieh, C. M*, Shih, T. S.*, Lin, T. H.
Method Development and Validation of Biological Monitoring for Workers Exposed to Toluene and Xylene	Institute of Occupational Safety and Health Journal, Vol. 8, No. 1	Yang, G. Y., Mao, I. F., Hsieh, C. M.*
Establishment of a Cohort of Dyestuff Workers in Taiwan	Institute of Occupational Safety and Health Journal, Vol. 8, No. 1	Yeh, C. Y., Chen, R. Y., Chen, C. J.*, Du, C. L.*, Ho, J. J.*, Chang, Y. M.*
The Evaluation of Hazardous Gases Emission from the Preventive Maintenance Procedure in Semiconductor Factory	Institute of Occupational Safety and Health Journal, Vol. 8, No. 2	Chang, C. P.*, Song, L. Y., Chu, C. Q.*, Lin, Y. C.*
Analytical Method Development for Measurement of	Institute of Occupational	Hsieh, C. M.*

Workplace Mercury Vapor	Safety and Health Journal, Vol. 8, No. 2	
Exposure assessment Techniques for Pesticides Workers	Institute of Occupational Safety and Health Journal, Vol 8, No. 2	Li, H. P., Wong, S. S., Li, G. C., Chou, J. S.*,, Chen, C. Y.*, Shih, T. S.*
The Subjective Symptom of Work Fatigue, Heart Rate, Blood Pressure, and Life Style of the High Elevation Operators	Institute of Occupational Safety and Health Journal, Vol. 8, No. 2	Mao, I. F., Chen, M. L., Huang, J. W.*, Chen, C. J.*, Lin, C. C., Cheng, S. F.*
The Evaluation of Hazardous Gases Emission from the Preventive Maintenance Procedure in Semiconductor Factory	Institute of Occupational Safety and Health Journal, Vol.8, No. 2	Chang C. P.*, Song, L. Y., Chu, C. Q., Lin, Y. C.
Survey of Background Noise Level in Audiometric Room	Institute of Occupational Safety and Health Journal, Vol. 8, No. 3	Chang, S. J.*, Chen, C. J.*, Chen, L. H., Chen, H.
Analysis and Evaluation of Manual Materials Handling Tasks: A Field Study	Institute of Occupational Safety and Health Journal, Vol. 8, No. 3	Lin, C. H., Wang, S. Z., Chen, C. Y.*, Yeh, W. Y.*
Development of Sampling and Analytical Method for Trimethylamine	Institute of Occupational Safety and Health Journal, Vol. 8, No. 3	Chien, Y. C.,

		Uang, S. N.*, Kuo, C. T., Shih, T. S.*, Shu, L. C., Jen, J. F.
The Development of an Occupational Chemical-Factor Exposure Intensity Predictive Model	Institute of Occupational Safety and Health Journal, Vol. 8, No. 4	Tsai, P. J., Yeh, W. Y.*, Chang, C. W.*, Lin, M. H.*
The Study on Extractive FTIR Analysis Method for Industrial Hygiene Evaluation	Institute of Occupational Safety and Health Journal, Vol. 8, No. 4	Chang, C. P.*, Huang, Y. S., Wang, S. P., Lin, Y. C.
Survey on the Processes and Dust Exposure in Refractory Brick Manufacturing	Institute of Occupational Safety and Health Journal, Vol. 8, No. 4	Lin, M. H.*, Yeh, W. Y.*
The Study on Extractive FTIR Analysis Method for Industrial Hygiene Evaluation	Institute of Occupational Safety and Health Journal, Vol. 8, No. 4	Chang, C. P.*, Huang, Y. S., Wang, S. P., Lin, Y. C.

Note: \*IOSH Staff

### 3. Presentation of Theses - Foreign Publications

Table 5 Presentation of Theses - Foreign Publications

<b>Title</b>	<b>Publications</b>	<b>Authors</b>
Design and Testing of a Porous Metal Denuder	Aerosol Science Tech. 2000, (in press)	Tsai, C. J., Huang, C. H.,

		Wang, S. H., Shih, T. S.*
Determination of Uniformity of Filter Deposit	Aerosol Science Tech.2000, (in press)	Lai, C. Y., Chen,C. C., Huang, J. S., Shih, T. S.*
Aerosol Penetration through Silica Gel Tubes	American Industrial Hygiene Association Journal 2000, (in press)	Chen, C.C., Wu, C.H., Lin, W. Y., Kuo, Y. M., Shih, T. S.*
Computer Simulation of Particle Overlap in Fiber Count Samples	American Industrial Hygiene Association Journal 2000, (in press)	Chen, C.C., Yu, T. S., Shih, T. S.*, Baron, P. A.
Lip Lead as an Alternative Measure for Lead Exposure Assessment of Lead Battery Assembly	American Industrial Hygiene Association Journal, 2000, 61:825-831	Hwang, Y. H., Chao, K. Y., Chang, C.W.*, Hsiao, F. T., Chang, H. L., Han, H. Z.
Analytical Method for Monitoring Airborne Trimethylamine Using Solid Phase Micro- extraction and Gas Chromatography-flame Ionization Detection	Anal Chim Acta. 2000; 419:73-79	Chieh, Y. C., Uang, S. N.*, Kuo, C. T., Shih, T. S.*, Jen, J.F.
Amethod for Measuring 1,3-Butadiene in	Appl Occup Environ Hyg.	Chang, H. Y.,

Blood, Saliva, and Exhaled Brearh	2000. (in press)	Shih, T. S.*, Lee, C. C. Smith, T. J.
A new Technology to Measure Skin Absorption of Vapors	Archives of Environmental Health, 2000; 55:250-258	Shih, T. S.*, Wang, P. Y., Chen, C. Y., Lu, C. J., Smith, T. J.
Belt Effect on Lumbar Sagittal Angles	Clinical Biomechanics, 2000,15:78-82	Lee, Y. M., Chen, C. Y.*
Hsp70 Related Epitopes Are Common Allergenic Determinants for Barley and Corn Antigens	Electrophoresis, 21: 297-300, 2000	Chiung, Y. M.*, Lin, B. L., Yeh, C. H., Lin, C.Y.
Lumbar Vertebral Angles and Muscle Loading with Belts	Industrial Health, 1999, 37:390-397	Lee Y. M., Chen C. Y.*
Field Evaluation of a Passive Sampler for 2-Methoxy Ethanol Exposure Assessment	International Archives of Occupational and Environmental Health, 2000; 73:98-104	Shih, T. S.*, Chen, C. Y., Cheng, R. I., Wu, L. J., Smith T. J.
Partition Coefficients of Volatile Hydrocarbons in Blood and Saliva	J. Toxicol Environ Health. 2000.(in press)	Chang, H.Y., Lin, W. C., Shih, T. S.*, Smith, T. J.
Measurement of Percutaneous Uptake of 2-Methoxy Ethanol Vapor in Humans	Journal of Occupational and Environmental Medicine, 2000; 42:475-482	Shih, T. S.*, Wang, P. Y., Chen, C. Y., Smith T. J., Hu, Y. P.
Increased Iymphocyte Sister Chromatid Exchange Frequency in Workers with Exposure to Low Level of Ethylene Dichloride	Mutation Research, 470: 109-114, 2000.	Cheng, T. J., Chou, P. Y.,

		Du, C. L.*, Wong, R. H., Chen, P. C.
Hematological Effects after Exposure to Ethylene Glycol Monomethyl Ether in a Copper-clad Laminate Factory	Occupational and Environmental Medicine, 2000; 57:348-352	Shih, T. S.*, Hsieh, A. C., Liao, G. D., Chen, Y. H., Liou, S. H.
Design and Testing of a Porous Metal Denuder	Aerosol Science Tech. 2000, (in press)	Tsai, C. J., Huang, C. H., Wang, S. H., Shih, T. S.*
Determination of Uniformity of Filter Deposit	Aerosol Science Tech.2000, (in press)	Lai, C. Y., Chen, C. C., Huang, J. S., Shih, T. S.*
Aerosol Penetration through Silica Gel Tubes	American Industrial Hygiene Association Journal 2000, (in press)	Chen, C. C., Wu, C. H., Lin, W. Y., Kuo, Y. M., Shih, T. S.*
Computer Simulation of Particle Overlap in Fiber Count Samples	American Industrial Hygiene Association Journal 2000, (in press)	Chen, C. C., Yu, T. S., Shih, T. S.*, Baron, P. A.
Lip Lead as an Alternative Measure for Lead Exposure Assessment of Lead Battery Assembly	American Industrial Hygiene Association Journal, 2000, 61:825-831	Hwang, Y. H.,

		Chao, K. Y., Chang, C. W.*, Hsiao, F. T., Chang, H. L., Han, H. Z.
Analytical Method for Monitoring Airborne Trimethylamine Using Solid Phase Micro-extraction and Gas Chromatography-flame Ionization Detection	Anal Chim Acta. 2000; 419:73-79	Chieh, Y. C., Uang, S. N.*, Kuo, C. T., Shih, T. S.*, Jen, J. F.
A method for Measuring 1,3-Butadiene in Blood, Saliva, and Exhaled Breath	Appl Occup Environ Hyg. 2000. (in press)	Chang, H. Y., Shih, T. S.*, Lee, C. C., Smith, T. J.
A new Technology to Measure Skin Absorption of Vapors	Archives of Environmental Health, 2000; 55:250-258	Shih, T. S.*, Wang, P. Y., Chen, C. Y., Lu, C. J., Smith T. J.
Belt Effect on Lumbar Sagittal Angles	Clinical Biomechanics, 2000,15:78-82	Lee, Y. M., Chen, C. Y.*
Hsp70 Related Epitopes Are Common Allergenic Determinants for Barley and Corn Antigens	Electrophoresis, 21: 297-300, 2000	Chiung, Y. M.*, Lin, B. L., Yeh, C. H., Lin, C. Y.
Lumbar Vertebral Angles and Muscle Loading with Belts	Industrial Health, 1999, 37:390-397	Lee, Y. M.,

		Chen, C. Y.*
Field Evaluation of a Passive Sampler for 2-Methoxy Ethanol Exposure Assessment	International Archives of Occupational and Environmental Health, 2000; 73:98-104	Shih, T. S.*, Chen, C. Y., Cheng, R. I.*, Wu, L. J., Smith, T. J.
Partition Coefficients of Volatile Hydrocarbons in Blood and Saliva	J. Toxicol Environ Health. 2000.(in press)	Chang, H. Y., Lin, W. C., Shih, T. S.*, Smith, T. J.
Measurement of Percutaneous Uptake of 2-Methoxy Ethanol Vapor in Humans	Journal of Occupational and Environmental Medicine, 2000; 42:475-482	Shih, T. S.*, Wang, P. Y., Chen, C. Y., Smith, T. J., Hu, Y. P.
Increased Lymphocyte Sister Chromatid Exchange Frequency in Workers with Exposure to Low Level of Ethylene Dichloride	Mutation Research, 470: 109-114, 2000.	Cheng, T. J., Chou, P. Y., Du, C. L.*, Wong, R. H., Chen, P. C.
Hematological Effects after Exposure to Ethylene Glycol Monomethyl Ether in a Copper-clad Laminate Factory	Occupational and Environmental Medicine, 2000; 57:348-352	Shih, T. S.*, Hsieh, A. C., Liao, G. D., Chen, Y. H., Liou, S. H.

Note: \*IOSH Staff

#### 4. Presentation of Theses - Local Academic Conferences

Table 6 Presentation of Theses - Local Academic Conferences

Topic	Conference	Date	Presenters
Application of LISM in Industrial-Hygiene Accredited Laboratories	2000 Occupational Health Conference	00/04/29-30	Hsiech, C.M.*, Shih, T. S.*, Lin, Y. C.*
Method Development for the Biological Monitoring of Methyl Isobutyl Ketone Exposure	2000 Occupational Health Conference	00/4/29-30	Chou, J. S.*, Shih, T. S.*, Shen, Y. J., Chan, H., Chen, C. M.
High Performance Liquid Chromatographic Determination of 2-thiothiazolidine-4-carboxylic acid as a marker of exposure to CS2	2000 Occupational Health Conference	00/04/29-30	Chen, C. W., Shih, T. S.*, Li, C. C., Liu, C. M.
Organic Solvent Content Analysis of Detergents	2000 Occupational Health Conference	00/04/29-30	Chen, C. Y.*, Shih, T. S.*, Liu, Y. H.
Multicomponent Analytical Method in PU Artificial Leather Factory	2000 Occupational Health Conference	00/04/29-30	Cheng, R. I.*
The effect of industrial process to the transformation of silicon dioxide composition	2000 Occupational Health Conference	00/04/29-30	Tang, D. T.*
Development of Sampling and Analytical Method for Airborne Hydrogen-containing Chlorofluorocarbons (HCFCs)	2000 Occupational Health Conference	00/04/29-30	Huang, W. Y.*, Uang, S. N.*

Workers Exposure Assessment Techniques for Mercury Vapor	2000 Occupational Health Conference	00/04/29-30	Hsieh, C. M.*, Lin, Y. C.*
Tenax-TA Diffusive Tube Field Validation	2000 Occupational Health Conference	00/04/29-30	Wu, L. J.*, Chien, Y. C., Lwo, J. H.
Application of FTIR in Semiconductor Industry	2000 Occupational Health Conference	00/04/29-30	Chang, C. P.*, Lin, Y. C.
Comparison in different methods on lung deposition	2000 Conference on Occupational Health	00/04/29-30	Ra, Y. C., Huang, J. S., Chen, C. C., Chen, C. W.,
Evaluation of filter Performance	2000 Conference on Occupational Health	00/04/29-30	Huang, J. S., Chen, C. C., Chen, C. W.,
Evaluation of filter test requirement	2000 Conference on Occupational Health	00/04/29-30	Chen, C. W.*, Chen, C. C., Dai, C. W., Yen, W. Y.*,
Psychosocial Work Stressors And Their Implications For Health in Taiwanese Workers	2000 Conference on Occupational Health	00/04/29-30	Cheng, Y. W., Yeh,

			W.Y.*, Guo, Y. L.
Musculoskeletal Discomfort among Health-Care Workers In Taiwan	2000 Conference on Occupational Health	00/04/29-30	Guo, H. R., Hong, M. C., Shiao, J. S., Yang, Y. J., Guo, Y. L., Yeh, W.Y.*
Musculoskeletal Disorders and Workplace Risk Factors in Construction Workers	2000 Conference on Occupational Health	00/04/29-30	Chen, C. W.*, Yeh, W. Y*
Application of FTIR in Semiconductor Industry	2000 Conference on Occupational Health	00/04/29-30	Chang, C. P.*, Lin, Y. C.
An Anthropometric Evaluation on Semiconductor manufacturing Equipments	2000 Conference on Occupational Health	00/04/29-30	Lin, Y. H.*, Chen, Y. C., Yu, C. Y., Yeh, W. Y.*
The Study of Noise Exposure on Semiconductor Manufacturing	2000 Conference on Occupational Health	00/04/29-30	Lin, S. S.*, Yeh, W. Y.*, Yu, T. S.*, Lu, S. Y.*
Assessment of Occupational Exposure to Whole Body Vibration In Container	2000 Conference on Occupational Health	00/04/29-30	Liou, Y. W,

Tractors			Hu, S. M., Jang, S. H., Ho, S. T, Lu, S. Y.*, Yeh, W. Y.*
Assessment of Safety and Health in Telecom Operators and Service Desk Workers	2000 Conference on Occupational Health	00/04/29-30	Huang, J.W.*,  Chen, C. J.*,  Chen, M. L.,  Mao, I. F.
Analysis and Application Index of Labor Insurance Data	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua)  00/8/24-25 (Taipei)  00/8/31-09/01 (Tainan)	Du, C. L.*
Study on Work-related Fatigue and Physiological Conditions of Telecom Workers	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua)  00/8/24-25 (Taipei)  00/08/31-9/1 (Tainan)	Huang, J. W.*,  Chen, C. J.*,  Chen, M. L.,  Mao, I. F.
Development of an Occupation referent Population for Epidemiological Study	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua)	Wu, Y. P.*,  Chen, C.

		00/08/24-25 (Taipei) 00/08/31-09/01 (Tainan)	J.*, Kuo, H. W.
A study of Hearing Threshold in Taiwan	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua) 00/08/24-25 (Taipei) 00/08/31-09/01 (Tainan)	Chang, S. J.*, Chen, C. J.*
Medical Surveillance of Medical Personnel	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua) 00/08/24-25 (Taipei) 00/08/31-09/01 (Tainan)	Chen, C. J.*, Chen, R. Y., Pan, C. H.*
A Survey of Zoonotic Virus Infection-Influenza and JEV	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua) 00/08/24-25 (Taipei) 00/08/31-09/01 (Tainan)	Chiung, Y. M.*, Hu, D. G., Liao, C. C., Chang, C. N.
Cohort Study of VCM Exposed Workers in Taiwan	Presentation of Research Results on Occupational Medicine and Occupational Health Promotion	00/08/16-17 (Changhua)	Cheng, T. J., Du, C.L.*

		00/08/24-25 (Taipei)  2000/08/31-09/01  (Tainan)	
Field Test of Different Acidic Aerosol Samplers	The 2000 Conference on Aerosol Science and Technology	00/09/13-16	Shih, T. S.*
Effects of Static Electricity and Environmental Conditions to Weighing Accuracy of Different Filters	The 2000 Conference on Aerosol Science and Technology	00/09/13-16	Shih, T. S.*
Fungi Genus and Concentration in the Air of Onion Fields and its Opportunistic Action Related to Mycotic Keratitis	2000 Conference on Occupational Health	00/09/15-16	Chang, C. W.*, Ho, C. K., Chen, Z. C., Chen, M. J., Chen, C. Y., Liu, S. T., Chen, Q. Y
Characterization of Suspended Matters In Onion Farms	2000 Conference on Occupational Health	00/09/15-16	Hwang, Y. H., Chou, E J., Chang, C. W.*, Ho, C. K., Chou, C. L.,
Formaldehyde Exposure Survey of Hospital Workers	2000 National Labor Safety and Health Symposium	00/11/28	Cheng, R. I.*
Chemical Laboratory Safety	2000 National Labor Safety and Health Symposium	00/11/28	Tang, D. T.*

An Evaluation of Noise Exposure for Airport Parking Bay	The 13th Symposium of the Acoustical Society of the ROC	00/12/08	Yeh, W. Y.*, Lu, S.Y.*, Huang, Y. S., Wang, K. S.
An Investigation of Sound Field for Engine Test Cell and Hush House	The 13th Symposium of the Acoustical Society of the ROC	00/12/08	Chen, J. W., Lu, S. Y.,* Yu, T. S., Su, D. S., Hong, Y. J.
Analysis Surveillance Data of Noise-Induced Hearing Loss in Taiwan	The 13th Symposium of the Acoustical Society of the Republic of China	00/12/08	Hsu, J. H*, Chen, C. J*
Comfort Evaluation for Hearing Protectors	The 13th Symposium of the Acoustical Society of the Republic of China	00/12/08	Hsu, Y. L., Chen, C. J.*, Pan, C. H.*, Hung, P. C.*, Huang, C. C.

Note: \*IOSH Staff

## 5. Presentation of Theses - Foreign Academic Conferences

Table 7 Presentation of Theses - Foreign Academic Conferences

Topic	Conference	Date	Authors
Longitudinal Exposure	2000 American Industrial Hygiene	00/03/20-	Shih, T. S.*,

Assessment of 2-Methoxy Ethanol	Conference and Exposition	25	Cheng, R. I.*, Wu, L. J.*, Chou, R. S.*, Chen, C. Y.*
Factors Influencing Filter Penetration and Quality	2000 American Industrial Hygiene Conference & Exposure!USA!^	00/5/20-25	Chen, C. C., Huang, S. S., Chen, C. W.*, Huang, Y. C.
Trunk Muscle Activity and Lift Angle for Lumbar and Pelvic Belts	HAAMAH 2000!Poland!^	00/8/26-31	Chen, C. Y.*, Lee, Y. M., Chen, W. J.

Note: \*IOSH Staff

### 1. Research Awards

Award	Recipients	Thesis	Date
Outstanding Research Award of National Science Council	Shih, T. S.*	A New Technology to Measure Skin Absorption of Vapors	00/05/09
2000 AIHA David L. Swift Memorial Award	Chen, C. C., Shih, T. S.*	Laboratory Performance Comparison of Respirable Sampler	00/05/21

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 9).

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 2000, a total of 131 new publications were published, with approximately 45,000 copies printed.

Table 9 Publications for Fiscal Year 2000

Title	Type	Issues	Copies	Remarks
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IOSH Annual Report 2000	Yearly	1	150	Available in books, CDs, and Adobe PDF files
Institute of Occupational Safety and Health Journal	Quarterly	4	1100	Vol. 8, No. 1-4
IOSH Newsletter	Bimonthly	6	4600	No. 39-44
Technical Books	Irregular	9	200	1. Titles listed in appendix. 2. Available in books, CDs, and Adobe PDF files

### 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 2000, the library had a collection of 3,766 books and 85 periodicals (see Table 10), 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	1999	Addition/ Subtraction in 2000	Total
Books	3,360	+406	3,766
Subscribed Periodicals	99	-14	85
Chinese	37	-10	27
English	43	+1	44
Japanese	19	-5	14
Audio Visual Materials	257	+0	257
Video Tapes	60	0	60
Audio Cassettes	214	0	214

#### 2. IOSH's Computer/Networking Services

The main purpose of the IOSH's computer/networking services is to support occupational safety and health research in the Institute. The long-term goal is to become a national safety and health information center. The work completed in 2000 includes:

1. On-line search for materials available through the library of the Institute;

2. Press releases from the Institute simultaneously available on-line;
3. Articles from the IOSH journal are all available on the Internet;
4. Video clips available on-line;
5. Fix the Y2K problem;
6. Workers Insurance Database for statistical purposes; the Workers Physical Fitness Database, and database on Hearing Monitor System for workers in the Noise Producing industries available on the Internet.

The IOSH also continues the effort in digitize all the publications, which not only makes it easier to disseminate the information to the academia and the public, but also saves the cost of printing. All IOSH's publications are available on-line for free download, which include: research reports, introduction to research projects, abstracts in English, technical books series, the IOSH Journals, IOSH Newsletters, Chinese and in English versions of IOSH Annual Report, and other materials from IOSH for promotion purpose. In 2000, free download service for research reports and technical books is served 30,471 times.

#### IV. Technology Promotion and Services

For the year 2000, IOSH sponsored one exhibition, assisted in three investigations into suspected cases of occupational diseases, and offered inspection apparatus calibration services four times (see Table 10-13).

Table 11 Exhibitions

Topic	Summary of Activities	Location	Date
Occupational Safety and Health Expo 2000	Exhibition of IOSH's research results, there were plenty of IOSH's publications given for free	Kaohsiung World Trade Center	00/12/02-03

Table 12 Investigation into Suspected Cases of Occupational Diseases

Name of Organization	Items Investigated	Date
Tung-Ho Steel Corporation	Collapse of excavation	00/05/29
National Taiwan Ocean University	Explosion in Laboratory	00/08/22
Yao-Hwa Electrical Co.	Pipeline Explosion	00/09/10

Table 13 Inspection of Apparatus and Calibration Services

Name of Agency	Services	Date
Inspection Organizations	1 wind tunnel and 37 anemometers	00/3-00/6
Inspection	55 photometers	00/3-

Organizations		00/8
Inspection Organizations	4 oxygen and combustible gas detectors; 26 industrial safety inspection apparatus	00/5-00/8

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 14 Patents

Patent No.	Invention	Inventors
United State Patent No. 6,124,798	Alarm Device Designed to Warn of Danger of Hitting High Voltage Power Line by Crane in Motion	Tai, C. F., Su, W. Y., Yang, C. F., Wu, C. J., Yen, S. S.
United State Patent No. 6,151,970	Virtual Cyclone Sampler	Shih, T. S., Chen, C. C., Huang, S. H.
ROC Patent No. 155299	Hand Driller	Wu, S. H., Gau, C. Y., Chen, K. H.
ROC Patent No. 157806	Alarm Device for Vehicle Hydraulic Brake System	Tai, C. F., Wu, S. H., Gau, C. Y., Li, S. R., Lin, K. F.

Note: \*IOSH Staff

In terms of exhibition activities, IOSH's Mobile Exhibition began its virgin voyage since March 29, 1999. During the year 2000, it had successfully toured through 45 exhibitions. Among these were schools of all levels, industrial areas, business districts and related joint activities. It is estimated that 60,000 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. The introduction of these new products helped the Mobile Exhibition 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 Mobile Exhibition has been temporarily transferred to private occupational safety and health organizations starting in 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 Mobile Exhibition 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 15 Oversea Research Trips

Category	Country, Organization	Topic	Name	Date
Research Study	Japan	Prevention of Workers' Muscular Skeletal Injuries in Workplaces	Cheng, R. I.	00/01/16-02/02
Visit	Harvard School of Public Health	Occupation Health Management System Research in the USA	Pan, C. H.	00/01/29-12/28
Conference	Switzerland WHO, ILO	Swiss Workers Health Promotion Related Research	Du, C. L.	200/10/26-11/6

## APPENDICES

## I. Technical Books Publications

<b>Serial No.</b>	<b>Title</b>	<b>Publishing Date</b>
IOSH89-T-029	Validation Protocol of Biological Monitoring Analytical Methods for Workers Exposure in Workplace	00/01
IOSH89-T-030	The Safety Operation Handbook of Arc Welding	00/02
IOSH89-T-031	Technical Safety Guideline for Hydraulic Transmission System in Track Crane	00/06
IOSH89-T-032	A Guideline for Health Promotion	00/07
IOSH89-T-033	Safety Checklist in Semiconductor Fabs: Smoke Control Systems, Fume Exhaust Systems, Scrubber and Wet Bench	00/07
IOSH89-T-034	Occupational Protection Guidance Manual for Hazardous Waste Handling	00/09
IOSH89-T-035	A Selection Guideline for Respirators in Taiwan Market (2000 Revised)	00/09
IOSH89-T-036	A Handbook of Range of Motion in Upper Extremity and Machinery Safety	00/12
IOSH89-T-037	A Guideline for Vibration Hazard Prevention	00/12