National Strategy for Major Accident Prevention in the Chemical Industry

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SUMMARY

The tragedies that occurred at Bhopal and Mexico City had raised the consciousness of both government and industry on the prevention of major hazardous accidents. The present research is an attempt to understand the situation in Thailand and to formulate a strategy for the future to face this new challenge.

A field survey was conducted in 27 chemical plants producing pesticides, basic chemicals, explosives, LPG and paints. The objective is to identify the types and quantities of dangerous substances at the disposal of the factories, the safety procedures being followed, and in particular the chemical handling and storage practices.

Using the World Bank criteria, it is alarming to find that 20 of 27 plants visited possess hazardous substances in sufficient quantity to be classified as major hazard installations. It was also observed that there are several obvious potentially unsafe practices such as the unsafe methods of loading and unloading chemicals, and the improper storage of chemicals. The level of knowledge and understanding of potential hazards, both acute and chronic, in the manufacturing and use of chemicals, among the employees of these factories are also found to be inadequate. Many factories do not have an accident recording system. Emergency and contingency plans are totally abscent.

It has been found during the survey that toxic wastes from some pesticide formulation plants are not properly disposed of.

This is a potentially hazardous situation since toxic wastes may contaminate ground water or cause accidental poisoning.

From the analysis of existing legislation and regulations, at least 6 ministries are directly responsible for managing hazardous substances. In addition there are several national committees with overlapping authorities on toxic substances.

This study underlies the fact that routine inspection and regular maintenance alone are not adequate to contain potential hazards. There is a need for additional "fail-safe" measures in the form of a "major hazard assessment".

The inadequacy of statistics and information on the cause of accidents, properties of dangerous substances and chronic health effects is also highlighted.

Finally the success in accident prevention ultimately lies with the attitude of all parties concerned. Proper training on accident prevention of workers, safety officers and government inspectors is a prerequisite.

After the survey, a seminar was conducted on January 22, 1986 to discuss the findings and policy issues on major-accident prevention. The Seminar was attended by representatives of governmental agencies, industries, research institutes and labour unions. The consensus of the seminar has been incorporated in the final recommendations of this report.

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The success of this project would not have been realized without the full cooperation from the management and staff of the 27 factories surveyed (Appendix D). The research team is also grateful for the invaluable contributions from participants of the Seminar (Appendix J) held prior to the finalization of this report. Special acknowledgement is due to Dr. Snoh Unakul who delivered the opening speech.

Finally, the research team is thankful to the contribution of Ms. Lana Larsen in editing the manuscript, and the tireless typing of Ms. Chuchitt Sombunthawong and Mr. Monchai Sorapipatcharoen.

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LIST OF ABBREVIATIONS

ADI	Acceptable Daily Intake
B.E.	Buddhist Era
BMA	Bangkok Metropolis Administration
CIS	Center for the International Occupational Safety and Health Information of ILO
DEG	Diethylene Glycol
DIW	Department of Industrial Works
DOA	Department of Agriculture
DOL	Department of Labour
DOPH	Department of Public Health
ECDIN	European Communities Data Bank for Environmental Chemical
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EIT	Engineering Institute of Thailand
FCD	Factory Control Division
IDRC	International Development Research Center, Canada
IED	Industrial Environment Division
IER	Institute of Environmental Research, Chulalongkorn University
ILO	International Labour Office
IPCS	International Programme on Chemical Safety
IRPTC	International Register of Potentially Toxic Chemicals
LC_{50}	Median Lethal Concentration
LD_{50}	Median Lethal Dose
LNG	Liquefied Natural Gas

LPG	Liquefied Petroleum Gas
MIC	Methyl Isocyanate
MOAC	Ministry of Agriculture and Cooperatives
MOI	Ministry of Industry
MOPH	Ministry of Public Health
MRL	Maximum Residue Limits
MW	Mega-watt
NEB	National Environment Board
NICE	National Institute for the Improvement of Working Conditions and Environment
NIOSH	National Institute of Occupational Safety and Health
NSCT	National Safety Council of Thailand
PPE	Personal Protective Equipment
PSA	Poisonous Substance Act
RTG	Royal Thai Government
TDIS	Toxic Data Information System
SIC	Standard Industrial Classification
TDRI	Thailand Development Research Institute
TLV	Threshold Limit Value
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
USAID	US Agency for International Development
VAM	Vinyl Acetate Monomer
VCM	Vinyl Chloride Monomer
rai	A measure of land area = 1,600 m^2

National Strategy for Major Accident Prevention in the Chemical Industry

CHAPTER 1

INTRODUCTION

1.1 WHY THIS STUDY ?

In December 1984, the news of the Bhopal catastrophe struck the world. This was the worst industrial accident in human history claiming the lives of more than 2,000 innocent victims--old, young, women and children alike. The toxic chemical which normally was under control, suddenly turned into a dangerous killer. The exact cause of the leak is still unknown. With this disaster came many dismaying questions. When will the next industrial accident strike? If it can happen in India, can it also happen in Thailand? Are we ready? What needs to be done now?

Many toxic chemicals are regularly in use in our daily lives. Because of the rapid increase in both the number and the quantity of chemicals that are manufactured, transported, stored and used, it is inevitable that the number of accidents involving the production and use of chemicals will rise. Several recent international accidents in the chemical industry clearly point out that accidents involving toxic chemicals are not just a few isolated incidences, they happen regularly, and each time causing the loss of human life or causing great property damage.

Considering the potential hazard to human life and to the environment, and considering the rapid increase in the use of chemicals in Thailand, disastrous accidents are bound to happen, sooner or later, if there are no adequate plans to prevent them. As the age old adage says "an ounce of prevention is worth a pound of cure"; it is essential that a national strategy for preventing accidents involving the use of chemicals be formulated now.

This study is an attempt to look at these issues in perspective. A technical survey was conducted on 27 selected chemical plants and first-hand assessment of the toxicity and potential hazards of the chemicals used and the processes employed were taken. Works already completed in this area were analyzed. The opinions of local experts were sought, as well. A seminar was held on January 22, 1986 to discuss the issues on formulating a national strategy for major accident prevention in the chemical industries. It is hoped that the strategy and recommendations formulated in this report will alert the government and the public at large of the urgency of the issue and the appropriate direction to take in trying to prevent a major chemical accident from happening here in Thailand.

1.2 SCOPE OF THIS STUDY

This report is the result of a study conducted jointly by the Thailand Development Research Institute (TDRI) and the National Institute for the Improvement of Working Conditions and Environment (NICE) during the period of October 1, 1985 to January 31, 1986 with the financial support of the International Labor Organization (ILO) Regional Office, Bangkok.

The Terms of Reference of the study are as follows:

(1) To prepare a profile of selected chemical industries in Thailand emphasizing the manufacturing processes, working environment, including occupational safety and health, welfare of employees, and wastes generated. Special attention will be given to accident prevention and control in small and medium-scale industries which require additional assistance from the government.

(2) To formulate a national strategy on accident prevention in the chemical industry covering:

   a) the evaluation of the role of various governmental agencies including research institutes,

   b) the effectiveness and need for standards,

   c) the evaluation of existing legislations,

   d) the institutional framework necessary to respond to major accidents,

   e) any preventive measures, particularly the dissemination of information to employees and to the public, and

   f) financial measures necessary to implement any proposed governmental strategy including the role of employers.

Organization of this report

The working definition of accident prevention in this study and classification of dangerous substances are presented in Chapter 2 of this report. As part of this study, an overview of major accidents that have occurred in other countries is reported in Chapter 3. Chapter 4 presents an analysis of past, present and planned programs of various government agencies as well as a review of the research related to accidents and hazards from toxic chemicals. Chapter 5 presents the survey results from field visits to 27 chemical manufacturing companies on safety conditions and practices in Thailand. Chapter 6 presents the recommendations in formulating the national policy on accident prevention in the chemical industry.

It is envisaged that the profiles developed will project a picture of the existing situation and needs on accident prevention in the chemical industry in Thailand. A seminar on "Strategy for Major Accident Prevention in the Chemical Industry" was held on January 22, 1986, to duscuss the various issues and findings of this study. The Seminar was attended by representatives of governmental agencies, industry, federations of employees, and international organizations (see Appendix J). The opinions and the consessus of these experts have been incorporated into the strategy and recommendations of Chapter 6.

Finally, it should be mentioned at this stage that this study on major accident prevention in the chemical industry is intended to serve as a groundwork for the proposed continuation of technical collaboration between ILO and NICE, which, according to plan, will begin in January, 1987.

CHAPTER 2

DEFINITIONS AND CLASSIFICATION OF DANGEROUS SUBSTANCES

This chapter presents the definition of accident prevention as it relates to the chemical industry, the United Nations' classification of dangerous substances and a list of substances with the potential to cause major hazards.

2.1 DEFINITION OF ACCIDENT PREVENTION

The Webster's New World Dictionary gives several definitions of the word "accident", i.e., (1) "a happening that is not expected, foreseen, or intended, (2) an unpleasant and an unintended happening, sometimes resulting from negligence, that results in injury, loss or damage, etc.". Accident prevention in industry in this study is defined as "the preventing of accidents by some prior actions or measures, including but not limited to, the use of government regulations, guidelines, education and training of the work force and voluntary actions of the chemical industry".

Accidents involving chemicals may be broadly divided into four categories: (1) those that occur during the manufacturing process, (2) during transportation, (3) from end uses, through various routes such as inhalation and ingestion, and (4) from disposal of used and unused chemicals.

The first category covers those accidents that occur during the manufacturing of chemicals which require high temperature or pressure, or in the handling of large quantities of chemicals. Because of the volume, a major accident may effect both the workers inside a chemical plant, and the public in the vicinity.

The second category involves the transportation of dangerous substances, especially bulk transportation of chemicals. In general, it implies land and sea transportation since shipment of chemicals by air is not the normal mode employed because of the high associated costs. With transportation, hazards from chemicals have become mobile, imposing their potential danger along the routes taken.

The third category of accident may be generated from the end use of chemicals, such as from the use of LPG as fuel in households or the accidental ingestion of pesticides by agricultural workers. This is particularly relevant to Thailand due to the application of chemicals in agriculture in the form of pesticides, fertilizers, etc.

Finally, the fourth and last category involving accidents from chemicals is the impact from the disposal of used and unused chemicals. This also refers to the disposal of second-generation wastes left over from the waste treatment processes.

In 1976 the International Labor Organization (ILO) identified the means that are available for the prevention of accidents as follows:

1) Regulations in such matters as general working conditions; the design, construction, maintenance, inspection, testing and operation of industrial equipment; and the duties of employers and workers.

2) Standards of equipment, hygienic practices, or personal protective devices.

3) Inspection and enforcement of regulations by government agencies.

4) Research on properties of chemicals, in equipment design, medical research, physiological research and statistical research.

5) Education and training of students in schools and colleges and of workers in safety matters.

6) Public relations promoting safety awareness to the general public through mass media, and

7) Insurance or financial incentives to promote accident prevention.

To this list we may add automation because increasing automation has tended to reduce the possibility of human failings in plant operations. At the same time, however, the risk of extensive damage increases due to the higher amount of dangerous substances handled.

2.2 CLASSIFICATION OF DANGEROUS SUBSTANCES

In order to facilitate the safe handling and transport of dangerous substances, the United Nations has classified dangerous substances, most of which are chemicals, into 8 classes:

Class 1. Explosives

An explosive substance is a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.

Class 2. Gases: compressed, liquefied, dissolved under pressure or deeply refrigerated

This class comprises :

a) Permanent gases, which cannot be liquefied at ambient temperatures, e.g., carbon monoxide, hydrogen, methane.

b) Liquefied gases, which can become liquid under pressure at ambient temperatures, e.g., liquefied petroleum gas (LPG), ammonia, ethane, chlorine, sulphur dioxide.

c) Dissolved gases, gases dissolved under pressure in a solvent, which may be absorbed in a porous material, e.g., acetylene.

d) Deeply refrigerated permanent gases, e.g., liquid air, oxygen, nitrogen, hydrogen.

Class 3. Inflammable liquids

Inflammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension which give off an inflammable vapor at temperatures of not more than 60.5oC, closed-cup test, or not more than 65.6o C, open-cup test (e.g., paints, varnishes, lacquers, etc.).

Class 4. Inflammable solids

Inflammable solids are solids which are readily combustible or cause or contribute to fire through friction; substances which are liable to spontaneous heating, or to heating up in contact with air and being then liable to catch fire; or substances which, by interaction with water, emit inflammable gases.

Class 5. Oxidizing substances; organic peroxides

Substances which, while themselves are not necessarily combustible, may by yielding oxygen, cause or contribute to, the combustion of other materials. Organic peroxides are thermally unstable substances, which may undergo exothermic self-accelerating decomposition. They may be liable to explosive decomposition, burn rapidly, be sensitive to impact or friction, react dangerously with other substances, or cause damage to the eyes.

Class 6. Poisonous (toxic) and infectious substances

These are substances which are liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact, or substances containing viable micro-organisms or their toxins which are known, or suspected, to cause disease in animals or humans.

Class 7. Radioactive substances

Radioactive substances are those with specific activity greater than 0.002 microcurie per gram.

Class 8. Corrosives

Corrosives are substances which by chemical reaction will cause material damage or severe damage when in contact with living tissue.

From this classification, danger symbols have been derived to create visual effect, examples are shown in Figure 2.1.

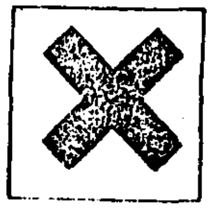
(a) Explosive (E)

(b) Toxic (T)

(c) Oxidizing (O)

(d) Corrosive (C)

(e) Highly flammable(F)



(f) Harmful (X_n) and Irritant (X_i)

Figure 2.1 Symbols for Labelling Dangerous Substances

2.3 SUBSTANCES WITH POTENTIAL TO CAUSE MAJOR HAZARDS

In considering the risks associated with the handling of chemicals, the amount in storage or in use in the process, as well as the pressure and temperature conditions must be taken into account. Table 2.1 summarizes some of the potentially hazardous chemicals.

Table 2.1 Chemicals with Potential to Cause Major Hazards

Organic Liquids	**Inorganic Liquids**
Hydrocarbons (petroleum products)	Chlorine
Chlorinated hydrocarbons	Sulphur dioxide
Halogenated hydrocarbons	Hydrochloric acid
Alcohols	Nitric acid
Esters	Phosphoric acid
Ethers	Sodium hydroxide
Ketones	Mercury
Formic acid	Carbon sulfide
Acetic acid	
Sodium pentachlorophenate	
Polychlorinated biphenyls	
Organic Solids	**Inorganic Solids**
Phenols, cresols	Arsine, Barium, Mercury
Chlorophenols	Chromium, Copper, Lead and their salts
Organic mercury compounds	Cyanides
Pesticides	Fluorides
Phtalic anhydride	NaOH, KOH
Maleic anhydride	
Gases	
Ammonia	
Chlorine	
Propane (LPG)	
Nitric oxides	
Carbondisulfide	
Hydrogen sulfide	
Sulphur dioxide	
Sulphur trioxide	

Source: Janhunen (1984)

CHAPTER 3

MAJOR ACCIDENTS: THE INTERNATIONAL EXPERIENCE

Tragic accidents in industries working with chemicals could be traced back to as early as 1921, more than 64 years ago, when man started to employ chemicals in quantity. The case of Bhopal referred to earlier, or the explosion of liquefied gas tanks in Mexico City which took 452 lives in November 1984, brought the issue of accident prevention home. Before a discussion of accident prevention in Thailand, it is important to learn from the experience of other countries.

3.1 MAJOR ACCIDENTS IN THE PAST

This section gives brief descriptions of some major accidents during the past 64 years. The majority of these accidents originated from fires or explosions involving fuels or petrochemical-derived feedstocks which tend to be used in much larger quantity than toxic or reactive chemicals.

This chronological list is not intended to be exhaustive, but exemplifies a few major cases that have already occurred in a number of countries over the world.

Bhopal, India, December 2-3, 1984. About 40 tons of methyl isocyanate (MIC) leaked from the Union Carbide pesticide manufacturing plant. It has been estimated that at least 2,000 persons were killed, 10,000 seriously injured, 20,000 partially injured and 180,000 adversely affected in some ways.

Mexico City, Mexico, November 19, 1984. Shortly before dawn, liquefied-gas tanks exploded at the San Juan Ixhautepec storage facility operated by state-owned Petroleos Mexicanos. The resulting fire took 452 lives and injured 4,248 in Mexico's largest industrial disaster.

Cubatao, Brazil, February 25, 1984. Gasoline from a leaky pipeline in this southeastern Brazilian town exploded into a giant fireball that killed at least 500 people.

San Carlos de la Rapita, Spain, July 11, 1978. An overloaded 38-ton tank truck carrying 1,518 cubic feet of combustible propylene gas skidded around a bend and slammed into a wall, sending flames 100 feet high into a campsite where 780 tourists were eating, sunbathing and swimming. The death toll: 215.

Seveso, Italy, July 10, 1976. Between one pound to 22 pounds of poisonous dioxin were released into the atmosphere over an area of 4,500 acres when a chemical reaction at the Hoffman - La Roche plant set off an explosion. More than 1,000 residents were evacuated, and many children developed a disfiguring rash called chlorance, but no lives were lost.

Beek, Netherlands, July 11, 1975. A reactor exploded and released about 5.5 tons of propene fraction which killed 14 persons.

Flixborough on Humberside, United Kingdom, June 1, 1974. Britain's largest peacetime explosion occurred at the Nypro

(U.K.) Ltd. chemical plant when a pipe ruptured. The plant produced caprolactum, which is woven into nylon. The blast killed 28 workers and leveled every building on the 60-acre site.

Times Beach, Missouri, USA, early 1970s. The town hired a contractor to spread oil on ten miles of unpaved streets to keep down the summer dust. Waste sludge from a chemical factory was used. An estimated tens of thousands of gallons of dioxin - laced oil were sprayed all over town. No lives were lost but the town had to be abandoned.

Ludwigshafen, Germany, July 28, 1948. A railway car transporting dimethylether, used in making acetic acid and dimethylsulfate, to the I.G. Farben chemical plant exploded inside the factory gates. The blast and resulting fire killed 207 people and injured 4,000.

Texas City, Texas, April 16, 1947. During the night of April 15, a fire broke out on the Grand Camp, a freighter anchored in the harbor of this port town in Galveston Bay. The Grand Camp carried 1,400 tons of ammonium nitrate fertilizer. At 8 o'clock the next morning, the Grand Camp exploded in a blast that rattled windows 150 miles away. Flames leaped 700 feet to a nearby Monsanto plant that produced styrene, a combustible ingredient of synthetic rubber. Minutes later the Monsanto plant exploded, setting off fires throughout the city. On April 17 the freighter High Flyer, also loaded with nitrates, exploded in the harbor. The toll: 576 dead, 2,000 seriously injured.

Cleveland, Ohio, USA, October 20, 1944. A liquefied-natural-gas tank belonging to the East Ohio Gas Co. developed a structural weakness that led to a huge explosion. The blast and fire killed 131.

Oppau, Federal Republic of Germany, September 21, 1921. The largest chemical explosion in German history occurred in a warehouse about 50 miles south of Frankfurt when workers used dynamite to pry loose 4,000 tons of caked ammonium nitrate fertilizer. The blast killed 561 people and leveled houses four miles away.

3.2 LEGISLATION AND REGULATIONS FROM THE EEC AND SELECTED COUNTRIES

With all the disasters caused by major accidents, it is recognized in the developed countries that accident prevention cannot be left to routine equipment inspection or regular maintenance programs. Governments have passed legislation and regulations creating double-checking and other preventive measures. A few cases will be discussed here.

European Economic Community (EEC)

The EEC has taken concrete steps to minimize major accident hazards. Member countries of EEC have adopted new directives on accident prevention requesting: (a) national regulations be issued before August, 1984, (b) industrial enterprises notify the national authorities about the quantities of dangerous substances at their disposal before August, 1985, and (c) detailed information concerning accident prevention be given to the EEC before August, 1989.

The EEC directive lists 178 dangerous substances, storage installations and processes where these substances are used. The enterprises involved must notify the authorities and inform them concerning: (a) dangerous substances, their properties, detection and analyses methods, instructions for their use, emergency measures and details of the potential hazards, (b) installation information, location, number of personnel, description of the processes, probable circumstances where a major accident could occur and precautionary measures, and (c) emergency plans, equipment, alert systems, protection organizations, rescue plans for outsiders and names of responsible people.

United Kingdom

National regulations were issued and became enforceable in January, 1983. Specified enterprises had to notify the authorities before January, 1984. Detailed information and hazard analysis submissions were requested from 300 enterprises.

The Netherlands

The Dutch Safety Law of 1934, which was concerned with the safety of employees, was revised in 1977 with an additional requirement for a safety report from specified installations. This provision came into force in February 1982 for the most dangerous categories of installations in the process industry. Full implementation was gradually spread over 10 years according to the degree of potential hazards. The Labour Inspectorate issued guidelines on the contents of the Safety Report, and is the sole authority empowered to assess them.

Belgium

Legislation on unsanitary, noxious or dangerous factories was incorporated into the 1946 General Protection at Work Regulation. This requires a license for the building and operation of classified plants.

The Regulation is aimed primarily at protecting the workers, but the application for a license under this regulation must, apart from providing technical details of the installation, also include information on measures to prevent, or reduce the consequences of accidents affecting the surroundings of the installation.

The application and the authority's decision are displayed for public inspection and, in certain cases, communicated in writing to those in the immediate vicinity of the establishment.

In addition, the provincial authorities may require a Safety Survey, the extent of which is determined locally.

Federal Republic of Germany

In 1974 the Federal Government passed the law "Bundes-Immissionsschutzgesetz" (Protection against Emissions) which provides for a system of licenses for facilities having substantial emissions. A list of categories of such facilities requiring a license for building and operation was promulgated.

The license application must contain information on technical features of the facilities and processes, the nature and quantity of substances handled, emissions, as well as measures taken to protect workers, the population in the vicinity and the environment.

The public is consulted in public hearings, though restricted to those who have raised objections, and has access to a summary of the application if the license application itself contains business secrets. The decision on the approval of a license is published in the official gazette and in the local press.

To alleviate fire hazards and explosions at work, the succeeding Regulation of 1975 provides for the preparation of emergency plans covering the facilities and the organization of safety training.

The Decree on the Control of Disturbances was passed in 1980 providing protection against major hazards from industrial activities; fire, explosion, and the release of 142 classified substances. Under this Decree, industry is obliged to prepare a "Safety Analysis" to be readily available for the inspection of designated authorities.

Sweden

The responsibility for major hazard control is partly covered by the National Board of Occupational Safety and Health, Ministry of Labor and partly by other authorities. Existing legislation, although extensive, does not refer specifically to major hazard control.

CHAPTER 4

PRESENT STATUS OF ACCIDENT PREVENTION IN THAILAND

This chapter discusses what has already been done in Thailand on accident prevention from dangerous chemicals. The existing government regulations and legislations, environmental quality standards, activities of government regulating agencies, and other studies which have been conducted are reviewed.

4.1 EXISTING REGULATIONS AND LEGISLATION

This section briefly discusses existing regulations and legislations that will be pertinent to any new strategy concerning accident prevention in the chemical industries.

Poisonous Substance Act (PSA) B.E. 2510 amended B.E. 2516

PSA was enacted for the control of import, export, manufacture, sales, storage, transport, and use of poisonous substances. Under this act, poisonous substances used in agriculture, industry and public health are under the joint control of three ministries, namely, the Ministry of Agriculture, Ministry of Industry, and Ministry of Public Health. The respective ministries are empowered to register a chemical onto the list of poisonous substances. Once a chemical is enlisted, it is subject to control under this Act. Permission must be obtained from the respective ministries prior to the import, export or manufacture of the listed chemicals. The three ministries are empowered to issue ministerial regulations governing the storage, transportation, manufacture, use, labelling, and disposal of both the poisonous substances and their containers.

A Poisonous Substance Board (PSB) was also created under this Act. The duty of the Board is to advise the respective ministries in registering a particular substance as poisonous and permitting or banning the import of poisonous substances.

<u>The National Environmental Quality Act</u> B.E. 2518 amended B.E. 2521

This Act created the National Environment Board (NEB) and the Office of the National Environment Board (ONEB). It authorizes NEB to perform functions which mostly concern policy development and coordination with other government agencies in matters relating to environmental quality.

The B.E. 2521 amendment empowers NEB to issue ministerial regulations in designating projects that are required to submit an Environmental Impact Assessment (EIA) to NEB for prior approval. Presently, ten types of projects are required to submit EIA to NEB for approval, the list of these projects is given in Appendix C.

<u>Announcement No.103 of the National Executive Council</u> B.E. 2515

Announcement No. 103 was promulgated for the general protection of workers. There are sections related to working hours, female workers, child labor, wages and overtime, worker compensation and the general welfare of workers.

Section 2 (7) of the Announcement gives broad powers to the Ministry of Interior to issue regulations for the protection of workers' welfare, including safety standards, air quality standards and the working environment.

The Factories Act B.E. 2512

This Act empowers the Ministry of Industry to control the establishment and operation of factories. Under this Act, the Ministry of Industry can issue regulations limiting waste discharges from factories, air emissions, occupational safety and the working environment inside the factories. However, government owned factories are exempted from the control of this Act.

Section 39 of the Factory Act (1969 empowers the Ministry of Industry (MOI) to issue regulations related to pollution, occupational safety and accidents. Regulations issued under this section such as Notification No.4 of MOI (1971) deal with toxic substances, chemicals, flammables and explosives but only in very general terms: the question of public safety is not directly addressed. It should also be noted here that MOI can only control "factories", whereas establishments that are not classified as factories but potentially hazardous, such as gas stations, are beyond its mandates.

Regulation of the Office of the Prime Minister on Accident Prevention B.E. 2526

This regulation created the National Safety Council of Thailand (NSCT). The Council, consisting of representatives from various government agencies, is chaired by a Deputy Prime Minister. The primary duties of the NSCT are to advise the Council of Ministers in matters related to accident prevention, coordinate the works of various government agencies, propose new laws or regulations to the Council of Ministers, and promote public awareness and public relations.

Other Acts

There are several other related acts that govern or control the use of gasoline, LPG, fire codes and control of nuisances and are listed here as follows:

The Minerals Act B.E. 2510. This Act governs the establishment and operation of mines including pollution and safety control.

Announcement No.18 of the National Executive Council B.E.2524. Controls the storage and use of liquefied petroleum gas (LPG).

Land Transportation Act B.E. 2522. Governs land transportation with provisions for the control of transportation of hazardous substances.

Petroleum Storage Act B.E. 2497. Regulates the storage, distribution and transportation of petroleum and other flammable substances.

Public Health Act B.E. 2484. Regulates activities affecting public health and welfare including refuse handling, maintenance of public lavatories, nuisances, control and sales of food.

Fire Protection Act B.E. 2495. Regulates the storage of combustible substances.

Announcement No. 290 of the National Executive Council. Contains provisions to regulate the safe transport of materials on the rapid transits.

Navigation Act B.E. 2456. Contains regulations on the transport of dangerous substances within the Thai waterways.

4.2 EXISTING ENVIRONMENTAL QUALITY STANDARDS

Standards on environmental quality were already compiled in an NEB publication (1985). The standards are grouped into five categories:

1) Air Quality Standards. These include environmental air quality standards, motor vehicle emission standards and emission standards for motorboats. The pollutants that are specified in these standards are CO, NOx, SO2, O3, total particulates, and lead.

2) Noise Standards. These include environmental noise standards, motor vehicle and motorboat noise, emission standards and noise standards for the workplace.

3) Solid Wastes. Most of these are regulations prohibiting the improper disposal of solid wastes in a manner that would be a nuisance to the public. Most of the provisions are in very general terms. For example Notification No. 2 (B.E. 2513) of Ministry of Industry, section 5, item No.20 stipulates that:

> "The factory must separately store the solid wastes or other waste materials that have been contaminated with toxic substances or cloth or cotton wool or other waste fibres that are combustible. These wastes shall have proper covers and shall be disposed of by special methods in a safe manner that does not create any nuisance."

4) Toxic Substances. These include the maximum residue level of toxic substances in food, the threshold limits of chemicals in the workplace and the general manner in which toxic substances are to be stored or transported.

5) Water Quality Standards. These include drinking water quality standards, wastewater effluent standards, surface water supply standards and sea water quality standards.

Of these standards, only three have direct relevance to toxic substances, i.e.:

a) Notification No.12 of the Ministry of Industry B.E. 2525. This contains the wastewater effluent standards for factories. The standard limits the concentration of several pollutants in the wastewater effluence including several toxic substances such as chromium, arsenic and pesticides. The standard is given in Appendix A.

b) Announcement of the Ministry of Interior May 30 B.E. 2520. This standard limits the concentrations of chemicals, dusts, fibers, vapors, fumes and gases in the workplace (see Appendix B). The standard is divided into four parts specifying:

- o The allowable average concentration of chemicals during working hours.
- o The allowable maximum concentration of chemicals at any time.
- o The allowable concentration of chemicals for a specified duration.
- o The allowable average concentration of minerals.

c) NEB Standard for Surface Water Sources. This standard classifies surface water sources into five classes according to the intended uses. The maximum allowable concentrations of several pesticides, heavy metals, and toxic substances are specified.

Consequently, NEB has classified the lower Chao Phraya River according to the above standard.

4.3 ACTIVITIES OF GOVERNMENT REGULATING AGENCIES

Authority for regulating accident prevention measures and potentially dangerous chemicals lies with a number of government agencies. The primary agencies involved are the Department of Labor (DOL), the National Environment Board (NEB), the Department of Industrial Works (DIW), the Department of Agriculture (DOA), the Department of Public Health (DOPH) and the National Safety Council of Thailand (NSCT). Table 4.1 shows the functions of these agencies.

TABLE 4.1 Role of Governmental Agencies involved in Accident Prevention in the Chemical Industry

Functions	Agencies 1/					
	DOL	NEB	DIW	DOA	DOPH	NSCT
Policy formulation	o	o	o	o	o	o
Coordination		o				o
Enforcement	o		o	o	o	
Research	o	o	o	o	o	
Standard setting	o	o	o	o	o	
Monitoring	o	o	o	o	o	

1/ Note:

DOL - Department of Labor
NEB - National Environment Board
DIW - Department of Industrial Works
DOA - Department of Agriculture
DOPH - Department of Public Health
NSCT - National Safety Council of Thailand

This section does **not intend** to elaborate on the functions and mandates of each **agency**, **but** rather on the major activities related to accident prevention already carried out by these agencies.

National Environment Board (NEB)

NEB is primarily a policy and advisory organization responsible for formulating policies for the conservation and enhancement of the national environment. NEB also coordinates the work of various other governmental agencies involved in the conservation of the environment. It has set up a **Toxic Substance Committee** which oversees matters related to toxic substances. Currently the Toxic Section of NEB is studying and monitoring the adverse effects of toxic and hazardous substances, preparing guidelines for health and environmental protection, and establishing contingency and management plans.

NEB through its Environmental Impact Evaluation Division is responsible for reviewing the Environmental Impact Statement (EIS) which is now a prerequisite for 10 major development activities including petrochemical, oil refinery, natural gas separation and processing, chlor-alkaline, iron and steel, cement, smelting and pulp production (See Appencix C). The EIS system has proved to be an effective tool for NEB in injecting precautionary measures to reduce adverse impacts to the environment. Unfortunately, accident prevention related to the use of chemicals is not yet one of the requirements in the EIS.

In 1983 the **Toxic Substance Committee** of NEB reviewed the problems arising from toxic substances and ranked the priorities of the issues. The results represent the consensus of various government agencies and can be summarized as follows:

1) Legislation and Environment. The Poisonous Substance Act (PSA) B.E. 2510, amended in B.E. 2516, has several weaknesses. Before any poisonous substances can be regulated, they must first be registered. Substances that have not been registered are not subject to control under the provisions of this Act. This has resulted in a large number of hazardous substances being imported or used freely. The PSA also does not cover hazardous substances that are already parts of products, such as asbestos in brake linings and PCBs in electrical equipments.

There is also an inadequate number of inspectors to visit various establishments thus making it difficult to enforce the law or to ensure compliance with existing standards.

2) Absence of Sales Restrictions. Users can purchase toxic substances freely with no limitations on quantity or use. This has resulted in toxic substances that are incorrectly applied or used in excessive quantities.

3) Absence of Knowledge. Agricultural workers are often ignorant of the hazards of pesticides to health and to the environment.

4) Lack of Research. There is a lack of research in the area of toxic substances, such as the effects on health, synergistic effects and environmental pollution. Manufacturers often hold

back information such as the amount of toxic substances emitted from various manufacturing processes, information on the fate and the degradation of toxic substances in the environment, and information on toxicology, especially substances that are newly introduced.

5) Laboratory Analysis. Lack of standard methods in sample collection, sample storage, sample preparation, preparation of standard solutions, preparation of solvents, and analysis and reporting of results makes it difficult to compare results from the monitoring and laboratory analyses undertaken by different government agencies.

6) Personnel. There is a shortage of technical expertise to cope with the increasing seriousness of the problem.

Last year NEB commissioned a review of the existing legislation on toxic substances. The Manring Report (1985) stated that because the present Poisonous Substance Act (PSA) is administered by three ministries, it is ineffective and mainly emphasizes the impact on agriculture. It was recommended that a single lead agency should be set up to administer the Act. Detailed amendments that should be made were also specified, including the registration of establishments, the keeping of books and records, the regulation of hazardous chemical substances and mixtures, the control of imminent hazards, the research, development, collection, dissemination and utilization of data, enforcement and seizure regulations, and the definitions of prohibited acts.

The remainder of the report contains fairly general recommendations on maximum residue limits (MRL), the acceptable daily intake (ADI), occupational health guidelines for chemical hazards, the storage, transport, and waste treatment of hazardous chemicals, recommendations for environmental quality standards for toxic chemicals, and general recommendations on public policy.

Complementary to the Manring Report, NEB, in the same year, commissioned a review on the existing management of hazardous substances in Thailand. The Roos Report (1985) echoed the earlier calls of Manring with specific recommendations, such as:

1) Clear definitions of responsibilities of government agencies in the PSA. Policy could be developed wherein NEB is given authority to delegate certain aspects of hazardous substance management to other specified agencies.

2) Consistency in the laws and regulations. The PSA should be expanded to include all hazardous chemicals used in Thailand. Fines should be increased substantially and levied on a daily basis. Enforcement mechanisms should be established. A uniform and coordinated method of inspection and monitoring is required among the agencies.

3) Standards and specifications should be referenced by laws and regulations. Specific standards, designs, packaging requirements, transport requirements and specifications should be recorded on labels and placed on containers, storage containers, and transport vehicles. The United States Department of Transportation labelling regulation methods could be adopted.

4) A hazardous substance inventory. A hazardous substance inventory should be compiled and computerized. This should be a joint effort with MOI, NICE and MOPH. The PSA and other newly developed legislation should all refer to the chemicals classified in this inventory. A tracking of manifest system similar to the US system should be adopted.

5) Centralized information management. NEB should employ a centralized information management system to compile and disseminate data related to hazardous/toxic chemicals and their wastes.

6) Standardized labelling, storage, containerization and transportation. This should be developed and referenced in the PSA.

7) Toxicological evaluation of chemical data. This should be researched with the Thai climate, diet and economics in mind.

8) Cooperation and coordination within NEB itself and with other agencies.

9) Timing and scheduling in setting up milestones for data acquisition. The type of data required from each agency, format type and extent of detail required could be included in a long-term schedule.

10) Training and contingency planning for government and industry personnel. Programs should be geared to train supervisors and trainers as well as workers and inspectors.

Department of Industrial Works (DIW)

DIW is responsible for the control of industrial pollution and occupational safety in the factories. The Factory Control Division (FCD) of DIW is responsible for the registration of all factories in Thailand. Newly proposed factories must submit information including detailed drawings and specifications on the plant and the processes as well as pollution control facilities to FCD. Matters related to environmental pollution are reviewed by the Industrial Environment Division (IED). IED is responsible for the control of pollution from industries, including wastewaters, air pollution, noise pollution and solid wastes.

In 1985 DIW commissioned the Faculty of Engineering of Kasetsart University to study the siting for industrial waste disposal. DIW plans to establish a toxic industrial waste disposal service center for industries located in the Thonburi area. Toxic industrial wastes are to be treated and the settled sludge mixed with cement to form stabilized concrete cubes, which will be transported to a dumping site in Ratchaburi province.

Department of Agriculture (DOA)

DOA of the Ministry of Agriculture and Cooperatives handles toxic substances through its Division of Toxic Substances for Agriculture. This Division is responsible for research in the use of toxic chemicals in agriculture and for the monitoring of residues of toxic substances in the environment. Currently this Division is engaged in research to establish maximum residue limits (MRL) in food and agricultural products.

The Division of Agriculture Regulation is responsible for issuing permits for the importation and manufacture of poisonous substances used in agriculture under the provisions of the Poisonous Substance Act. Presently there are more than 200 chemicals that have been declared as poisonous substances in agriculture.

Ministry of Public Health (MOPH)

In the area of accident prevention, MOPH is responsible for occupational health of workers in the factories, for controlling the quality of food consumed by the public and for the general environmental health of the people in both the urban and rural areas.

In 1985 MOPH organized a seminar on strategies to solve occupational health problems and to prepare a master plan to be incorporated in the Sixth National Economic and Social Development Plan. The concensus from the seminar is that occupational hazards are still prevalent in Thailand. Recommendations arising from the seminar are as follows:

1) Coordination and management at the national level. There must be an agency at the national level for occupational health management, and a national body to coordinate the work of various government agencies. Central and regional occupational health centers should be set up.

2) Amendment of existing regulations and legislation. Regulations and legislation should be amended to avoid duplication. A compendium of occupational regulations should be

prepared. The setting of standards must take into consideration the economics and the technology level of the country.

3) Increase personnel and efficiency of agencies. The government should increase the budget in the areas related to occupational health in order to increase the number of personnel and the efficiency of the government agencies. Laboratories should be set up for work in this area.

4) Promotion of occupational health. The promotion of public awareness and knowledge of occupational health and hazards should be undertaken using all types of media.

5) Safety officers in factories. There should be safety officers or volunteers in the factories to promote the safe use of equipment.

6) Coordination between government and the private sector. The private sector should be encouraged to participate in the field of occupational health and encouraged to make improvements in the factories through the reduction of taxes on safety equipment and other facilities provided by the employer. Labor unions should also be encouraged to participate in occupational health activities.

7) Data and research. Data in occupational safety should be systematically compiled and disseminated. Funds should be provided for research.

8) Promotion of occupational health in the agricultural sector. Works on occupational safety in the agricultural sector should be initiated through the existing public health systems.

The National Safety Council of Thailand (NSCT)

NSCT concentrates on raising public awareness of accident prevention issues and measures. It publishes and disseminates information on various kinds of accidents including those from automobiles, LPG and fire. The NSCT handbook on "Accidents" (1984) covers chemical labelling, body injuries caused by chemicals, pesticide poisoning and the associated medical treatments.

NSCT has been effective in mass media communication, particularly in conveying its message on TV.

Department of Labour (DOL)

The Department of Labour (DOL) of the Ministry of Interior is responsible for the protection of workers. It enforces various legislations related to labour. Its daily functions include carrying out inspections, improving industrial relations, conducting occupational safety and health, and other technical and laboratory work.

A tripartite advisory council called the National Advisory Labour Development Council assists DOL in policy making and implementation and ensuring commitment of all labour matters at the national level.

In recent years Thailand has shown its concern in protecting its working population from occupational accidents and diseases. This concern was reflected in the formulation of occupational safety and health policies in the country's Fifth National Economics and Social Development Plan 1982-1986. The plan calls for policy objectives and measures which "provide protection for workers against occupational injury and disease" and which "promote better working conditions and living standards of workers as goals to be pursued jointly with employment promotion and economic growth".

Two additional tripatite boards have been set up by the Government to assist DOL to review and improve all legislation regarding occupational safety and health and working environment. These are the National Occupational Safety and Health Standards Board, and the National Working Conditions and Environment Board.

With respect to working conditions, workers' welfare and occupational safety and health, DOL has at its disposal the Labour Standards Division, which has 50 inspectors trained in engineering, occupational safety and industrial hygiene, the Labour Protection Division with 90 inspectors and the Woman, and Child Labour Division with 6 inspectors, responsible for enforcement of legislation related to general conditions of work. Adding the provincial labour inspectors there are altogether 450 officers capable of carrying out the tasks related to working conditions and occupational safety and health. In 1983 the National Institute for the Improvement of Working Conditions and Environment (NICE) was established with assistance from UNDP/ILO.

The objective of NICE is to enhance and to improve the protection of workers from occupational accidents and diseases and from unsatisfactory working conditions. Its main activities are:

- the development and implementation of training programmes on occupational safety and health and working conditions;
- the provision of technical support and assistance for developing administrative and operational procedures;
- the provision of laboratory facilities in occupational hygiene, work physiology and ergonomics and the testing of safety equipments;
- the development and operation of a management information system to centralise information collected and to provide a basis for planning;
- the development of a focal point for national exchange of information and expertise; and
- the provision of support, through research and technical advisory services for extending protection to small-scale enterprises.

An Information Centre is currently operated by NICE, the Centre has a small reference library and documentation unit, a statistical analysis unit, an inquiry service and a computer section. The current library collection comprises approximately 500 books, 22 subscribed English language and 6 Thai journals.

NICE is also the national focal point for the Centre for the International Occupational Safety and Health Information (CIS) of the ILO. NICE is responsible for disseminating CIS information, collecting and updating CIS materials with Thai information and producing abstracts of Thai information to be added in CISDOC. NICE is also currently finalising arrangements for direct on-line access to the CIS data base - CISDOC, and other international data bases such as ECDIN (European Communities Data Bank for Environmental Chemicals) for toxic chemicals and the International Register for Potentially Toxic Chemicals (IRPTC).

With regard to training, during the last 12 months NICE has organised 120 workshops/training courses for an aggregate of 5,500 participants. 33 safety exhibitions were organised. Approximately 5,000 audio-visual aids sich as slides, transparencies, posters, etc. were produced.

Very recently, the new Notification of the Ministry of Interior, promulgated on 6 May 1985, requires that an establishment having a hundred or more employees in each individual place of operation have at least one safety officer in order to perform duties throughout the time that there is work going on. NICE is responsible for training these safety officers. The syllabus contains various aspects of occupational safety and health, ergonomics, working conditions and control of major hazards. There are approximately 2,000 safety officers to be trained during the first two years.

DOL has designed a Major Hazard Control System which is being implemented in collaboration with UNDP/ILO Project. The System consists of:

1) A list of hazardous chemicals and flammable gases, each having a specific quantity such that any factory storing or using any material above the stated quantity should be a major hazard works by definition. Full information on the properties of hazardous materials is being established on computer. Basic data base has already been established. A computer programme in both Thai and English has been designed and is in use.

2) A database on major hazard works and installations is being established.

3) A major hazard control unit to be established at NICE has been proposed for the next UNDP/ILO Project. The unit will have professionals at NICE, and in a few provincial centres to be set up.

4) The First Proposal for Major Hazard Control Legislation has been drafted.

NICE is already working on major hazard control. It has the following manpower and facilities at its disposal:

- more than 40 trained inspectors in Bangkok and in other provinces

- specialists available in industrial hygiene, pressure vessels, engineering, chemical information matters
- a modern chemical laboratory with pressure vessel testing instruments
- a well developed computerized information services as a part of the worldwide ILO-CIS information network
- Technical contacts and backstopping from ILO and other leading institutions in the world.

4.4 OTHER MAJOR ACCIDENT PREVENTION STUDIES

There are two other research studies which contributed to the understanding of the accident prevention scene in Thailand, namely those by Muangman (1985) and Cohen et al., (1985).

Muangman (1985)

Dhephanom Muangman explored the occupational health problems of workers inside factories, and pollution and nuisance problems affecting the public in the vicinity of factories. The research report states that there are still a large number of unregistered or illegal factories that breach the present regulations. The report noted an increase in the occupational health problems of workers and reported the following:

1) Workers are subject to increasing risk from accidents and occupational diseases. For example there are many factories with noise levels exceeding the present safety standards.

2) The number of accidents and injuries are on the rise. In 1983 the workmen's compensation fund paid out 199 million baht to more than 30,000 workers.

3) Many work related diseases have been identified and further research is needed in this area.

Muangman targeted pesticide formulation plants and firework factories that are located in densely populated areas as potential causes of major hazards.

Cohen, et al. (1985)

In 1985 a survey was conducted by Cohen, et al., funded by USAID, to assess health consequences and to develop recommendations for minimizing potential adverse health effects from industrialization and urban development in Thailand.

Field surveys of 29 industrial plants throughout the country were conducted. The key findings of this study are reported as follows:

1) There is a general lack of awareness of environmental and occupational health problems, especially at the provincial and local levels of government and among factory management. This leads to the belief that there are no problems.

2) Regulations for environmental and worker protection are sound, but levels of enforcement are inconsistent. Lack of adequate number of inspectors and equipment have caused inadequate enforcement of existing regulations.

3) Job related injuries in Thailand are increasing. The rapid industrial development and concomitant introduction of more chemicals into the workplace will likely lead to increased frequencies of occupational diseases and poisonings. Equipment and workplace safety standards must be considered.

4) Growth of industry in rural areas will increase the amount of hazardous raw materials and products being transported throughout Thailand. Contamination and transport of hazardous materials are not currently regulated, creating the potential for accidents from spills and leaks. Emergency preparedness and planning for such events must be undertaken.

To minimize potential adverse health effects from industrialization and urban development in Thailand, Cohen, et al., recommended the following be undertaken:

1) Incorporate environmental and worker protection schemes into the National Economic and Social Development Plan.

2) Increase awareness and knowledge of environmental and occupational health issues among provincial and local governments, through training and other promotions.

3) Study of occupational injuries, poisonings and diseases in provincial hospitals.

4) Study of approved and disapproved industrial accident claims to determine economic losses and hardships to families.

5) Study of pollution from rural industries including baseline emission and effluent monitoring.

6) Develop manuals for hazardous control technology.

7) Define responsibilities and increase coordination among government agencies.

8) Set up an information center for environmental and health related data in Thailand.

9) Enforce environmental and worker protection standards.

10) Implement environmental and occupational health programs at provincial levels.

11) Promulgate additional standards for industry design, equipment safety, workplace safety, chemical containerization/labelling/transport, and chemical inventory control.

12) Develop a national hazardous materials/wastes management program, including implementation of hazardous waste disposal sites and research into disposal methods.

CHAPTER 5

PROFILE OF ACCIDENT PREVENTION IN THE CHEMICAL INDUSTRY

This chapter presents information concerning past developments in relation to the chemical industry in Thailand followed by a discussion on injuries from the chemical industry. Survey methodology, major findings and general impressions are given in Section 5.3, followed by the conclusions of the results.

5.1 PAST DEVELOPMENT

Industrialization has been progressing rapidly in Thailand during the past decade. In 1978 the Ministry of Industry (MOI) counted 60,384 factories in the country: in 1983 the total number increased to 91,214. The number of factories in various regions of Thailand from 1978 to 1983 are given in Table 5.1.

Using the Standard Industry Classification (SIC) system, there are 2,023 factories of category 35 which are manufacturers of chemicals, petroleum, coal, rubber and plastic products. Of the total, 1,483 are located in Bangkok and the five surrounding provinces, namely, Nonthaburi, Samut Prakarn, Nakhon Pathom, Pathum Thani and Samut Sakorn. Figure 5.1 shows the geographical distribution of these factories in Thailand. Table 5.2 gives the number of workers employed by various chemical industries according to the size of factory in Bangkok and the five surrounding provinces.

These statistics show that there is a concentration of chemical factories in and around Bangkok. This is natural since Bangkok is the center for industry and commerce and serves as the

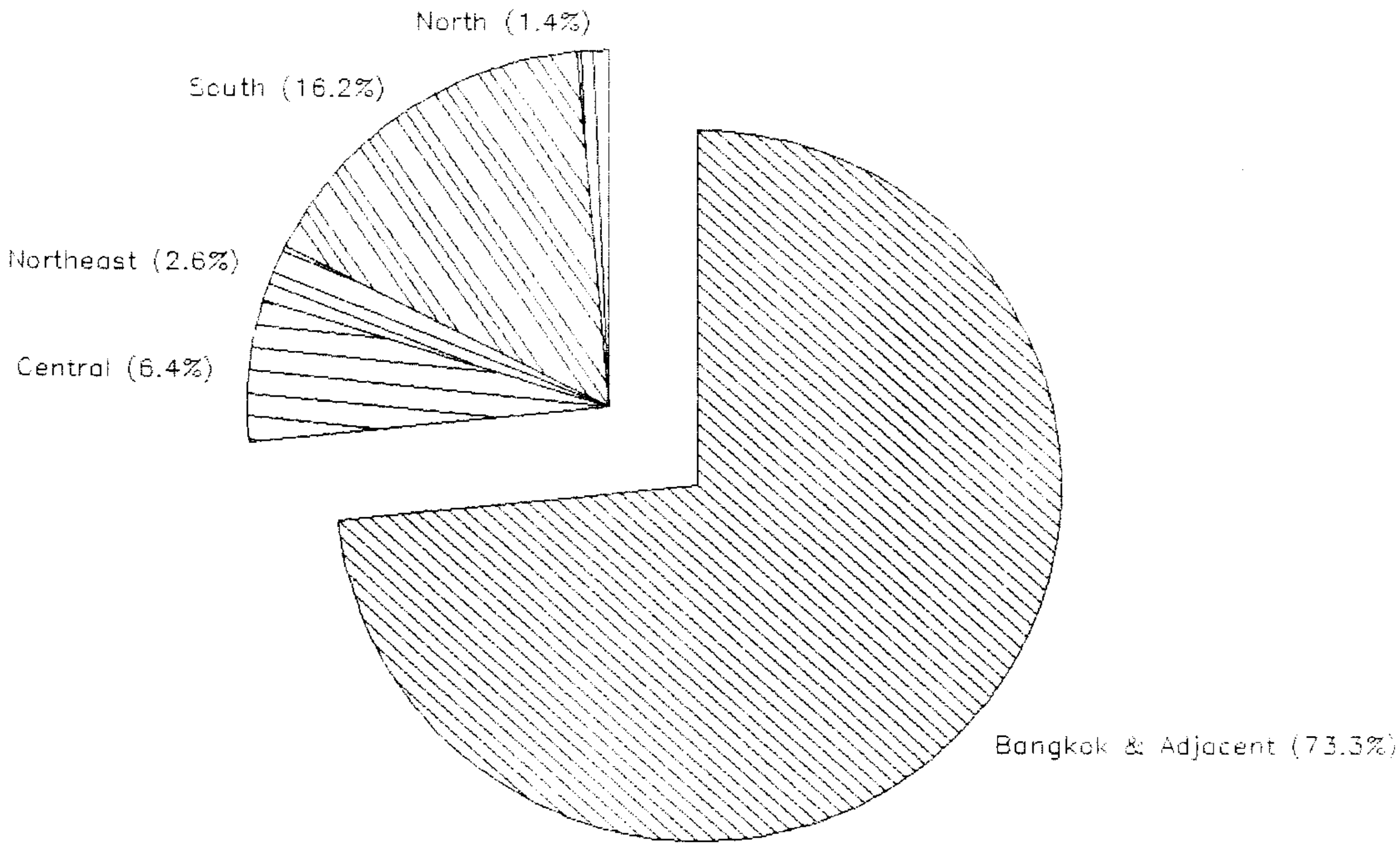
Table 5.1 Number of Factories in Thailand from 1978-1983

Region	Year 1978	1979	1980	1981	1982	1983
Central	21,598	23,915	26,444	28,816	31,428	33,087
- Bangkok	12,954	14,337	15,982	17,470	19,269	19,981
- Samutprakarn	1,520	1,685	1,856	2,047	2,240	2,454
- Other provinces	7,124	7,893	8,606	9,299	9,919	10,652
East	3,360	3,810	3,981	4,164	4,369	4,619
North	9,707	10,885	11,868	12,537	13,394	14,366
Northeast	19,427	22,336	24,769	27,173	29,093	31,096
South	6,292	6,749	7,163	7,500	7,733	8,046
Total	60,384	67,740	74,225	80,190	86,017	91,214

Source : MOI, 1984

largest market of the country. However, this is in itself a point of concern considering that the growth rate of Bangkok, in terms of the number of its population, grows at twice the national rate. With more than 5 million inhabitants, the impact of accidents from the manufacturing and transportation of chemicals is bound to be more severe in congested areas.

Figure 5.1 Geographical Distribution
of Chemical Industries in Thailand



Source : MOI, 1984

Table 5.2 Distribution of Enterprises and Number of Workers According to the Size of Factory in Bangkok and the Five Surrounding Provinces.

SIC No.		Total		1-9 Emp		20-49 Emp		50-99 Emp		>100	
		1/ Ent	2/ Emp	Ent	Emp	Ent	Emp	Ent	Emp	Ent	Emp
351	Manufacturer of industrial chemicals	119	5718	60	411	33	974	14	974	12	3359
352	Man. of other chemical products	416	22647	208	1736	103	3307	50	3376	55	14228
353	Petroleum refineries	6	831	1	7	1	52	2	121	2	651
354	Man. of misc. petr. & coal products	4	173	1	9	1	20	2	144	-	-
355	Man. of rubber products	331	16407	197	1561	66	1974	33	2230	35	10642
356	Man. of plastic products	607	16378	444	3142	87	2504	41	2951	35	7781
35	TOTAL Manufacturer of chemicals & products	1483	62154	911	6866	291	8831	142	9796	139	36661

Source : 1/ Ent = No. of enterprises
2/ Emp = No. of employees

It should be noted that manufactured chemicals are on the rise, and that Thailand also imports a substantial amount of chemicals from abroad. This is particularly valid in the case of pesticides, whose processes are limited to formulation and repackaging. Thailand manufactures only a small quantity of intermediate compounds, most of those needed are imported.

Figure 5.2 shows the amount of imported pesticides with LD_{50} less than 50 mg/kg in 1984. LD_{50} stands for the amount of lethal dose per weight of a tested annimal, mostly rats, above which will be fatal to at least half of the number of animals tested.

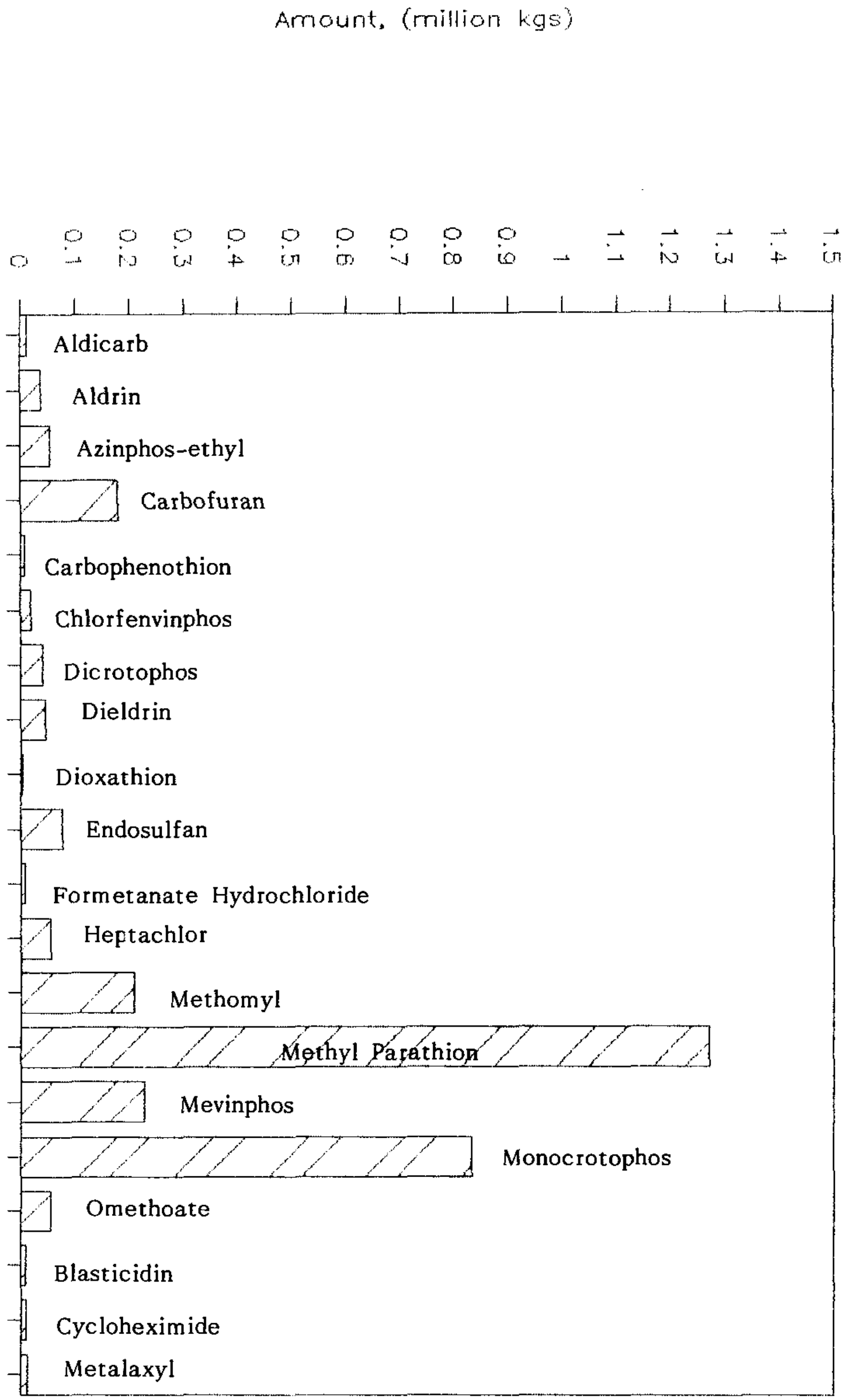


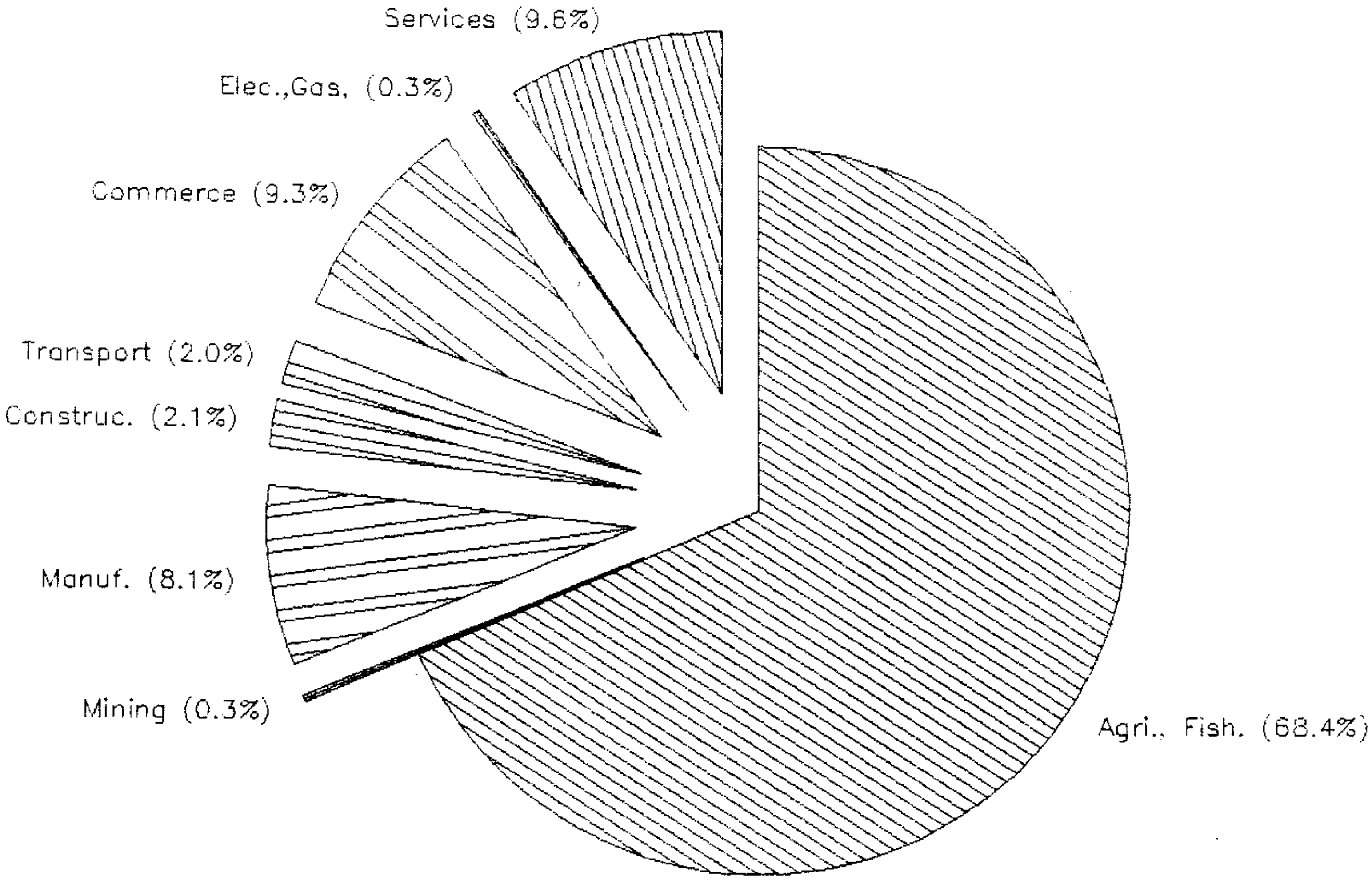
Figure 5.2 Imports of Pesticides Having LD50 < 50 mg/kg in 1984.

5.2 INJURIES FROM THE CHEMICAL INDUSTRY

Thailand has a population of approximately 50 million. The labor force in 1984 was estimated to be about 24.9 million, out of which 23.5 million were employed and 1.4 million unemployed. Figure 5.3 shows the number of persons employed by type of industry. The majority (68.4 percent) are in the agricultural sector, with only 8 percent in the manufacturing sector.

Statistics on injuries from industrial activities have been compiled by the Department of Labor in its administering of the Workmen's Compensation Fund. Due to financial constraints, the present Fund only covers those establishments with 20 employees or more. Table 5.3 shows the steady increase of the number of injuries throughout the country in the last seven years.

Figure 5.3 Employed Persons
by Industry, 1984.



Source : DOL, 1984

Table 5.3 Industrial Injuries and Amount of Compensation Paid, 1978-1984

Year	No of Establishments	No. of Employees	Injured Employees	Per cent	Amount of Compensation Paid (million Baht)
1978	5,403	590,640	20,135	3.41	62.17
1979	6,101	659,041	24,366	3.70	75.22
1980	7,337	745,513	26,034	3.49	98.27
1981	8,465	797,270	28,374	3.56	148.17
1982	9,286	824,565	29,974	3.63	151.28
1983	10,047	873,059	33,213	3.80	205.44
1984	11,133	994,190	39,182	3.94	246.70

Source: DOL, 1984

As can be seen from Table 5.3, in 1984, 39,182 injuries were reported. Out of this number, 2 to 3 percent were considered as serious, involving the loss of limbs, eyesight or death. It is estimated that the actual number of serious injuries should be 3 to 5 times higher. The lower figures are due to the limited coverage of the Workmen's Compensation Fund as cited earlier.

It should also be noted that the economic implications of occupational injuries can be expensive. The amount of compensation paid quadrupled, from 62.17 million baht in 1978 to 246.70 million baht in 1984.

Although the chemical industry represents 5.79% of all employees registered under the Workmen's Compensation Fund, it has a 5.92% share of reported injuries. More alarming is the fatality rate of 53.7 deaths per 100,000 employees which is much higher than the overall figure of 33.0. Table 5.4 compares the fatality rates of different industries. However, the numbers presented in the Table do not include other victims who cannot benefit from the Workmen's Compensation Fund.

Hazards from chemicals are not restricted only to factories. Fatality from explosives and pressured gas have occurred regularly in past years. Table 5.5 provides a synopsis of some recorded accidents in Thailand.

Table 5.4 Fatality Rate in Different Industries (1984) (per 100,000)

Building and Construction industry	109.7
Transportation and Communication industry	101.4
Mining, Quarrying, Gravel, Sand and Clay industry	61.0
Wood and Wood Products industry	58.6
Chemical, Chemical Products, Petroleum, Gas, Rubber and Plastic industry	53.7
All industries	33.0

Source : Department of Labor (1983)

Table 5.5 List of Recorded Hazards from Chemicals in Thailand

Date	Description of Hazard
Nov. 1980	Explosion at an arms depot in Bang Sue, Bangkok killed 35 persons. 600 families near the plant had to be relocated due to home and property damage.
April 6,1983	"Siam Mira", a 3,000 ton oil tanker exploded 10 miles off shore from Srichang Island, 2 persons were killed and 19 persons missing.
April 16, 1983	Explosion from an LPG-leak in restaurant in Soi Nana, Bangkok killed 5 persons.
August 16, 1983	A 10-ton oxygen tank exploded in the Sahapan Steel plant in Pra Pradaeng, Samut Prakarn. The explosion killed 4 persons passing by in a small bus.
Jan 30, 1984	An LPG tank for cooking exploded at a house on Bangkok Street, Phuket. Nine persons were killed, five injured, and 50 houses destroyed.
Feb 20, 1984	Ammonia gas leaked from a refrigerator under repair in a seafood processing plant in Hatyai, 35 persons were injured, one killed while fleeing the scene and fell from a building.

Table 5.6 compares the risk of accidental deaths from various activities in Britain, the Netherlands and Thailand. It is alarming to see that the risk of accidental death in the chemical industry in Thailand is more than 20 times that of Britain and the Netherlands.

Table 5.6 Risk of Accidental Death in Various Activities Expressed in the Number of Fatalities per 100,000 persons per year

Activity / Country	Britain	Netherlands	Thailand
Chemical industry	1.6 (8.7) 1/	2.4 (12.5) 1/	53.7
Building Construction/ building	9.9	13.1	109.7
At work generally	2.1	4.6	32.2
Motor vehicle accidents	13	16.5	6.1 2/
Accidents at home	12	-	-
Falls	-	14.6	-
Suicides	8	8.7	-

1/ Figures in parenthesis include fatalities from the Flixborough and Beek disasters respectively.

2/ Whole Thailand, the vehicle density (and the risk) is low in rural areas. Bangkok figure is 14.2 (Source : National Safety Council, statistics taken from Police Dept, Thailand.)

5.3 SURVEY METHODOLOGY, MAJOR FINDINGS AND GENERAL IMPRESSIONS

Methodology

Field visits were conducted to 27 factories (see Appendix D) as categorized in Table 5.7

Table 5.7 Types and Numbers of Chemical Factories Visited

SIC	Type	Number	(%)
35111	Manufacture of basic industrial chemicals, except charcoal and fertilizer	9	(33.3)
35120	Manufacture of pesticides	10	(37.1)
352	Manufacture of explosives and ammunitions; paints, varnishes and lacquers; and matches	6	(22.2)
35130	Manufacture of synthetic resins, plastic materials and artificial fibers except glass	1	(3.7)
353	Petroleum refineries	1	(3.7)
	Total	27	(100.0)

In each factory a systematic analysis based on a predesigned questionnaire was undertaken. The content of the questionnaire with detailed statistics of the results on pesticide plants is attached as Appendix E.

Although the field survey was limited to only 27 plants, an effort was made to ensure that these are indicative of each category of industry. Emphasis was given to small and medium factories based on the classification of the Department of Labor. Table 5.8 provides the details.

Table 5.8 Size of the 27 Chemical Factories Visited

Type of	Number of Factories	Number of Employees < 50	50-199	> 200
SIC 35111	9	3	5	1
SIC 35120	10	5	5	-
SIC 352	6	3	3	-
SIC 35130	1	-	-	1
SIC 35300	1	-	1	-
Total	27	11 (40.7%)	14 (51.9%)	2 (7.4%)

In trying to identify potential major hazard installations, The World Bank Guidelines for Identifying, Analyzing, and Controlling Major Hazard Installations in Developing Countries was used as the reference, particularly its lists of toxic, reactive, explosive and flammable substances (Appendix F).

In addition to the field survey, the opinions of local experts in identifying major hazardous substances were also compiled through an additional questionnaire survey by mail, the results of which provide a preliminary list of dangerous chemicals in Thailand. This is attached as Appendix G.

Major findings

Twenty-eight out of 224 chemicals used or produced in the plants visited were identified as hazardous substances based on the World Bank guideline. The substances are :

Group 1 - Highly toxic substances

- o Carbofuran
- o Chlorfenvinphos
- o Mevinphos
- o Nickel (powder)
- o Parathion

Group 2 - Toxic substances

- o Formaldehyde
- o Hydrochloric acid
- o Chlorine
- o Methyl bromide

Group 3 - Highly reactive substances

- o Acetylene
- o Ammonium nitrate
- o Hydrogen

Group 4 - Explosive substance

- o Diethylene glycol

Group 5 - Flammable substances not specifically named in Group 1-4

- o Acetone
- o Acrylonitrile monomer
- o Benzene
- o Cyclohexane
- o Ethyl acetate
- o Ethyl alcohol
- o n-Hexane
- o Isopropanal
- o Liquefied petroleum gas
- o Methyl alcohol
- o Methyl ethyl keton (MEK)
- o Nitrocellulose
- o Toluene
- o Vinyl acetate monomer
- o Xylene

Twenty out of 27 factories visited, used or produced at least one identified hazardous substance listed above.

Details on the location of the factories with identified hazardous substances are provided in Table 5.9.

Table 5.9 Location and Details of Factories Visited

No.	Area	SIC	No. of Employees	Registered Capital (10^6 Baht)	Products	Quantity of Products (10^6)/yr	Hazardous Chemicals Identified
1	Samut-prakarn, Bangplee	35111	172	60	Latex Alkyd resin Polyester Urea glue Plasticizers	1.2 kg 2.5 kg 0.3 kg 4.0 kg 3.0 kg	Xylene Acrylonitrile monomer Methanol
2	Phathum-thani, Klong-luang	35111	40	-	HCl NaOH	1.7 liters 3.12 kg	HCl
3	Bangkok, Bangkhun-thian	35111	32	-	ZnO	0.6 kg	NA
4	Samut-prakarn, Phrasa-mutjedee	35111	350	50	HCl NaOH Liquid Cl_2 Bleaching powder Chlorinated lime NaOCl $ZnCl_2$ H_2	96.0 kg 74.4 kg 18.0 kg 6.0 kg 0.96 kg 21.6 kg 3.0 kg 200 liters	H_2 Cl_2 HCl
5	Samut-prakarn, Bangplee	35111	86	70	Latex Alkyd resin	2.4 kg 2.4 kg	VAM HCl Formalene Methanol Xylene DEG IPA
6	Bangkok, Bangkhun-thian	35111	6	0.5	Alum	0.25 kg	NA
7	Prathum-thani, Klong-luang	35111	90	47	Fatty acid Glycerine	2.0 kg 0.2 kg	Nickel HCl Hydrogen

Table 5.9 (Continued)

No.	Area	SIC	No. of Employees	Registered Capital (10^6 Baht)	Products	Quantity of Products (10^6)/yr	Hazardous Chemicals Identified
8	Samut-prakarn, Phrasa-mutjedee	35111	158	NA	Alum H_2SO_4 N_2O Fertilizer	9.6 kg 12.0 kg 0.027 kg 20.0 kg	NH_4NO_3
9	Samut-prakarn, Muang	35111	110	NA	Citric acid	1.2 kg	NA
10	Bangkok, Phraka-nong	35120	72	NA	Pesticide	NA	Acetone Carbofuran Chlofenvinphos Cyclohexane Ethyl acetate Isopropyl alcohol Methyl bromide Mevinphos MEK VCM Xylene
11	Samut-prakarn, Muang	35120	60	18.3	Pesticide	0.264 liters 1.727 kg	Xylene
12	Bangkok, Phasi-chareon	35120	10	NA	Pesticide	0.012 kg 0.42 liters	Parathion
13	Karnja-naburi, Muang	35120	32	20	Pesticide	0.718 kg	Xylene Cyclohexane
14	Nontha-buri, Muang	35120	92	7.6	Pesticide Latex	0.21 kg 0.007 kg	Ethyl acetate VCM
15	Samut-sakorn, Krathum-ban	35120	107	20	Pesticide	0.165 kg	Xylene Acetone

Table 5.9 (Continued)

No.	Area	SIC	No. of Employees	Registered Capital (10^6 Baht)	Products	Quantity of Products (10^6)/yr	Hazardous Chemicals Identified
16	Phathum-thani, Klong-luang	35120	50	19	Pesticide	0.74 kg	Xylene
17	Bangkok, Phasi-chareon	35120	24	NA	Pesticide	0.012 kg 0.357 liters	Mevinphos
18	Nontha-buri, Parkkret	35120	9	NA	Pesticide	NA	NA
19	Samut-prakarn, Muang	35120	52	358	Pesticide	6.0 liters	NA
20	Bangkok, Minburi	352	33	20	Paints	0.84 kg	Xylene
21	Bangkok, Minburi	352	31	10	Ink	1.44 kg	Toluene Ethyl acetate Methanol IPA Hexane Acetone MEK Ethyl alcohol Nitrocellulose
22	Bangkok, Phasi-chareon	352	80	10	Paints	0.36 kg	Toluene Xylene MEK
23	Phathum-thani, Dhanya-buri	352	191	NA	Match	6,000 boxes	Acetylene Vinyl acetate
24	Phathum-thani, Muang	352	136	NA	Fire crackers	900 boxes	NA

Table 5.9 (Continued)

No.	Area	SIC	No. of Employees	Registered Capital (10^6 Baht)	Products	Quantity of Products (10^6)/yr	Hazardous Chemicals Identified
25	Samut-sakorn, Krathum-ban	352	24	NA	Fire crackers	1,800 boxes	NA
26	Samut-Prakarn, Phrapra-daeng	35130	360	100	PVC resin PVC compound	60.0 kg 24.0 kg	Benzene
27	Bangkok, Bangjak	35300	60	NA	LPG	52.0 kg	LPG

Note:

VAM - Vinyl Acetate monomer
DEG - Diethylene Glycol
IPA - Isopropyl Alcohol
NA - Not available

General Impressions

1) Arrangement of Premises

Premise arrangements cover the location of production facilities, spacing between equipment, location of loading and unloading areas, location of storage tanks and their protective measures, location of waste disposal areas, and accessibility of the premise.

Production facilities of the factories visited are generally located next to either living quarters, warehouses, or offices. Spacing between equipment is normally adequate. In smaller plants, loading and unloading of hazardous substances are conducted within the premises without proper accident prevention measures. Large chemical storage tanks are often situated on the ground rather than underground. Most of the waste disposal facilities are located inside the premises with the treated effluents directly connected to public sewers. It is difficult to assess the efficiency of the treatment methodologies employed.

2) Buildings

Conditions of the plant buildings, i.e., include structure, foundation, materials used, potential of fire hazards, ventilation, drainage facilities and emergency exits.

One of the potential problems is the use of flammable materials such as wooden walls and wooden posts. Most of the factories visited lack efficient ventilation systems, thus fire can easily spread through openings. In those cases where ventilation systems were installed, they were not functioning properly.

Figure 5.4 Empty Pesticide Containers that have not been Properly Discarded.

Figure 5.5 Improper Ventilation Design.

Figure 5.6 Foreign Language Labels on a Gas Container

This may be due to poor design or poor maintenance. Emergency exits in buildings are noticable in only a few factories.

3) Fire Fighting Facilities

A common problem is the lack of a designated officer to look after the fire fighting equipment. In several factories the checking and refilling of fire extinguishers is left to the dealers. Employees in many factories have never attended an emergency drill. Electrical appliances are not routinely checked and naked electrical switches are common in smaller plants.

4) Materials, Intermediates, and Products

Understanding the effects and handling of chemical materials, intermediates, and products by concerned personnel in the workplace is an important safety measure.

The properties of hazardous chemicals are not well understood by responsible officers and workers in general. This leads to negligence and avoidable accidents. Handling of hazardous substances is entirely in the hands of each individual operator. This should be properly regulated following established procedures.

5) Processes

Almost none of the factories studied has issued job regulations for the process operation in order to prevent human errors. Little effort has been observed in minimizing the use of dangerous materials. One of the major concerns in process safety is to ensure that the responsible staff has assessed all foreseeable process failures, particularly those related to temperature, pressure, and chemical reactions. Most of the factories have never studied the possibility of volatile chemical reactions, nor have the potential affected areas been mapped out in case of an emergency.

6) Transport, Storage

Transport of raw materials into the plants are either conducted by company trucks or by outside contractors. Most of the private truck drivers are ignorant about the risk of handling chemicals. The factories themselves rarely issue job regulations for the reception of raw materials. In any case, only a limited number of transport workers understand chemical properties and their health effects.

7) Process Equipment

Inspection and maintenance systems for process equipment plays an important role in plant safety. Generally, such a system should record all past failures so that a factory can learn from its past mistakes. Routine inspection and maintenance is a necessity. There was no systematic inspection of process equipment in most of the factories visited. A systematic approach based on standard practices was found lacking in many factories.

Protective devices include pressure/vacuum relief valves, bursting discs, explosion vents, high/low level alarms, high/low temperature alarms, weight tables, content gauges, maximum fill devices, padding air/gas reducing valve stations. Such devices should be carefully checked and protected from damages. The survey confirms that the use of protection devices varies from one extreme to the other in the factories visited -- from total compliance with standard practices to complete neglect.

8) <u>Housekeeping</u>

Good housekeeping means the removal of objects which obstruct passageways so that collisions and stumbling can be prevented and exit facilitates identified in case of emergencies. Passageways should be clearly marked and should not be used for storage of materials. Materials must be properly stored and waste materials promptly removed. In general, housekeeping is adequate in large factories due to their more established system. In smaller plants, it was observed that good housekeeping is not accorded due priority by management.

9) <u>Location</u>

In case of emergencies, two major factors predominate: a) whether rescue effort can be easily mobilized to reach the emergency area, and b) whether hazards can easily spread to nearby installations. With these criteria, it was observed that all factories are located at a reasonable distance from the support system, i.e., fire stations, hospitals. However, in quite a few locations, the accessibility of the factory is a hindrance.

10) <u>Job Training</u>

Workers are not well-informed about the risk associated with the production and use of chemicals in the manufacturing processes. Contingency plans for emergencies are not known to workers.

Figure 5.7 A Dry-Mixing Operation for Pesticides, the Floor Area is not Clean

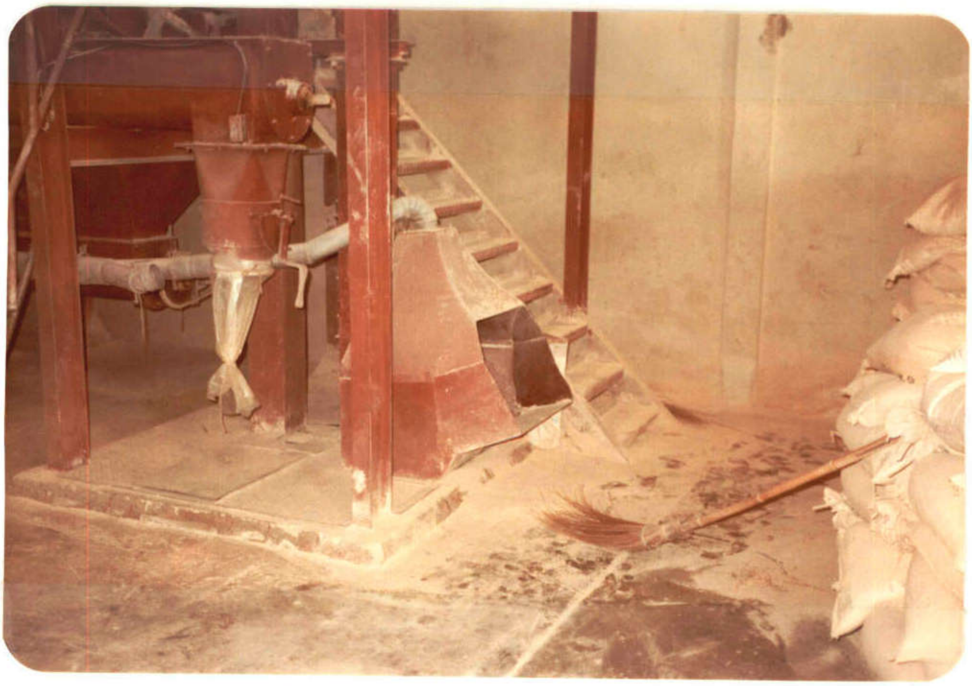


Figure 5.8 A Dusty Packaging Area for Pesticides

On-the-job training is conducted only as a necessity but not as a prerequisite. Training courses on safety and accident prevention are not readily available.

11) <u>Safety Activities</u>

Safety activities such as the appointment of a safety officer, the appointment of an inter-departmental safety committee, safety training, and safety audit all prove valuable in accident prevention. Safety promotion activities, such as safety-work campaigns, safety consciousness programs, safety contests, safety awards, safety posters and slogans all are useful.

In the factories visited, safety officers have not fully assumed their responsibilities on accident prevention due to their other workload.

Safety committees to generate participation of workers on accident prevention have still not been established in most of the factories visited.

12) <u>Personal Protective Equipment (PPE)</u>

It was noted that in some cases PPEs were wrongly used. For example, in a number of places, dust masks were used instead of respirators. Changing PPE wearing habits of workers remains to be a problem. The heat and humidity of the tropics often make the use of PPEs uncomfortable. Safety campaigns to promote the use of PPEs is found wanting.

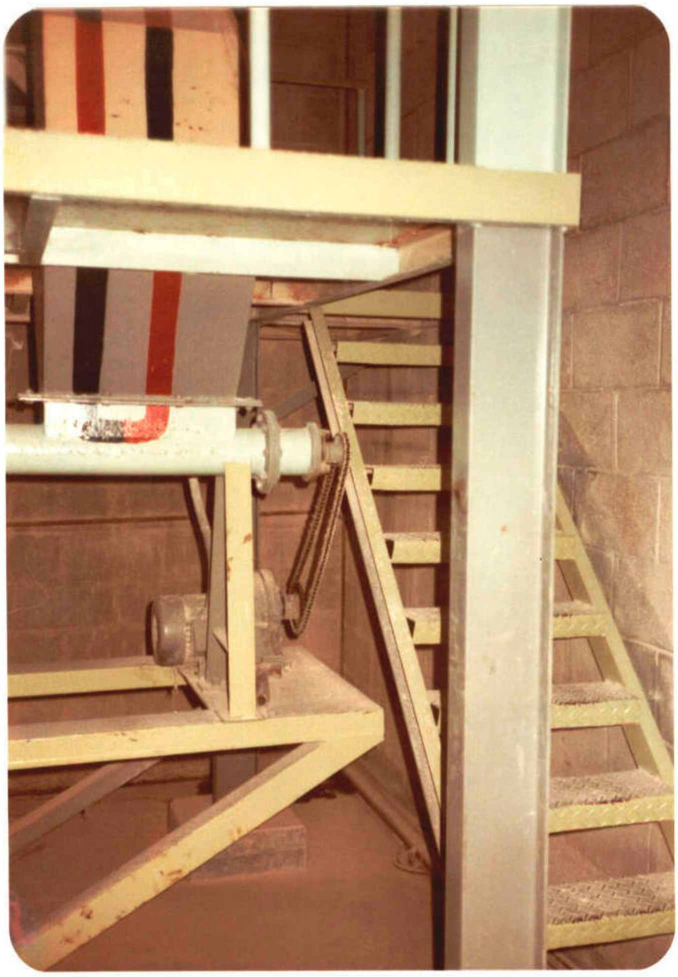


Figure 5.9 Unguarded Chains Near Stairway

Figure 5.10 Use of a Dust Mask instead of a Respirator.

5.4 CONCLUSIONS

Twenty out of 27 plants surveyed can be classified as major hazard installations if the World Bank's criteria are followed. The number is alarmingly high and is a cause for concern.

Safety practices vary widely among the factories surveyed. Only a few well established large factories were found to have reasonably good safety measures while most others still need improvement.

Some obvious examples of potentially unsafe conditions or practices were found during the survey, these include: no safety regulations available in the plant, unsafe methods of loading or unloading of chemicals, improper storage of chemicals or storing chemical drums in the open exposing them to rain, improperly designed ventilation systems, absence of labels on chemical drums and packages, naked electrical switches, insufficient attention to the maintenance of fire fighting facilities, no color codes on pipes, no containment structures around large liquid containers to contain accidental spills, and no alarm systems to warn workers or the public in case of emergencies.

Accident recording and reporting varies considerably among the factories. Most of the smaller factories have no recording system at all.

If accident prevention is the objective, it is obvious that more must be done now.

CHAPTER 6

STRATEGY FOR MAJOR ACCIDENT PREVENTION IN THE CHEMICAL INDUSTRY

The survey discussed in the preceeding chapter unfortunately confirms that potential hazards do exist in the chemical industry in Thailand. Despite all the past and present activities of various government agencies, there is still a need for more concerted effort from all concerned parties.

This chapter presents the recommendations and proposed actions in formulating a strategy for major accident prevention in the chemical industry. It has incorporated the consesus of the participants in the Seminar on the same topic held at TDRI on January 22, 1986. The Seminar was atended by representatives of governmental agencies, industries, research institutes, and labour unions. (appendix J)

6.1 ESTABLISHMENT OF A MAJOR HAZARD ASSESSMENT SYSTEM

It is evident that industrial installations employing toxic chemicals can be hazardous to their employees and to the public in the vicinity. Potential hazards vary from one installation to another depending on the nature of the manufacturing process, the chemicals used, the affiliation of the installation (e.g., if a particular installation is affiliated with a multinational organization, it must conform to headquarters' regulations), and also the attitude of the management on accident prevention.

From the interviews undertaken during the field survey with safety officers, it is noted that safety procedures are, at present, entirely left to the practices and conscious of each particular installation. Safety procedures range from non-existent, to relying on routine safety inspection of process equipments, to the installation of safety instruments, such as safety valves or other preventive devices such as the use of water pumps for creating a water curtain surrounding flammable chemicals.

The survey also confirmed the lack of an adequate recording system to deal with toxic chemicals. Information on the tracking of pesticides from import, to formulation, to repackaging is not normally available. At the same time, the personnel in charge of safety are not totally aware of proper procedures to control accidents. In fact, accident prevention and the associated management of dangerous chemicals are not accorded due priority commensurate with the "explosive" nature of the issue.

In a way, Thailand is fortunate in that it is not producing harmful intermediate chemicals such as methyl isocyanate which claimed thousands of lives at Bhopal. However, the potential of major hazards is visible in many of the plants visited, such as the bulk storage of paraquat without proper safety containments and poorly ventilated pesticide-mixing rooms with workers exposed to fumes and dust generated from the mixing processes.

Furthermore, although it may be argued that present legislations, such as Notification No 4 of the Ministry of Industry B.E. 2514 and Notification No 1 B.E. 2525 of the MOAC, MOH and MOI, already contain regulations on the storage, transportation and use of poisonous, flammable and explosive substances, the present system still contains weaknesses. Firstly, some of the provisions in the regulations are broad specifications that are difficult to enforce. For example, Section 13, Clause 63 of Notification No.4 of the Ministry of Industry B.E. 2514 stipulates that:

> Containers and other accessories for poisonous substances, flammable substances and explosives must be of the type that is sturdy, durable and safe in use. They must always be maintained in good condition and must be safe.

Enforcement of this regulation would be difficult as it does not stipulate as to what type of containers are suitable for what type of chemicals. Words like "durable" and "sturdy" are subject to wide and varied interpretations.

Secondly, the present system relies on the availability of an effective enforcement mechanism. It presupposes that the various responsible government agencies have an adequate number of inspectors to carry out routine inspections and when violations are found, proper legal actions can then be taken. However, at present the various government agencies do not have enough trained inspectors to cover the estimated 90,000 factories in existence today. Yet the responsibility still lies with the government agencies to enforce the regulations.

Guidance from the World Bank.

In 1985 the World Bank issued a set of guidelines for identifying, analyzing and controlling major hazard installations in developing countries. According to the guidelines, factories seeking loans from the World Bank, that use dangerous, explosive, flammable and toxic substances must conduct a "major hazard assessment" demonstrating that major accidents or hazards have been recognized, suitable measures have been taken to prevent such accidents, and that contingencies have been planned to control and minimize the consequences of such accidents. The World Bank guidelines specifies the criteria, the names and the threshold quantities of hazardous substances requiring a major hazard assessment. (see Appendix F).

According to the World Bank a "major hazard assessment" should contain the following information:

- Substance names
- Monitoring methods
- Hazards of the substances
- Composition of process streams
- Location
- Plant plan
- Process/flow description
- Personnel on site
- Local land use and population distribution
- Management
- Responsible person and staffing
- Quality control and safety
- Training
- Potential major accidents
- Identification of potential major hazard events
- Process flow diagrams
- Preventative and control systems
- Emergency procedures
- Meteorological conditions
- Numbers at risk

As reported in Chapter 3, the European Economic Community already adopted a similar measure requiring an assessment of potential major hazard installations. For developing countries such as Thailand, it is even more necessary to add such a precautionary measure due to the relatively lower quality of equipments and lack of expertise in the local market.

Guidelines for Thailand.

It is therefore recommended that a Major Hazard Assessment System be developed for Thailand, the System should be based on four premises, namely:

1) **For installations with potential major hazards, routine inspection and maintenance are not sufficient.** An additional major hazard assessment will be required to reduce the risk of accidents.

2) **The responsibility in accident prevention lies with industry not with the government.** A factory may use its own safety engineer to conduct a major hazard assessment of its operations, or it may choose to commission outside consultants to undertake such a study. In the case of a large factory which has its own scientists or engineers, there should be no question that they are in a better position than anyone else to perform such an assessment because they are most familiar with the processes with which they are working and they understand the complexities of the installation more than a governmental inspector who has only a few hours in which to make the inspection. For the smaller establishments, guidance should be provided by the government.

However, there should not be any deviation from the fact that those whose operations might cause accidents, must take full responsibility and must be held liable to any following consequences should an accident occur.

3) **Any new recommendations should be based on the existing foundation already established in various governmental agencies.** DOL, NEB, DIW, MOPH, MOA, NSCT are all actively working on related aspects of accident prevention. The intention of a new recommendation should be to refocus the direction to face new challenges arising from potential major hazards, not to create another layer of bureaucratic regulation.

4) **The issue of major hazard assessment is encompassing.** It involves the work of at least 6 ministries. As described earlier in Chapter 4, the Ministry of Agriculture and Cooperatives, the Ministry of Public Health, and the Ministry of Industry are jointly responsible for the Poisonous Substance Act (PSA) which covers the transportation, storage, disposal and handling of containers of both ordinary poisonous and highly poisonous substances, of which more than 300 have been registered. Aside from the PSA, DIW of the Ministry of Industry issues licenses for industrial works for both new establishments and the extension of existing ones. DIW's notifications already require the preparation of an Environmental Impact Assessment (EIA) from specified industries and the control of environmental quality standards, particularly effluent standards. DOL, Ministry of Interior is responsible for accident prevention and occupational safety and health control, whereas NEB is empowered with the authority regarding the EIA. In addition, NSCT under the Prime Minister's Office established two subcommittees dealing with the policy aspects of the use of chemicals for agriculture and industry.

With this background in mind, it is recommended that:

a) all the existing national committees dealing with dangerous substances, namely, the Poisonous Substance Board under the PSA, the Toxic Substance Committee of NEB and the two subcommittees on Accident Prevention for Agricultural Chemicals and Industrial Chemicals of NSCT jointly prepare a definitive list of dangerous substances with specific criteria based on both the lethal dose and quantity. Such a list can be adapted from The World Bank and EEC guidelines and the registered list of ordinary and highly poisonous substances under PSA. One alternative that has been proposed is to declare all pesticides as toxic substances, but this approach would create problems in assessing import duties, because the import duties for farm chemicals are different from other chemicals, and the Customs Department would face the difficult task of determining whether a particular chemical being imported is a pesticide or not. A better alternative is to develop a set of criteria and a list of chemicals based on the World Bank guidelines, including those chemicals that are currently on the World Bank list but not in the PSA list (see Appendix H).

b) The Poisonous Substance Board who executes the Poisonous Substance Act and is currently considering the amendment of PSA, incorporates the criteria and the master list of dangerous substances as mentioned in a) into PSA. By doing so, all classified dangerous substances will be legally registered before they can be manufactured or imported into the country.

In this connection, the penalty clause of PSA should be revised to increase the penalty to a higher amount commensurate with the seriousness of the potential hazards.

c) DOL in collaboration with DIW design the guidelines for the preparation of the safety report required in a major hazard assessment. The objective is to enable industry to prepare only one main report, parts of which could then be submitted to the respective government agencies as stipulated in existing laws.

d) Based on c) NEB and NSCT jointly review the content of item 10 of its Notification of Types and Sizes of Projects or Activities Requiring an EIA Report (Appendix C) to reflect the urgency of accident prevention in industry. Concurrently, the Manual of NEB Guidelines for Preparation of Environmental Impact Evaluations, under the section "Supplementary EIS Guidelines for Industries," should also be revised using the World Bank Guidelines as a reference.

e) Similarly, DIW review its notifications related to effluent quality and working environment with the *objective to ensure that major hazard assessments will be carried out by the factories which will be specified in a) and c) above. In this connection, DIW plans to survey 200 priority factories to identify major hazard potentials.*

f) DOL strengthen its work on classification, identification and labelling of dangerous substances. The survey conducted in this study reconfirms the need for more stringent precautionary measures and the dissemination of information to both employers and employees alike. The information to be disseminated should be prepared using simple language which is readily comprehensible to workers.

It is not justifiable to propose recommendations without considering the associated costs, particularly if the brunt of the required actions will be passed to industry who will end up preparing the major hazard assessment reports.

In this case, developing guidelines and amending ministerial notifications would not incur excessive additional costs since they can be considered as normal functions of responsible agencies to meet changing challenges. For large factories, the preparation of major hazard assessment reports can be done by environment officers or safety officers which are already required by law in pollution producing industries or in the establishments with more than 100 employees.

An additional burden may be felt by those smaller establishments which are presently not required to maintain an environmental officer or a safety officer. However, the assessment is necessary to protect the safety of both the employees and the innocent people living in the vicinity. The safety of the public cannot be compromised.

6.2 ACCIDENT PREVENTION INFORMATION SYSTEM

Statistics are essential for the planning of accident prevention. It is from statistics that information is obtained on how many accidents have occurred, how they occurred, what kind of machines or chemicals were involved, etc. The inadequacy of statistical data on accidents and injuries has been well recognized in Thailand. Currently, the only systematic and continuous statistical data available is from claims filed with the Workmen's Compensation Fund, whose claim records are used in granting compensations.

It is recommended that an Accident Prevention Information System be developed. The System should consist of three elements: (1) accident reporting system which covers accidents resulting in injuries to the workers and major accident investigation (2) chronic health hazards, and (3) dangerous substance information system.

a) Accident Reporting System

Statistics of accidents resulting in injuries should be comprehensive covering the cause, frequency, type of industry as well as other contributing factors. It is thus recommended that a standardized accident reporting system be designed and implemented. Data collected should then be analyzed and results and findings published annually. It is envisaged that this information will assist in accident prevention by identifying the causes of accidents so that remedial measures can be taken to reduce their number, frequency and severity.

The factors to be considered for the design of an accident reporting system include:

1) Definition of Accident. Accident statistics should be compiled based on a uniform definition of accidents and what constitutes a reportable accident. Accidents may result in serious, minor or no injuries. Some investigators give the ratio of serious to minor to no injuries as 1:20:300. Thus, for every serious accident that occurs, there are 300 no-injury accidents. While it is relatively easy to identify and arrange for the report of the serious and minor accidents, the no-injury cases are normally not recorded. As a preventive measure, it is useful to understand these near-miss cases so that they will not lead to minor or serious ones.

DOL reported that in 1982, the total number of injuries from the chemical industry was 2,072 persons which is correspondent to a fatality rate of 53.7 per 100,000 persons.

2) Classification of Accidents. Accidents may be classified according to:

- the type of accident,
- the agency causing the accident,
- the nature of injury, and
- the body location of the injury.

3) <u>Causes of Accidents.</u> Accidents are rarely due to a single factor, but are generally the result of a combination of factors such as material, physiological, psychological, organizational, educational factors, etc. Some of these factors are not easy to analyze because of their subjective nature.

4) <u>Calculation of accident rates.</u> In order to be able to compare the number of accidents in one factory with those in another, or to determine trends, the differences in the number of workers must be taken into account. This can be done by computing the accident rate, such as the number of injuries per million man-hours, or number of injuries per 100,000 workers, or other similar rates. However, the former rate would be more precise because factories differ in the number of shifts per day.

The severity rates can be similarly expressed as the number of loss days per 1,000 man-hours. Difficulty arises when an accident results in permanent disability or death. To cover this case the number of days counted as lost must be agreed first for statistical purposes. However, there are considerable differences in the numbers used by different countries to assess the number of days lost as a result of permanent disability or death. Further study is needed to determine the suitable number for Thailand.

5) <u>Other Factors.</u> Other factors such as time of accident, age, sex, level of skill, and other human factors may add relevant information to the nature of accidents.

Aside from normal accident reporting, when it comes to a major hazard, it is imperative to dispatch specialists to undertake an accident investigation. This will require advance planning so that specialists can be quickly mobilised. Such an effort is vital to the understanding of the cause and the impact of a major hazard so that preventive measures can be initiated to avoid recurrent cases.

b) Information on Chronic Health Hazards

Aside from immediate fatality and physical injuries which can be easily counted, chemicals can cause chronic health hazards. In addition, many industrial chemicals are known to be carcinogens or cancer producing substances. It is a well-accepted notion that the long-term impact of many chemicals in use today is subject to further research, and it is not likely that precise understanding of health effects of all chemicals is possible. For example, Table 6.1 shows the National Institute of Occupational Safety and Health (NIOSH), USA list of selected chemicals, and their potential health effects.

In Thailand, record of chronic illnesses from industrial activities is non-existent. To understand the full impact of potential hazards, it is necessary that a systematic and continuous recording and reporting system on chronic health hazards from exposure to industrial chemicals be established now. In this arena, it is recommended that NICE and the Workmen's Compensation Fund Division serve as the principal information collection agencies.

In this connection, the workers registered under the Workmen's Compensation Fund would serve as the logical group to monitor since records of their health are already established.

Table 6.1 NIOSH List of Selected Chemicals with Potential Health Effects.

Substance	Health Effect Considered
Acetylene	Indirect asphyxia
Acrylamide	Skin, eye, nervous system effects
Acrylonitrile	Lung and bowel cancer
Alkanes (C5-C8)	Skin and nervous system effects
Allyl chloride	Liver, kidney, lung effects
Ammonia	Airway irritation
Arsenic inorganic	Dermatitis, lung and lymphatic cancer
Asbestos	Asbestosis, lung cancer
Asphalt fumes	Eye and respiratory irritation
Benzene	Blood changes including leukemia
Benzoyl peroxide	Airway and eye irritation, skin effects
Beryllium	Lung cancer
Boron trifluoride	Respiratory system effects
Cadmium	Lung and kidney effects
Carbaryl	Nervous and reproductive system effects
Carbon dioxide	Respiratory effects
Carbon disulfide	Heart, nervous and reproductive system effects
Carbon monoxide	Heart effects
Carbon tetrachloride	Liver cancer
Chlorine	Eye/airway irritation
Chloroform	Liver or kidney tumors and central nervous system effects
Chloroprene	Reproductive effects; potential for cancer
Chromic acid	Nasal ulceration
Chromium (VI)	Lung cancer, skin ulcer, lung irritation
Coal tar products	Lung and skin cancer
Coke oven emissions	Lung cancer
Cotton dust	Pulmonary disease (byssinosis)
Cyanide, hydrogen and cyanide salts	Thyroid, blood, respiratory system effects
Decomposition products of fluorocarbon	Lung effects, polymer fume fever
Dibromochloropropane	Sterility; renal and liver effects
Dioxane	Liver and kidney effects; cancer
Epichlorohydrin	Skin, kidney, liver and respiratory system effects
Ethylene dibromide	Damage to skin, eyes, heart, liver, spleen, respiratory and central nervous systems. Potential for cancer and mutagenesis
Ethylene dichloride	Nervous system, respiratory, heart, liver effects
Fibrous glass	Eye and skin and airway effects
Fluorides, inorganic	Kidney and bone effects
Formaldehyde	Irritation, lung effects

Table 6.1 (contd)

Substance	Health Effect Considered
Hydrogen fluoride	Skin/eye/airway irritation; bone effects
Hydrogen sulfide	Irritation; severe acute effects, nervous and respiratory systems
Isopropyl alcohol	Mucous membrane irritation; possible cancer threat in manufacturing process
Kepone	Nervous system effects; liver cancer
Lead, inorganic	Kidney, blood, and nervous system effects
Malathion	Nervous system effects
Mercury, inorganic	Central nervous system and mental effects
Methyl alcohol	Blindness; metabolic acidosis
Methyl parathion	Nervous system effects
Methylene chloride	Central nervous system effects; carbon monoxide toxicity
Nickel, inorganic and compounds	Skin effects; lung and nasal cancer
Nitric acid	Dental erosion, nasal/lung irritation
Nitrogen, oxides	Airway effects
Organotin compounds	Eye, skin, liver, nervous system, and heart effects
Parathion	Nervous system effects
Phenol	Skin, eye, CNS, liver, and kidney effectc
Phosgene	Airway effects
Polychlorinated biphenyls	Cancer; skin, liver and reproductive effects
Refined petroleum solvents	Skin, lung, and nerve irritation
Silica, crystalline	Chronic lung disease (Silicosis)
Sodium hydroxide	Airway irritation
Sulfur dioxide	Respiratory effects
Sulfuric acid	Pulmonary irritation
1,1,2,2-Tetrachloro-ethane	Liver, gastrointestinal, and nervous system effects
Tetrachloroethylene	Nervous system, heart, respiratory, liver effects
Toluene	Central nervous system depressant
Toluene diisocyanate	Airway effects
1,1,1-Trichloroethane	Nervous system, liver, and heart effects
Trichloroethylene	Central nervous system depressant
Tungsten and cemented tungsten carbide	Lung and skin effects
Vanadium	Eye, skin, and lung effects
Vinyl chloride	Liver cancer
Waste anesthetic gases and vapors	Reproductive effects and audiovisual performance decrements
Xylene	Central nervous system depressant; Airway irritation
Zinc oxide	Metal fume fever

o) Dangerous Substance Information System

With thousands of factories using thousands of chemicals, nowadays, there clearly is a need to have an accessible database containing information on the characteristics of all potentially hazardous chemicals including their uses, treatment and disposal. This need is recognized by the governmental agencies involved and consequently, some are making an effort in this direction.

There is no standard method in setting up an information system. At the upper level we can have a sophisticated network using mainframe computers all wired together or linked by telephone lines. At the lower end we can have a network using the ubiquitous micro-computers linked by physical transfer of floppy disks. Sophisticated systems are expensive and take a long time to set up, but they are the most powerful and very much sought after. A less powerful system can be set up quickly without incurring much cost, but it requires much more planning and coordination. A large computer information system will entail major investment in the development of staff capabilities and collection of baseline data. Due to the large financial investment required, the development of a fully automated system will not be feasible unless a long-term commitment by the government can be assured.

Presently NICE, with support from UNDP through ILO, is experimenting with a Management Information System (MIS) using micro-computers. About 2,000 chemicals have already been entered into the system. NICE is currently designing a new computer program and moving to a more powerful micro-computer. In the future NICE plans to install a mini-computer with telephone links to four other provincial centers.

The information system of NICE is linked with the database of ILO at its headquarters in Geneva. Similarly, NEB is serving as the focal point for the International Register of Potentially Toxic Chemicals (IRPTC) database of the United Nations Environment Programme (UNEP). Concurrently, the Food and Drug Administration is the focal point of the International Programme on Chemical Safety which is being executed by the World Health Organization (WHO).

At this stage, it is recommended that a simple system be set up taking advantage of the micro-computers already available in various agencies. First, the agencies that wish to be part of the network will be identified and one of them designated as the lead agency. Initially, the lead agency will then design the database using one of the commercial database programs. The database developed can then be made available to other interested agencies. The lead agency would periodically update its database and physically transfer the information compiled through the mailing of floppy disks.

The topics for consideration of a dangerous substance information system include the following:

1) Selection of the type of micro-computer. Since this network is going to make use of the existing computers, the major criterion will be the selection of a model compatible to those available to other participating agencies.

2) <u>Identification of participating agencies.</u> Participating agencies should include hospitals, rescue squads, police stations, factories and government agencies.

3) <u>Identification of users.</u> The usefulness of an information system is determined by the number of users and the accessed audience. Initially, only a limited number of users would be permitted to have access to the system. These would include the chemical industries and the government agencies involved in the field of occupational health and accident prevention. As the system is sufficiently tested, all interested parties would be allowed to have access to the system.

4) <u>Type of access.</u> No direct dial up at the initial stage is proposed. The purpose is to keep the system simple and the associated costs low. Requests for information can be made by mail or phone.

5) <u>Type of output.</u> Only computer printouts are to be made available. When requests for information are received, computer printouts will be produced and mailed out.

6) <u>Content of the database.</u> The database to be developed can be expanded from the information presently collected in the material safety data sheets prepared by NICE. An example is attached as Appendix I. Also the works done by International Programme on Chemical Safety (IPCS) and the International Register of Potentially Toxic Chemicals (IRPTC) should be consulted.

6.3 DISPOSAL OF DANGEROUS SUBSTANCES

There are two types of toxic wastes that were identified during the survey. The first type consists of the unsellable chemicals either because they have expired or there is no market demand for them. The second type consists of the sludges resulted from wastewater treatment. Since at present there are no toxic waste dumps in Thailand, the factories visited either bury the wastes within their compounds or have contractors hauled them away. Nothing is known about how these wastes are disposed of. This is a potentially hazardous situation since the wastes may contaminate ground water or find their way into surface water.

Many small plants, because of limited financial capacity, or lack of technical expertise or lack of land, simply cannot afford to dispose of their toxic wastes properly even if they wanted to do so. These industrial wastes will ultimately find their ways to the surrounding environment.

At present, no estimation of the amount of toxic wastes generated each year is available. During the survey we spotted 20 to 30 cartons, 200 kg in weight each, of unsold pesticides in some pesticide formulation plants. Assuming that 10% of the total 75 pesticide formulation plants carry the same amount of left-over products, this would work out to be at least 30 tons of unsellable pesticides to be disposed of.

Plan of the Department of Industrial Works (DIW)

The toxic wastes from other industries, such as metal plating plants have long been recognized. For example, DIW has estimated that presently there are about 800 m^3/day of wastewaters from textile dying plants and about 200 m^3/day of plating wastewaters that are not properly treated. DIW is currently considering setting up three central wastewater treatment plants in the Bangkok Metropolitan area to collect and treat these wastes. The first of such treatment plants will be located in Thonburi. If this is proved to be viable, two more plants will be constructed at Rajaburana and Bangkhuntien. The sludges resulted from these wastewater treatment plants will be cast into concrete blocks. These blocks will then be hauled to a burial site in Rajburi. It has been estimated that there will be about 40,000 tons of these concrete blocks per year. When burried at stacks of 5 meter high, an area of 185 rai will be required. Three of such sites in Rajburi have already been surveyed. Initially DIW is planning to build these facilities after which they will be contracted to private operators who will recover the costs through charges.

The cost for the development of a toxic waste dump system has already been estimated. The program has been proposed to be incorporated into the 6th National Economic and Social Development Plan. The total costs are shown in Table 6.2.

Table 6.2 Estimated Costs of the Toxic Waste Dump Program to be Incorporated into the 6th National Plan

Item	Costs	
	Government Budget (Baht)	Foreign Assistance (US$)
Initial survey	645,580	0
Feasibility Study	391,080	230,000
Policy Development	411,080	0
Design & construction	35,000,000	200,000
Total	36,447,740	430,000

The design and construction of the toxic waste dump as shown above is under the responsibility of DIW.

Recommendation on additional study

In the factories surveyed, the treatment methods range from no treatment in small plants to sophisticated treatment in large ones. For example one plant incinerates all toxic wastes in a high temperature incinerator; while another uses imported fuller's earth to absorb toxic chemicals and buries the fuller's earth on site.

In the US, contamination of underground water from 850 hazardous-waste dumps has been identified as "the" major environmental issue of the 1990's. The US Government has created a $1.6 billion, five-year "Superfund" crash program to solve this urgent problem. In Thailand, one can claim that there are an innumerable number of dumping sites depending on where the users or the manufactures decide to dispose of their wastes or their left-over products.

It is thus encouraging to note that DIW is setting up proper treatment facilities for inorganic wastes, particularly heavy metals from textile mills and electroplating plants. Similarly, a parallel program should be launched to take care of hazardous wastes from toxic chemicals. Components of such a program are:

(1) Surveys to estimate the quantity of toxic wastes. In order to understand the magnitude of the problem, the quantity of the toxic wastes must be known. Such data are necessary for site selection and the design of treatment facilities.

(2) Selection of appropriate technologies for the treatment and disposal of toxic wastes. Since this subject is new to

Thailand, the service of foreign experts is desirable.

(3) Establishing criteria for the selection of toxic waste dump sites. Special attention should be given to ground water contamination. Preferably, an Environmental Impact Statement report should be requested.

(4) Establishing a long term monitering program to ensure that there is no water leaching.

(5) Determining the operation of treatment facilities. Should they be operated by a government agency or a private company ?

(6) Enforcement. Ensuring that all toxic wastes will be delivered to the treatment facilities.

6.4 TRAINING AND PUBLIC AWARENESS CAMPAIGN

a) Training

A thorough knowledge of safe working techniques and general safety rules is essential for successful prevention of accidents. The effectiveness of accident prevention will ultimately depend on the attitude of each individual operator. Training of workers is fundamentally important to instigate the right attitude towards accident prevention. Basically there are three levels of training; the training of workers, safety officers and government inspectors.

From the survey, it was observed that a few factories, mainly affiliates of multinationals, provide safety training to their employees. These companies have the resources, the technical expertise, and the assessibility to technical information compiled at their headquaters. With Bhopal still fresh in mind, large companies are willing to assist the government and share their technical expertise. Enlisting the assistance of large companies to provide training to smaller enterprises is one avenue that can be explored further.

On training of safety officers, courses are being offered by NICE throughout the year. Safety officers are instrumental in propagating the concept of accident prevention at the operational level. Such a training effort as the one operated by NICE thus merits further support.

The training of government inspectors is the remaining area which is found wanting. This will become more and more important in the coming years. To be able to assess an accident prevention program, an inspector must be up-to-date in the latest development in new technologies. It is envisaged that government inspectors will become more specialized in the future.

Special courses should be established so that trained inspectors can also offer technical guidance, particularly to small and medium enterprises, on top of their normal regulating functions.

In summary, training is basic to the success of an accident prevention program. The on-going training programs at NICE, although still in their beginning period, are steps in the right direction and should be further strengthened to enable NICE to respond effectively to increasing responsibility in accident prevention.

b) Public Awareness Campaign.

The main objective of an accident prevention program is to ensure safety of employees and the innocent public. To be successful, the public must be fully informed of the potential hazards from the manufacturing, transportation, use and disposal of dangerous substances.

In this connection NSCT has been successful in its public awareness campaign on TV, radio and through other mass media.

A successful public awareness program does not follow any fixed formula. It relies on the conscientious effort of the organizer to elicit public participation. The subject of accident prevention should be highlighted by NSCT to educate the public on potential hazards and to generate public interest and support for this program.

6.5 EPILOQUE

The Seminar organized by TDRI, referred to on page 73, had proved to be a timely one. It has rekindled the interest of governmental agencies on this long overdue topic of accident prevention.

The willingness of major chemical companies to collaborate with the government in accident prevention is noteworthy. Shell and Union Carbide have regularly supplied their customers with booklets, pamphlets and other printed materials on the property of their chemicals and their proper handling methods. Shell (Thailand) is, in fact, operating a one-of-its-kind high temperature incinerator which can heat up to 1000°C. It is willing to consider any request of the government in using this equipment for toxic waste disposal. Such healthy dialogue between industry and government should be further nurtured.

On the technical front, this study concentrates on major hazards within or around an industrial installation. Participants attending the Seminar unanimously called for a similar survey on the transport of dangerous substances. Concern was repeatedly voiced on the mobile danger from the transport of petrochemical products, particularly LPG.

As for the future, a successful accident prevention compaign must be continuous. Accident prevention should be formulated as a prominent part of the Plan for the Development of Natural

Resources and Environment within the Sixth Economics and Social Development Plan of Thailand (October 1986 to September 1991).

This study on major accident prevention in the chemical industry should be regarded as the necessary first step. It is hoped that the findings reported in this volume will stimulate preventive measures by both industry and government so that Thailand will not be in the unfortunate position to add more major hazard casualties to the world's list.

REFERENCES

1. Bretherick L., 1975, "Handbook of Reactive Chemical Hazards", Butterworths, London, 1975, 976 pages.

2. Bretherick l., 1976, "Industrial Safety Data Sheet", National Safety Council, Chicago, Ill.

3. Brown, A. W. A., 1978, "Ecology of Pesticides", John Wiley and Sons.

4. Clayton G.D., Clayton F.E.(eds.), 1981-1982, "Patty's Industrial Hygiene and Toxicology", 3rd rev. ed., John Wiley & Sons, N.Y., 1981-1982, p. 1467-5112.

5. Cohen, M. L., et. al., 1985, "Health Consequences of Industrialization and Urban Development in Thailand", A Project Report Submitted to USAID/Thailand, Office of Health, Population and Nutrition.

6. DIW, 1984, "Prefeasibility Study For The Construction of Inorganic Waste Treatment Facilities in Bangkok, Thailand, Stablex Canada Inc.

7. DIW, 1985, "Selection of a Suitable Site for Disposing Packed Industrial Waste", Summary, Department of Industrial Work, Ministry of Industry.

8. DIW, 1985, "Selection of a Suitable Site for Disposing Packed Industrial Waste", Final Report, Department of Industrial Work, Ministry of Industry. (in Thai)

9. Dean J.A. (ed.), 1979, "Lange's Handbook of Chemistry", 12th ed., McGraw-Hill Book Co., New York, N.Y., 1979.

10. DIW, 1985, "Survey for the Selection of Suitable Sites for the Disposal of Industrial Residues", Faculty of Engineering, Kasetsart University. (in Thai)

11. Dhephanom Muangman, 1985, "Public Health Problems in Factories as related to National Security", Institute of National Protection. (in Thai)

12. EEC, 1982, "Council Directive of June 24, 1982 on the Major Accident Hazards of Certain Industrial Activities", Official of the European Communities L230, Vol.25, 1982, Brussels.

13. HMSO, "Safety and Health at Work", Report of the Committee 1970 - 1972.

14. Hawley G.G., rev., 1971, "The Condensed Chemical Dictionary", 8th ed., Van Nostrand Reinhold Company,N.Y.,1971,971 pages.

15. Hommel G., 1980, "Handbuck der gefaehrliche Gueter 1-2", Springer-Verlag, Berlin, 1980.

16. ICFTU/ICEF, "Report on Bhopal Disaster", International Confederation of Free Trade Unions, International Federation of Chemical, Energy and General Workers' Unions, 20 pages.

17. ILO, "Occupational Exposure Limits for Airborne Toxic Substances", No. 37 in Occupational Safety and Health Series.

18. ILO, 1976, "Accident Prevention", A Workers Education Manual, Geneva 1976.

19. ILO, 1984, "Encyclopaedia on Occupational Safety and Health", ILO Geneva, 1984, 2 volumes.

20. ILO, 1985, "Working Paper on Control of Major Hazards in Industry and Prevention of Major Accidents", Tripartite Ad Hoc Meeting of Special Consultants on Methods of Prevention of Majobr Hazards in Industry, International Labour Office, Geneva, 21-25 October.

21. ILO,1985, "Asian Regional Tripartite Seminar on Occupational Safety and Health Policies", International Lobour Office, 14-17 January 1985.

22. ILO, 1985, "Control of Major Hazards in India", Geneva.

23. ILO, 1985, "Working Paper on Control of Major Hazards in Industry and Prevention of Major Accidents", MHC/1985/1, Geneva.

24. IVA, 1981, "Safety Measures Against Free Gas Cloud Explosions in the Process Industry", IVA Meddelande 238, Stockholm, Sweden, 1981, 109 pages (in Swedish).

25. Janhunen H., 1984, "Extremely Dangerous Substances and the Prevention in the Working Environment", Training Course - 1984, Institute of Occupational Health, Mikkeli, Finland, 1984, 7 pages & annexes (in Finnish and partly in English).

26. Kafka F.L., 1984, "The European Chemical Industry's View of Major Hazards Legislation", 1984 European Major Hazards Conference, London, 1984, 24 pages (in English).

27. Kirk - Othmer, 1971, "Encyclopaedia of Chemical Technology", 2nd ed., Vol. 1-22 + supl., A Wiley Interscience Publication, Toronto.

28. Lautkaski R., Niittymaki I., Weckman H., 1984, "Major Accident Hazards Caused by Dangerous Substances - Pilot Study", Technical Research Center of Finland, 1984, 40 pages (in Finnish).

29. Lewis R.J., Tatken R.J., 1980, "Registry of Toxic Effects of Chemical Substances", 1979 ed., Vol. 1-2, U.S. Dept. of Health and Human Services, NIOSH, Ohio, 1980, 828+770 pages.

30. Mackinson, Frank W, et al. (eds), 1981, "Occupational Health Guidelines for Chemical Hazards", NIOSH/OSHA.

31. Ministry of Labour, Japan, "(7) - 2 Safety Assessment in Chemical Industry".

32. MOI, 1984, "Accident Statistics in Industry 1983", Registra of Statistics, Lobour Standards Division, Department of Labour, Ministry of Interior, April 1984., 19 pages (in Thai).

33. MOPH, 1985, "Proceeding of National Seminar on Strategies and Occupational Health Problems", Department of Health. (in Thai)

34. Maizell R.E., 1979, "How to Find Chemical Information", A Wiley Interscience Publication, Toronto, 1979, 261 pages.

35. Malinee Wongphanich, 1985, "The Development of Provincial Industrial Health Service in Thailand", 2nd Ed., International Development Research Center, Ottawa, Canada.

36. Malinee Wongphanich, et. al., 1985, "Pesticides Poisoning Among Agricultural Workers", A Research Report Supported by IDRC, Canada.

37. Manring J. A., 1985, "Toxic and Harzardous Chemical Control in Thailand", National Environment Board.

38. Ministry of Labour (Singapore), 1975, "Accident Prevention in the Ship Building and Repairing Industries", Vol. 1; Nature and Cause of Accidents and Recommendations, Feb. 1975.

39. Mutaya Jarupan and Sunee Mulikamal, 1979, "Regulations in Environment Control for Factories", Institute of Environmental Research, Chulalongkorn University. (in Thai)

40. NEB and IER, 1979, "Proceedings of Seminar of Effect of Poisonous Substances on the Environment and the Public Health", National Environment Board and Institute of Environmental Research. (in Thai)

41. NEB, 1985, "Environmental Standards", Publication 1985-006, Environmental Quality Standard Division, National Environment Board. (in Thai)

42. NEB, 1982, "Report on the Environmental Status in Thailand", National Environment Board. (in Thai)

43. NEB, 1985, "Country Paper for Thailand on use of Clean Technologies by Industries in Developing Countries", National Environment Board.

44. NEB,1984, "Report of the Findings of the Sub-committe on Toxic Substances: Problem Identification and Ranking of Priorities", Toxic Substance Section, Environmental Quality Standard Division, National Environment Board. (in Thai)

45. Nedved, Milos, 1985, "Working Environment Contaminants; Chemicals and Process Safety, Fire and Explosion Hazards", Report of Consultant in the Field of Occupational Health and Safety, NICE/UNDP/ILO Project (THA/82/005), Bangkok.

46. NICE, 1985, "Dangerous Substances, Information, Labelling and Personnal Protection", NICE-Project, Technical Report 2, Bangkok, Thailand, 1985, 78 pages.

47. NSCT, 1984, "Proceedings of Seminar on Safety in the Use of Fuel Gases", National Safety Council of Thailand and Engineering Institute of Thailand.

48. National Board of Occupational Safety and Health, 1985, "Reply to ILO Call for Information on Major Hazard Control Systems", National Board of Occupational Safety and Health, AD 245/85; Sweden, February 22, 1985.

49. Navy Environmental Support Service, 1980, "NEPSS Guildlines for Pesticide Spill Prevention and Clean up".

50. New Scientist , 1985, "After Bhopal, Who Remembered Ixhuatepec", July 18, 1985, p. 23-23.

51. New Scientist, 1985, "Design Failings that Caused Bhopal Disaster", New Scientist March 28, 1985, p. 3-4.

52. Poisonous Substance Section, Department of Agriculture, 1983, "List of Registered Poisonous Substances used in Agriculture". (in Thai)

53. Preecha Chuapanich, et. al., "Imported Pesticides & Herbicides", Department of Agriculture, Ministry of Agriculture and Cooperative. (in Thai)

54. Roos, K.S., 1985, Toxicology Aspects of Environmental Protection in Thailand. Final Report to the Office of National Environment Board. NEB-PUB 1985-008

55. Salmon A.G., 1985, "Does Acute Toxicity Testing Tell Us Anything Useful?: Methyl Isocyanate as a Test Case", British Journal of Industrial Medicine, 1985, 42:577-578.

56. Satean Wichailuk and Soubwong Wichailuk, 1985, "Poisonous Substance Act, B.E. 2510", Nitivej Publication. (in Thai)

57. Satean Wichailuk and Soubwong Wichailuk, 1985, "Factory Act, B.E. 2512", Nitivej Publication. (in Thai)

58. Satean Wichailuk and Soubwong Wichailuk, "Revolutionary Council Decree Number 103 On the Subject of Labour Protection", Nitivej Publication. (in Thai)

59. Satean Wichailuk and Soubwong Wichailuk, "Labour Relations Act, B.E. 2518", Nitivej Publication. (in Thai)

60. Sax, N. I., 1984, "Dangerous Properties of Industrial Materials", Van Nostrand Reinhold Co., 6th Ed.

61. Shreve, Norris R., Brink, Joseph A. Jr., 1977, "Chemical Process Industries", 4th Ed., McGraw-Hill Book Company.

62. TIME Magazine, 1984, "India's Night of Death", December 17, 1984. p. 8-23.

63. Transport Research Board, 1983, "Transportation of Hazardous Materials: Toward a National Strategy (Volume 2)", National Academy of Sciences, National Research Council, Washington, D.C.

64. UN, 1984, "Transport of Dangerous Goods: Recommendations of the Committee of Experts on the Transport of Dangerous Goods", 3rd revised edition, United Nations, New York, 1984, 475 pages.

65. UNEP, 1982, "International Register of Potentially Toxic Chemicals".

66. Vichit Punyahotra, 1985, "Accidents", Accident Prevention Committe, Office of the Prime Minister. (in Thai)

67. Weast R.C., Astle M.J. (eds.), 1982, "CRS Handbook of Chemistry and Physics", CRC Press, Inc., Boca Raton, Florida, 1982.

68. World Bank, 1985, "Manual of Industrial Hazard Assessment Techniques", Office of Environmental and Scientific Affairs.

69. Willrich, T. L. and Smith, G. E., 1970, "Agricultural Practices and Water Quality", The Iowa State University Press.

APPENDIX A

MOI Effluent Standards

(1)	pH	Between 5.0 and 9.0
(2)	Permanganate Value	60 mg/l
(3)	Dissolved solids :	
	3.1 Discharge into watercourses :	2,000 mg/l or more but not except 5,000 mg/l, depending upon discharging point
	3.2 Discharge into sea or estuaries (Salinity higher than 2,000 mg/l)	5,000 mg/l higher than dissolved solids content in sea or estuary waters
(4)	Sulfide as H_2S	1.0 mg/l
(5)	Cyanide as HCN	0.2 "
(6)	Heavy metals :	
	6.1 Zinc	5.0 mg/l
	6.2 Chromium	0.5 "
	6.3 Arsenic	0.25 "
	6.4 Copper	1.0 "
	6.5 Mercury	0.005 "
	6.6 Cadmium	0.03 "
	6.7 Barium	1.0 "
	6.8 Selenium	0.02 "
	6.9 Lead	0.2 "
	6.10 Nickel	0.2 "
	6.11 Manganese	5.0 "
(7)	Tar	Nil
(8)	Oil & Grease	5.0 mg/l (Except for crude oil refinery and lubricant blending plant; less than 15 mg/l)
(9)	Formaldehyde	1.0 mg/l
(10)	Phenols & Cresols	1.0 "
(11)	Free chlorine	1.0 "
(12)	Insecticides and radioactive substances	Nil

(13) Suspended solids	30 mg/l or more depending on dilution ratio as shown below

Dilution Ratio	Allowable Suspended solids
8 - 150	30 mg/l
151 - 300	60 mg/l
301 - 500	150 mg/l

(14) BOD, 5 day, 20^{o}C		20 mg/l or more but not exceeding 60 mg/l depending upon discharging point, except for industries as shown below
14.1 Fish canning (category 7 (1))		200 mg/l Until 31 Dec. 1982
		100 " As of 1 Jan. 1983
14.2 Tapioca starch : (category 9 (3))	New process	100 mg/l Until 31 Dec. 1982; thereafter as in (14)
	Old process	200 mg/l Until 31 Dec. 1982
		100 " As of 1 Jan. 1983
14.3 Noodle factory, using less than 500 kg of rice per day (category 10 (3))		150 " Until 31 Dec. 1982
		100 " As of 1 Jan. 1983
14.4 Tanneries (category 29)		200 " Until 31 Dec. 1982
		100 " As of 1 Jan. 1983
14.5 Pulp mills (category 38 (1))		150 " Until 31 Dec. 1982
		100 " As of 1 Jan. 1983
14.6 Seafood processing (category 92)		200 " Until 31 Dec. 1982
		100 " As of 1 Jan. 1983
(15) Temperature		Less than 40^{o}C
(16) Color and Odor		Not objectionable when mixed in receiving water

APPENDIX B

Table B.1 Standards of the Department of Labour for the Allowable Average Concentration of Chemicals in a Workplace

NO.	SUBSTANCES	Amount of chemicals	
		(p.p.m.)	(mg/M^3)
1.	Aldrin	-	0.25
2.	Azinphos-methyl	-	0.2
3.	Chlordane	-	0.5
4.	D D T	-	1
5.	D D V P	-	1
6.	Dichlorvos	-	1
7.	Dieldrin	-	0.25
8.	Dimethyl 1,2-dibromo 2,2 dichloroethyl phosphate (Dibrom)	-	3
9.	Endrin	-	0.1
10.	Guthion	-	0.2
11.	Lead arsenate	-	0.15
12.	Lindane	-	0.5
13.	Malathion	-	15
14.	Methoxychlor	-	15
15.	Nicotine	-	0.5
16.	Systox	-	0.1
17.	Thallium (Soluble compounds) as Tl	-	0.1
18.	Thiram	-	5
19.	Toxaphene	-	0.5
20.	Parathion	-	0.11
21.	Phosdrin	-	0.1
22.	Pyrethrum	-	5
23.	Warfarin	-	0.1
24.	Carbaryl (Sevin) (R)	-	5
25.	2, 4 - D	-	10
26.	Paraquat	-	0.5

Table B.1 (contd)

NO.	SUBSTANCES	Amount of chemicals (p.p.m.)	Amount of chemicals (mg/M^3)
27.	2, 4, 5-T	-	10
28.	Acetic acid	10	25
29.	Ammonia	50	35
30.	Arsenic and Compounds(as As)	-	0.5
31.	Arsine	0.05	0.2
32.	Biphenyl	0.2	1
33.	Bisphenol A	0.5	2.8
34.	Carbon dioxide	5,000	9,000
35.	Carbon monoxide	50	55
36.	Chlorine	1	3
37.	Chlorine dioxide	0.1	0.3
38.	Chromium and Chromium compounds	-	1
39.	Copper fume	-	0.1
40.	Dust or mist of copper	-	1
41.	Cotton dust (raw)	-	1
42.	Cyanide as (CN)	-	5
43.	Ethyl alcohol (Ethanol)	1,000	1,900
44.	Fluoride (as F)	-	2.5
45.	Fluorine	0.1	0.2
46.	Hydrogen cyanide	10	11
47.	Iron oxide fume	-	11
48.	Methyl alcohol (Methanol)	200	260
49.	Nickel carbonyl	0.001	0.007
50.	Nickel, metal and soluble compounds, as Ni	-	1
51.	Nitric acid	-	5
52.	Nitric oxide	25	30
53.	Nitrogen dioxide	5	9
54.	Nitroglycerin	0.2	2
55.	Sodium hydroxide	-	2

Table B.1 (contd)

NO.	SUBSTANCES	Amount of chemicals	
		(p.p.m.)	(mg/M^3)
56.	Sulfur dioxide	5	13
57.	Sulfuric acid	-	1
58.	Tetraethyl lead (as Pb)	-	0.075
59.	Tetramethyl lead (as Pb)	-	0.07
60.	Tin and Inorganic compounds of Tin	-	2
61.	Tin and Organic compounds of Tin	-	0.1
62.	Phenol	5	19
63.	Phosgene (Carbonyl chloride)	0.1	0.4
64.	Phosphine	0.3	0.4
65.	Phosphoric acid	-	1
66.	Phosphorus (yellow)	-	0.1
67.	Phosphorus pentachloride	-	1
68.	Phosphorus pentasulfide	-	1
69.	Phosphorus trichloride	0.5	3
70.	Xylene (Xylol)	100	435
71.	Zinc chloride fume	-	1
72.	Zinc oxide fume	-	5

Table B.2 Maximum Allowable Concentration of Chemicals at Any Time

NO.	SUBSTANCES	Amount of Chemicals (p.p.m.)	Amount of Chemicals (mg/M^3)
1.	Allyl glycidyl ether (AGE)	10	45
2.	Boron trifluoride	1	3
3.	Butylamine	5	15
4.	Tert - Butyl chromate (as CrO_3)	-	0.1
5,	Chlorine trifluoride	0.1	0.4
6.	Chloroacetaldehyde	1	3
7.	Chloroform (trichloromethane)	50	240
8.	O - Dichlorobenzene	50	300
9.	Dichloroethyl ether	15	90
10.	1, 1 - Dichloro - 1 - nitroethane	10	60
11.	Diglycidyl ether (DGE)	0.5	2.8
12.	Ethyl mercaptan	10	25
13.	Ethylene glycol dinitrate and/or Nitroglycerin	0.2	1
14.	Hydrogen chloride	5	7
15.	Iodine	0.1	1
16.	Manganese	-	5
17.	Methyl bromide	20	80
18.	Methyl mercaptan	10	20
19.	Methyl styrene	100	480
20.	Methylene bisphenyl isocyanate (MDI)	0.02	0.2
21.	Monomethyl hydrazine	0.2	0.35
22.	Terphenyls	1	9
23.	Toluene - 2, 4 - Diisocyanate	0.02	0.14
24.	Vinyl chloride	1	2.8

Source : Department of Labour

Table B.3 Allowable Concentration of Chemicals for the Specified Duration

No.	Material	Amount of Chemicals: Average concentration during normal work period	Concentration for a specified time: Concentration	Concentration for a specified time: Maximum Duration	Acceptable concentration
1.	Benzene	10 p.p.m	50 p.p.m	10 minutes	25 p.p.m
2.	Beryllium and Beryllium compounds	2 ug/M^3	25 ug/M^3	30 minutes	5 ug/M^3
3.	Cadmium fume	0.1 mg./M^3	-	-	3 mg./M^3
4.	Cadmium dust	0.2 mg./M^3	-	-	0.6 mg./M^3
5.	Carbondisulfide	20 p.p.m	100 p.p.m	30 minutes	30 p.p.m
6.	Carbontetrachloride	10 p.p.m	200 p.p.m	5 minutes in any 4 hours	25 p.p.m
7.	Ethylene dibromide	20 p.p.m	50 p.p.m	5 minutes	30 p.p.m
8.	Ethylene dichloride	50 p.p.m	200 p.p.m	5 minutes in any 3 hours	100 p.p.m
9.	Formaldehyde	3 p.p.m	10 p.p.m	30 minutes	5 p.p.m
10.	Fluoride as dust	2.5 mg./M^3	-	-	-
11.	Lead and its inorganic compounds	0.2 mg./M^3	-	-	-
12.	Methyl chloride	100 p.p.m	300 p.p.m	5 minutes in any 3 hours	200 p.p.m
13.	Methylene chloride	500 p.p.m	2000 p.p.m	5 minutes in any 2 hours	1000 p.p.m
14.	Organo(alkyl)mercury	0.01mg./M^3	-	-	0.04 mg./M^3
15.	Styrene 100 p.p.m	100 p.p.m	600 p.p.m	5 minutes in any 3 hours	200 p.p.m

Table B.3 (contd)

No.	Material	Amount of Chemicals: Average concentre-tion during normal work period	Concentration for a specified time: Concentra-tion	Concentration for a specified time: Maximum Duration	Acceptable concentra-tion
16.	Trichloroethylene	100 p.p.m	300 p.p.m	5 minutes in any 2 hours	200 p.p.m
17.	Tetrachloroethylene	100 p.p.m	300 p.p.m	5 minutes in any 3 hours	200 p.p.m
18.	Toluene	200 p.p.m	500 p.p.m	10 minutes	300 p.p.m
19.	Hydrogen sulfide	-	50 p.p.m	10 minutes	20 p.p.m
20.	Mercury	-	-	-	0.05 mg./M^3
21.	Chromic acid and chromates	-	-	-	0.1 mg./M^3

Source : Department of Labour

Table B.4 Allowable Average Concentration of Mineral Dusts During Working Hours

No.	SUBSTANCES	Average Amount of dusts throughout normal working time	
		(Mppcf)	($mg./M^3$)
1.	Silica:		
	Crystalline:		
	Quartz (Respirable dust)	$\frac{250}{\%\ SiO_2+5}$	$\frac{10\ mg./M^3}{\%\ SiO_2+2}$
	Quartz (Total dust)	-	$\frac{30\ mg./M^3}{\%\ SiO_2+2}$
	Cristobalite	$\frac{1}{2}\left[\frac{250}{\%\ SiO_2+5}\right]$	$\frac{1}{2}\left[\frac{10\ mg./M^3}{\%\ SiO_2+2}\right]$
	Tridymite	$\frac{1}{2}\left[\frac{250}{\%\ SiO_2+5}\right]$	$\frac{1}{2}\left[\frac{10\ mg./M^3}{\%\ SiO_2+2}\right]$
2.	Amorphous, including natural diatomaceous earth	20	$\frac{80\ mg./M^3}{\%\ SiO_2}$
3.	Silicates (less than 1% crystalline silica):		
	Asbestos	5*	-
	Tremolite	5*	-
	Talc (Asbestos form)	5*	-
	Talc (non - asbestos form)	20	-
	Mica	20	-
	Soapstone	20	-
	Portland cement	50	-
	Graphite	15	-
	Coal dust (espirable fraction less than 5%SiO_2	-	2.4 $mg./M^3$
	Coal dust (for more than 5% SiO_2)		$\frac{10\ mg./M^3}{\%\ SiO_2+2}$
4.	Inert or Nuisance dust:		
	Respirable dust	15	5 $mg./M^3$
	Total dust		15 $mg./M^3$

* means fibres/1 cc. of air

Source : Department of Labour

Appendix A

Types of Projects Requiring Environmental Impact Assessment

Type	Projects or Activities	Sizes
1	Dam or Reservoir	storage volume greater than 100,000,000 cubic meters or storage surface area greater than 15 square kilometers.
2	Irrigation	irrigated area greater than 80,000 rais (12,800 hectares).
3	Commercial Airport	all sizes.
4	Hotel or Resort Facilities in environmentally sensitive areas such as areas adjacent to rivers, coastal areas, lakes or beaches or in the vicinity of national parks	more than 80 rooms.
5	Mass Transit System and Expressway as defined by the Announcement of the Revolutionary Party No.290, 24 November B.E.2515	all sizes.
6	Mining as defined by the Mineral Act No.1 B.E.2510, No.2 B.E.2516, and No.3 B.E. 2522	all sizes.
7	Industrial Estate as defined by the Industrial Estate Authority of Thailand Act, B.E. 2522	all sizes.
8	Commercial Port and Harbour	with capacity for vessels of greater than 500 gross.
9	Thermal Power Plant	capacity greater than 10 MW.

Type	Projects or Activities	Size
10	Industries	
	(1) Petrochemical Industry	greater than 100 tons/day of raw materials required in production processes of oil refinery and/or natural gas separation.
	(2) Oil Refinery	all sizes.
	(3) Natural Gas Separation or Processing	all sizes.
	(4) Chlor-Alkaline Industry requiring NaCl as raw material for production of Na_2CO_3, NaOH, HCl, Cl_2, NaOCl and Bleaching Powder	production capacity of each or combined product greater than 100 tons/day
	(5) Irons and/or Steel Industry	requiring iron ore and/or scrap iron as raw materials for production greater than 100 tons/day or using furnaces with combined capacity greater than 5 tons/batch.
	(7) Smelting Industry other than Iron and Steel	production capacity greater than 50 tons/day.
	(8) Pulp Industry	production capacity greater than 50 tons/day.

Appendix D

List of Factories Surveyed

1. Eternal Resin Co., Ltd.
29 Moo 5, Bangna-Trad H'way, Km 25, Bangsaothong,
Bangplee, Samutprakarn.

2. Superior Chemical Co., Ltd.
27/6 Moo 1, Viphawadi Rangsit H'way, Klong Nueng,
Klong Luang, Pathumthani.

3. Utis Industrial Chemicals Co., Ltd.
94/4 Moo 4, Soi Suksawad 2, Suksawad Rd., Jomthong,
Bangkhunthien, Bangkok.

4. Thai Asahi Caustic Soda Co., Ltd.
202 Suksawad Rd., Km 17, Pakklong Bangplakod,
Phrasamutjedee, Samutprakarn.

5. Acme Chemical Industries Co., Ltd.
31/1 Bangna-Trad H'way, Km 23, Bangsaothong,
Bangplee, Samutprakarn.

6. Dao Siam Alum Factory Co., Part.
16/54 Soi Vatjana, Dao-kanong-Jomthong Rd., Jomthong,
Bangkhunthien, Bangkok.

7. Imperial Industrial Chemicals (Thailand) Co., Ltd.
101/61 Moo 20, Phaholyothin Rd., Km 46, Klong Nueng,
Klong Luang, Pathumthani.

8. Siam Chemical Co., Ltd.
196 Suksawad Rd., Km 19, Klong Bangplakod,
Phrasamutjedee, Samutprakarn.

9. Citric Acid Industry Co., Ltd.
231 Bangpoo Industrial Estate, Phraeksa,
Muang District, Samutprakarn 10280.

10. Shell (Thailand) Co., Ltd.
10 Soonthornkosa Rd., Klongtoey,
Phrakanong, Bangkok.

11. T.J.C. Chemical Factory Co., Ltd.
185 Sukumvit Rd., Km 35. Bangpoomai,
Muang District, Samutprakarn.

12. Unico Chemical Co., Ltd.
49/1 Moo 2, Soi Boonmee, Sukhabhiban 1 Rd.,
Bangkae, Bangkok.

13. Agro Chemical Industrial Co., Ltd.
169 Karnjanaburi-Saiyok Rd., Wangdong,
Muang District, Karnjanaburi.

14. Union Carbide Thailand Co., Ltd.
47/2 Nondhaburi Sai 1 Rd., Km 5, Bangkasor,
Muang District, Nondhaburi.

15. Chia Tai Co., Ltd.
70 Moo 6, Phetkasem, Omnoi,
Krathumban, Samutsakorn.

16. Hertz Co., Ltd.
101/59 Moo 20, Phaholyothin Rd., Klong Nueng,
Klong Luang, Bangkok.

17. Small Pack Ltd.
Phasicharoen, Bangkok.

18. P. Chemical Sondserm Karnkasate Co., Ltd.
8/33 Soi Ruammitr, Tivanond Rd., Banmai,
Pakkred, Nondhaburi.

19. ICI Asiatic (Agriculture) Co., Ltd.
261, 304 Bangpoo Industrial Estate, Sukumvit,
Muang District, Samutprakarn.

20. Sigma Paint (Thailand) Co., Ltd.
36 Moo 14, Sukhabhiban 2 Rd., Bangchan,
Minburi, Bangkok.

21. Toyo Ink (Thailand) Co., Ltd.
Kor 44 Moo 14, Sukhabhiban 2 Rd., Bangkchan,
Minburi, Bangkok.

22. J.B.P. Paint Ltd., Part.
34/3 Soi Panich Thonburi, Bangwaek,
Phasicharoen, Bangkok.

23. Minsae Co., Ltd.
16/4 Moo 4, Rangsit-Nakorn Nayok, Prachathipat,
Dhanyaburi, Pathumthani.

24. Thai Firework Ltd., Part.
72 Moo 4, Leab Rim Klong Rangsit Rd., Bangpool,
Muang District, Pathumthani.

25. Siam Firework Co., Ltd.
40 Moo 1 Soi Sriboonruang, Setthakij Rd., Suan Luang,
Krathumban, Samutsakorn.

26. Thai Plastic and Chemical Industrial Co., Ltd.
    19 Soi Sukhabhibal 16, Poochaosamingprai Rd., Bangkyapraek, Phrapradaeng, Samutprakarn.

27. Petroleum Authority of Thailand,
    LPG Filling Plant,
    Bangjak, Bangkok.

Appendix E
Statistics on the 10 Factories visited under SIC 35120 : Manufacture of Pesticides

Table E.1 Arrangements on Plant's Premises of SIC 35120

Arrangements on Plant's Premises	Observation N = 10			
	YES	(%)	NO	(%)
1. Is the area in which production facilities are located adequately separated from the residential area, warehouses, offices. etc ?	3	(30.0)	7	(70.0)
2. Is the safety of the instrumentation room assured ?	9	(90.0)	1	(10.0)
3. Are spaces between equipment sufficient when the properties and quantity of materials, conditions of operation, emergency measures, fire fighting activities, etc. are taken into consideration ?	10	(100.0)	0	(0.0)
4. Is the loading and unloading area adequately separated from the plant ?	8	(80.0)	2	(20.0)
Is it sufficiently separated from the ignition sources ?	8	(80.0)	2	(20.0)
5. Are the storage tanks located with an adequate distance from the boundary ?	8	(80.0)	2	(20.0)
Is the distance between storage tanks too close ?	3	(30.0)	7	(70.0)
6. Are the storage tanks surrounded by liquid barriers ?	0	(0.0)	10	(100.0)
or, Is their safety assured by burying them ?	3	(30.0)	7	(70.0)
7. Is the waste disposal area adequately separated from the residential area ?	8	(80.0)	2	(20.0)
8. Are adequate roads available for the entry and exit of vehicles at the time of an emergency ?	9	(90.0)	1	(10.0)

Table E.2 Buildings of SIC 35120

Buildings	Observation N = 10			
	YES	(%)	NO	(%)
1. Are the foundation and ground good enough for the full load ?	10	(100.0)	0	(0.0)
2. Are the materials and supports of the structures adequate in strength ?	10	(100.0)	0	(0.0)
3. Are the floors, walls, etc. made of nonflammable materials ?	8	(80.0)	2	(20.0)
4. Are the openings of the elevators, air-conditioning systems, ventilation ducts and other devices so constructed that they will prevent the spread of fire to a minimum ?	3	(30.0)	7	(70.0)
5. Are the dangerous processes separated by fire and explosion prevention walls?	8	(80.0)	2	(20.0)
6. In case there is danger that dangerous and hazardous materials may leak in the buildings, is the ventilation fully assured ?	3	(30.0)	7	(70.0)
7. Are clearly indicated exits for emergency available ?	0	(0.0)	10	(100.0)
8. Are the drainage facilities in the buildings adequate ?	9	(90.0)	1	(10.0)

Table E.3 Fire Fighting Facilities of SIC 35120

Fire Fighting Facilities	Observation N = 10			
	YES	(%)	NO	(%)
1. Are substances like acetylene, liquid gases, oxygen, etc., stored in a suitable manner ?	3	(30.0)	1	(10.0)
	6 (60%) = not applicable			
2. Are substances like oil, petrol, paint and solvents stored as they should be ?	8	(80.0)	1	(10.0)
	1 (10%) = not applicable			
3. Are electrical appliances and equipments checked with a view to their fire risks?	7	(70.0)	3	(30.0)
4. Are the workers properly informed on the nature and possibility of fire risks ?	9	(90.0)	1	(10.0)
5. Is there adequate fire-fighting equipment like fire extinguishers and protective gloves ?	8	(80.0)	2	(20.0)
6. Is the equipment in usable condition and properly checked ?	7	(70.0)	3	(30.0)
7. Are there any notices indicating where the fire - fighting equipments are kept?	4	(40.0)	6	(60.0)
8. Are the workers allowed to handle the equipments ?	10	(100.0)	0	(0.0)
9. Have the workers been instructed in the use of the equipments ?	10	(100.0)	0	(0.0)
10. Has anyone been appointed to look after the equipments?	4	(40.0)	6	(60.0)
11. Is there a notice giving the telephone number to the nearest fire station ?	2	(20.0)	8	(80.0)
12. Do the employees know the fire emergency routine/drill?	4	(40.0)	6	(60.0)

Table E.4 Materials, Intermediates, Products of SIC 35120

Materials, Intermediates, Products	Observation N = 10 YES	(%)	NO	(%)
1. Are the raw materials brought into the plant by a safe method ?	4	(40.0)	1	(10.0)
	5 (50%) = not applicable			
2. Are job regulations available for the acceptance of the raw materials ?	2	(20.0)	8	(80.0)
3. Are the physical and chemical properties of raw materials, intermediates, products correctly understood?	1	(10.0)	9	(90.0)
4. As regards raw materials, intermediats, products, are their explosibility, ignitability and other dangerous properties and their effects on human bodies known ?	2	(20.0)	8	(80.0)
5. Is the corrosiveness or corrosion resistance of raw materials, intermediates, products ascertained?	6	(60.0)	4	(40.0)
6. Has a study been made of what effects the existence of impurities produce on raw materials, intermediates, products ?	0	(0.0)	10	(100.0)
7. Are the location and quantity of highly dangerous materials ascertained ?	6	(60.0)	4	(40.0)

Table E.5 Processes of SIC 35120

Processes	Observation N = 10			
	YES	(%)	NO	(%)
1. Are the problems that have cropped up from the research phase to the plant phase recorded and put to effective use ?	1	(10.0)	9	(90.0)
2. Is the quantity of highly dangerous materials minimized in the processes ?	3	(30.0)	7	(70.0)
3. Are the processes properly indicated with reaction equations or with flow charts ?	1	(10.0)	9	(90.0)
4. Are job regulations available for the process operation ?	3	(30.0)	7	(70.0)
5. Are appropriate measures taken for the prevention of abnormalities as regards the following matters ?				
a) Temperature	4	(40.0)	6	(60.0)
b) Pressure	3	(30.0)	7	(70.0)
c) Reaction	5	(50.0)	5	(50.0)
d) Vibration and shock	0	(0.0)	10	(100.0)
e) Supply of raw materials	5	(50.0)	5	(50.0)
f) Flow of raw materials	5	(50.0)	5	(50.0)
g) Ingress of water or impurities	4	(40.0)	6	(60.0)
h) Leak or overflow from equipments	4	(40.0)	6	(60.0)
i) Static electricity	0	(0.0)	10	(100.0)
6. Has any possible unstable reaction been studied ?	1	(10.0)	9	(90.0)
7. Has the affected area been mapped out in case of a leakage ?	1	(10.0)	9	(90.0)

Table E.6 Transport, Storage of SIC 35120

Transport, Storage	Observation N = 10			
	YES	(%)	NO	(%)
1. Are job regulation, including a safety guideline available for transport ?	3	(30.0)	7	(70.0)
2. Is the potential danger of materials being handled adequately known ?	3	(30.0)	7	(70.0)
3. Are appropriate preventive measures taken against an unexpected discharge of dangerous materials ?	5	(50.0)	5	(50.0)
4. When unstable material is handled, are appropriate measures taken for minimizing heat, pressure, rubbing and other stimulative factors ?	1	(10.0)	9	(90.0)
5. Is the corrosion resistance of materials of tanks, pipes, etc. adequate ?	8 1 (10%) = not applicable	(80.0)	1	(10.0)
6. Is the safety of operators assured in all transport operations ?	6	(60.0)	4	(40.0)
7. Is full consideration given to the flow speed in the pipes ?	7 1 (10%) = not applicable	(70.0)	2	(20.0)
8. Are the waste liquids properly treated with appropriate waste disposal facilities ?	5	(50.0)	5	(50.0)
9. Are showers, eye-washing facilities, etc. available near loading facilities ?	6	(60.0)	4	(40.0)

Table E.7 Process Equipments of SIC 35120

Process Equipments	Observation N : 10			
	YES	(%)	NO	(%)
1. In the selection of process equipments are their safety aspects taken into consideration ?	6	(60.0)	4	(40.0)
2. Are process equipments installed to facilitate the surveillance and action of the operator ?	8	(80.0)	2	(20.0)
3. As regards process equipments is erogonomic consideration given to the prevention of their erroneous operations?	5	(50.0)	5	(50.0)
4. Is an adequate checklist available for each process equipments ?	2	(20.0)	8	(80.0)
5. Are process equipments designed for full safety control ?	4	(40.0)	6	(60.0)
6. In designing and locating process equipments is consideration paid to facilitate their inspection and maintenance ?	7	(70.0)	3	(30.0)
7. Are process equipments so designed to work on the safety side at the time of an abnormality ?	5	(50.0)	5	(50.0)
8. Is the inspection and maintenance plan adequate and appropriate ?	6	(60.0)	4	(40.0)
9. Are spare parts and technicians for repair fully available ?	6	(60.0)	4	(40.0)
10. Are the safety devices fully protected from danger ?	6	(60.0)	4	(40.0)
11. Is the lighting of the important facilities adequate ?	9	(90.0)	1	(10.0)
12. Are extra lighting facilities fully available in case of a power failure ?	4	(40.0)	6	(60.0)

Table E.8 Housekeeping of SIC 35120

Housekeeping	Observation N = 10			
	YES	(%)	NO	(%)
1. Are means of access to and from workplaces (aisles, corridors, passageways, stairs) both clearly marked and free from obstruction ?	7	(70.0)	3	(30.0)
2. Is the floor of workplaces both free from obstruction and not slippery ?	10	(100.0)	0	(0.0)
3. Are workplaces including work benches, floors walls and cellings reasonably clean, taking into account the nature of the work ?	8	(80.0)	2	(20.0)
4. Are machines kept reasonably clean (free from metal turnings, waste material and rubbish) ?	8	(80.0)	2	(20.0)
5. Are there sufficient containers for waste, oily rags and other rubbish ?	10	(100.0)	0	(0.0)
6. Are there proper places for holding or storing tools (for example, shadow boards) ?	9	(90.0)	1	(10.0)
7. Are materials stacked and stored both in an orderly, neat fachion and away from machines and other workplaces ?	7	(70.0)	3	(30.0)
8. Are soap and clean towels (or some other means of drying) provided at wash-hand basins ?	4	(40.0)	6	(60.0)
9. Are there lockers for clothing of employees ?	6	(60.0)	4	(40.0)
10. Are the facilities for clothing (i.e. changing room, lockers or other storage arrangements) clean ?	7 1 (10%) = not applicable	(70.0)	2	(20.0)

Table E.9 Location of SIC 35120

Location	Observation N = 10			
	YES	(%)	NO	(%)
1. In the case of an emergency, is the support system of fire stations, hospitals, and other disaster-prevention and first aid institutions secured ?	10	(100.0)	0	(0.0)
2. Is due consideration given to possible disaster of nereby plants ?	6	(60.0)	4	(40.0)

Table E.10 Job Training of SIC 35120

Job Training	Observation N = 10			
	YES	(%)	NO	(%)
Any systematic job orientation, instruction and training given to the employees ?				
1. training in work tasks	10	(100.0)	0	(0)
2. information on machine function, risks, etc.	7	(70.0)	3	(30.0)
3. information on protective measures (guards, hygiene, protective equipment, etc.)	7	(30.0)	3	(30.0)
4. instruction on emergency procedures and escape facilities	2	(20.0)	8	(80.0)

Table E.11 Safety Activities of SIC 35120

	Safety Activities	Observation N = 10			
		YES	(%)	NO	(%)
1.	Any person specially responsible for safety in the enterprise ?	4	(40.0)	6	(60.0)
2.	Any organised safety committee ?	4	(40.0)	6	(60.0)
3.	Any safety training provided ? if yes, (a) On-the-job ?	10	(100.0)	0	(0.0)
	(b) In training courses?	3	(70.0)	7	(70.0)
4.	Any safety inspection carried out ?	5	(50.0)	5	(50.0)
5.	Any information on accidents and diseases systematically collected and recorded ?	6	(60.0)	4	(40.0)
6.	Any written safety rules being used ?	6	(60.0)	4	(40.0)
7.	Any safety promotional activities being organised ?	4	(40.0)	6	(60.0)

Table E.12 Personal Protective Equipments of SIC 35120

Personal Protective Equipments	Observation N = 10			
	YES	(%)	NO	(%)
Does the enterprise provide the following PPE to employees exposed to risk ?				
1. Safety shoes or boots	9	(90.0)	1	(10.0)
2. Safety helmets	5	(50.0)	5	(50.0)
3. Gloves	10	(100.0)	0	(0.0)
4. Goggles	8	(80.0)	2	(20.0)
5. Ear protectors	1	(10.0)	9	(90.0)
6. Face protectors	6	(60.0)	4	(40.0)
7. Protective clothing	2	(20.0)	8	(80.0)
8. Dust masks	10	(100.0)	0	(0.0)
9. Respirators	8	(80.0)	2	(20.0)

Appendix F

World Bank List of Hazardous Substances Requiring A Major Hazard Assessment

List of Hazardous Substances Requiring A Major Hazard Assessment

(A) "Very Acutely Toxic" Substances

The following indicative criteria are used to identify any "very toxic" substance requiring a major hazard assessment. These criteria are independent of the quantities of the substance stored, or processed, or that are formed by an unwanted by-product reaction.

Very toxic substances are defined as:

- substances which correspond to the first line of the table below;

- substances which correspond to the second line of the table below and which, owing to their physical and chemical properties, are capable of entailing major-accident hazards similar to those caused by the substance mentioned in the first line:

	LD 50 (oral) (1) mg/kg body weight	LD 50 (cutaneous) (2) mg/kg body weight	LC 50 (3) mg/l (inhalalation)
1	LD 50 <5	LD 50 <10	LC 50 <0.1
2	5<LD 50<25	10<LD 50<50	0.1<LC 50<0.5

Note: (1) LD 50 oral in rats.
Note: (2) LD 50 cutaneous in rats or rabbits.
Note: (3) LC 50 by inhalation (four hours) in rats.

If an LC 50 value is available for a shorter exposure time "t" the LC 50 (4 hr) may be estimated as follows:

$$LC\ 50\ (4\ hr) = \frac{LC\ 50\ (t\ hr) \times t}{4}$$

(B) Other Acutely Toxic Substances

(1) The following quantities of toxic substances represent the threshold above which compliance with Section 4.1 is required.

Named Substances	Quantity Tonnes
Phosgene	2
Chlorine	10
Hydrogen fluoride	10
Sulphur trioxide	15

Acrylonitrile	20
Hydrogen cyanide	20
Carbon disulphide	20
Sulphur dioxide	20
Bromine	40
Ammonia (anhydrous or as solution containing more than 50% by weight of ammonia)	60

(2) In addition to the above named substances, the following indicative criteria are used to identify other toxic substances which, owing to their physical and chemical properties, may cause a major accident and are stored or processed in quantities of greater than 1 tonne:

LD 50 (oral) (1) mg/kg body weight	LD 50 (cutaneous) (2) mg/kg body weight	LC 50 (3) mg/l (inhalalation)
$25 < LD\ 50 < 200$	$50 < LD\ 50 < 400$	$0.5 < LC\ 50 < 2$

Note: (1) LD 50 oral in rats.
Note: (2) LD 50 cutaneous in rats or rabbits.
Note: (3) LC 50 by inhalation (four hours) in rats.

3) Highly Reactive Substances

1) The following quantities of "highly reactive" substances represent the threshold above which compliance with Section 4.1 is required.

Named Substances	Quantity Tonnes
Hydrogen	2
Ethylene oxide	5
Propylene oxide	5
tert-Butyl peroxyacetate	5
tert-Butyl peroxyisobutyrate	5
tert-Butyl peroxymaleate	5
tert-Butyl peroxy isopropyl carbonate	5
Dibenzyl peroxydicarbonate	5
2,2-Bis(tert-butylperoxy) butane	5
1,1-Bis(ter-butylperoxy) cyclohexane	5
Di-sec-butyl peroxydicarbonate	5
2,2-Dihydroperoxypropane	5
Di-n-propyl peroxydicarbonate	5
Methyl ethyl ketone peroxide	5
Sodium chlorate	25
Liquid oxygen	200

General Groups of Substances	Quantity Tonnes
Organic peroxides (not listed above)	5
Nitrocellulose compounds	50
Ammonium nitrates	500

(2) In addition to the above named substances, the following indicative criteria are used to identify potential explosive hazards, irrespective of materials stored or processed.

- Substances which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

(D) Flammable Substances

The following quantities of "flammable" substances represent the threshold, above which and compliance with Section 4.1 is required.

Class of Flammable Substances	Quantity Tonnes
1. Flammable Gases:	
Gas or any mixture of gases which is flammable in air and is held as a gas.	15
2. Liquefied Gases and Flammable Liquids in Process at Pressure and/Temperature Above Ambient Levels:	
A substance or any mixture of substances which is flammable in air and is normally held in the installation above its boiling point (measured at 1 bar absolute) as a liquid or as a mixture of liquid and gas at a pressure of more than 1.4 bar absolute. (e.g. LPG's).	25 being the total quantity of substances above the boiling points whether held singly or in mixtures.
3. Refrigerated Liquefied Gas	
A liquefied gas or any mixture of liquefied gases, which is flammable in air, has a boiling point of less than 0°C (measured at 1 bar absolute) and is normally held in the installation under refrigeration or cooling at a pressure of 1.4 bar absolute or less (e.g., LNG).	50 being the total quantity of substances having boiling points below 0°C whether held singly or in mixtures.

4. **<u>Highly Flammable Liquids</u>**

A liquid or any mixture of liquids not included in items 1 to 3 above, which has a flash point of less than 21°C.	10,000

5. **<u>Flammable Liquids at High Temperature and Pressure</u>**

Substances which have a flash point lower than 55°C and which remain liquid under pressure, where particular processing conditions, such as high pressure and temperature, may lead to a major accident hazard.

List of Acutely Toxic and Reactive Hazardous Substances

Group A:

Very Toxic Substances

Aldicarb

4-Aminodiphenyl

Amiton

Anabasine

Arsenic pentoxide, Arsenic (V) acid and salts

Arsenic trioxide, Arsenious (III) acid and salts

Arsine (Arsenic hybride)

Azinphos-ethyl

Azinphos-methyl

Benzidine

Benzidine salts

Beryllium (powders, compounds)

Bis (2-chloroethyl) sulphide

Bis (chloromethyl) ether

Carbofuran

Carbophenothion

Chlorfenvinphos

4-(Chloroformyl) morpholine

Chloromethyl methyl ether

Cobalt (powders, compounds)

Crimidine

Cyanthoate

Cycloheximide

Demeton

Dialifos

OO-Diethyl S-ethylsulphinylmethyl
phosphorotioate

OO-Diethyl S-ethylthiomethyl
phosphorothioate

OO-Diethyl S-isopropylthiomethyl
phosphorodithioate

OO-Diethyl S-propylthiomethyl
phosphorodithioate

Dimefox

Dimethylcarbamoyl chloride

Dimethylnitrosamine

Dimethyl phosphoramidocyanidic acid

Diphacinone

Disulfoton

EPN

Ethion

Fensulfothion
Fluenetil

Fluoroacetic acid

Fluoroacetic acid, salts

Fluoroacetic acid, esters

Fluoroacetic acid, amides

4-Fluorobutyric acid

4-Fluorobutyric acid, salts

4-Fluorobutyric acid, esters

4-Fluorobutyric acid, amides

4-Fluorocrotonic acid

4-Fluorocrotonic acid, salts

4-Fluorocrotonic acid, esters

4-Fluorocrotonic acid, amides

4-Fluoro-2-hydroxybutyric acid

4-Fluoro-2-hydroxybutyric acid, salts

4-Fluoro-2-hydroxybutyric acid, esters

4-Fluoro-2-hydroxybutyric acid, amids

Glycolonitrile (Hydroxyacetonitrile)

1, 2, 3, 7, 8, 9-Hexachlorodibenzo-p-dioxin

Hexamethylphosphoramide

Hydrogen selenide

Isobenzan

Isodrin

Juglone (5-Hydroxynaphthalene-1,4-dione)

4,4' - Methylenebis (2-chloroaniline)

Methyl isocyanate

Mevinphos

2-Naphthylamine

Nickel (powders, compounds)

Nickel tetracarbonyl

Oxydisulfoton

Oxygen difluoride

Paraoxon (Diethyl 4-nitrophenyl phosphate)

Parathion

Parathion-methyl

Pentaborane

Phorate

Phosacetim

Phosphamidon

Phosphine (Hydrogen phosphide)

Promurit (1-(3,4-Dichlorophenyl)-
3-triazenethiocarboxamide

1,3-Propanesultone

1-Propen-2-chloro-1,3-diol diacetate

Pyrazoxon

Selenium hexafluoride

Sodium selenite

Stibine (Antimony hydride)

Sulfotep

Sulphur dichloride

Tellurium hexafluoride

TEPP

2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)

Tetramethylenedisulphotetramine

Thionazin

Tirpate (2,4-Dimethyl-2,3-dithiolane-2-carboxaldehyde O-methylcarbamoyloxime)

Trichloromethanesulphenyl chloride

1-Tri(cyclohexyl)stannyl-1H-1,2,4-triazole

Triethylenemelamine

Warfarin

Group B:

Other Toxic Substances

Acetone cyanohydrin (2-Cyanopropan-2-ol)

Acrolein (2-Propenal)

Acrylonitrile

Allyl alcohol (2-Propen-1-ol)

Allylamine

Ammonia

Bromine

Carbon disulphide

Chlorine

Ethylene dibromide (1,2-Dibromoethane)

Ethyleneimine

Formaldehyde (concentration > 90%)

Hydrogen chloride (liquefied gas)

Hydrogen cyanide

Hydrogen fluoride

Hydrogen sulphide

Methyl bromide (Bromomethane)

Nitrogen oxides

Phosgene (Carbonyl chloride)

Propyleneimine

Sulphur dioxide

Tetraethyl lead

Tetramethyl lead

Group C.1:

Highly Reactive Substances and Explosives

Acetylene

Ammonium nitrate (where it is in a state which gives it properties capable of creating a major accident hazard)

2,2-Bis(tert-butylperoxy) butane concentration > 70%)

1,1-Bis (tert-butylperoxy) cyclohexane (concentration > 80%)

tert-Butyl peroxyacetate (concentration) > 70%)

tert-Butyl peroxyisobutyrate (concentration > 80%)

tert-Butyl peroxy isopropyl carbonate (concentration > 80%)

tert-Butyl peroxymaleate (concentration > 80%)

tert-Butyl peroxyphivalate (concentration > 77%)

Dibenzyl peroxydicarbonate (concentration > 90%)

Di-sec-butyl peroxydicarbonate concentration > 80%)

Diethyl peroxydicarbonate (concentration > 30%)

2,2',4,4',6,6'-Hexanitrostilbene

Hydrazine nitrate

Lead azide

Lead styphnate (Lead 2,4,6-trinitroresorcinoxide)

Mercury fulminate

N-Methyl-N,2,4,6-tetranitroaniline

Nitroglycerine

Pentaerythritol tetranitrate

Picric acid (2,4,6-Trinitrophenol)

Sodium picramate

Styphnic acid (2,46,6,-Trinitroresorcinol)

1,3,5-Triamino-2,4,6-Trinitrobenzene

Trinitroaniline

2,4,6-Trinitroanisole

Trinitrobenzene

Trinitrobenzoic acid

Trinitrocresol

2,4,6-Trinitrophenetole

2,4,6-Trinitrotoluene

2,2-Dihydroperoxypropane (concentration > 30%)

Di-isobutyryl peroxide (concentration > 50%)

Di-n-propyl peroxydicarbonate (concentration > 80%)

Ethylene oxide

Ethyl nitrate

3,3,6,6,9,9-Hexamethyl-1,2,4,5-
tetroxacyclononane concentration > 75%)

Hydrogen

Methyl ethyl ketone peroxide (concentration > 60%)

Methyl isobutyl ketone peroxide (concentration > 60%)

Peracetic acid (concentration > 60%)

Propylene oxide

Sodium chlorate

Group C.2:

Explosive Substances

Barium azide

Bis (2,4,6-trinitrophenyl) amine

Chlorotrinitrobenzene

Cellulose nitrate (containing > 12.6% nitrogen)

Cyclotetramethylenetetranitramine

Cyclotrimethylenetrinitramine

Diazondinitrophenol

Diethylene glycol dinitrate

Dinitrophenol, salts

Ethylene glycol dinitrate

1-Guanyl-4-nitrosaminoguanyl-1-tetrazene

Appendix G

Identification of Hazardous Chemicals by Local Experts

As part of the study, a questionnaire survey by mail was conducted to identify priority hazardous chemicals in Thailand. A list of 954 chemicals was provided to local experts who were asked to rank the importance of these chemicals based on their frequency of use, quantity, toxicity and familiarity.

Sixteen of the questionnaires were returned. Tabulation was made on the ratings of all chemicals. The chemicals were classified into 5 groups, eg. explosives, flammables, pesticides, carcinogens and other toxic substances. The resultant chemicals in the first 10 highest rankings of each group were listed below.

The names of the local experts are also provided after the list of priority chemicals.

Table G.1 Priority Chemicals Selected by Local Experts

Priority	Name
Group 1 : Explosives	
1	NITROGLYCERIN E, T PICRIC ACID E, T
2	TRINITROBENZENE, ALL ISOMERS E, T
3	NITROCELLULOSE, CONT.>12,6% OF NITROGEN E TRINITROTOLUENE E, T
4	BENZOYL PEROXIDE E, XI
5	PICRIC ACID COMPOUNDS, SALTS E, T
6	CHLOROTRINITROBENZENE E, T DIETHYLENE GLYCOL DINITRATE E, T
7	ETHYL NITRATE E
8	AMMONIUM PERCHLORATE E, XN ETHYL NITRITE E, XN LEAD AZIDE E, XN MERCURY FULMINATE E, T MERCURY OXYCYANIDE E, T
9	AMMONIUM-BIS-(2,4,6-TRINITRO-PHENYL) E, T 1,2-ETHANEDIOL DINITRATE E, T TRINITROCRESOL, ALL ISOMERS E, XN
10	N-METHYL-N,2,4,6-TETRANITRO-ANILINE E, T PENTAERYTHRITOL TETRANITRATE E STYPHNIC ACID E, XN 1,2,3,4-TETRANITROCARBAZOLE E, XN 2,4,6-TRINITROANISOL E, XN
Group 2 Flammables	
1	BENZENE F, T
2	TOLUENE F, XN
3	PROPANE F
4	ACETONE F BUTANE F tert-BUTYL ALCOHOL F, XN DIETHYL ETHER F HYDROGEN CYANIDE F, T PHOSPHORUS, WHITE AND YELLOW F, T

5	ETHANE F METHANE F METHANOL F, T METHYL ISOCYANATE F, T
6	ETHANOL F HYDROGEN F SODIUM F, C VINYL CHLORIDE F, T
7	CARBON MONOXIDE F, T ISOPROPYL ALCOHOL F
8	ACETONITRILE F, T ACETYLENE F ACROLEIN F, T ACRYLONITRILE F, T ALLYL ALCOHOL F, T CARBON DISULFIDE F, T ETHYL ACETATE F ETHYL METHYL ETHER F HYDROGEN SULPHIDE F, T PENTANE F TETRAHYDROFURAN F, XI
9	DI-ISOPROPYL ETHER F 1,2-EPOXYPROPANE F, XN HEXANE, MIXTURE OF ISOMERS, CONTAINS n-HEXANE >5% F, XN ISOPROPYL FORMATE F MAGNESIUM POWDER, UNSTABILIZED F PHOSPHORUS, RED F VINYL ACETATE F
10	CELLULOSE NITRATE, NITROGEN CYCLOPROPANE F 1,4-DIOXANE F, XN HEXANE, MIXTURE OF ISOMERS, CONC. OF n-HEXANE <5% F ZINC ALKYLES, C1-C5 F, C

Group 3 Pesticides

1	PARATHION T
2	LINDANE T
3	ALDRIN T DDT T
4	PARAQUAT AND SALTS T
5	ENDRIN T

6	DIELDRIN, (HEOD 85%) T
7	DICHLORVOS T WARFARIN T
8	CHLORDANE XN HEPTACHLOR T
9	FENTHION XN MERCURY, ORGANIC COMPOUNDS PARATHION METHYL T
10	BROMOPHOS-ETHYL T CARBOFURAN T DICROTOPHOS T ETHION T

Group 4 Other toxic substances

1	CHLORINE T
2	CARBON TETRACHLORIDE T
3	HYDROGEN CYANIDE F, T
4	ARSENIC T MERCURY T NITROBENZENE T PHOSGENE T
5	BENZENE F, T
6	CARBON MONOXIDE F, T PHENOL T
7	AMMONIZ T VINYL CHLORIDE F, T
8	HYDROGEN SULPHIDE F, T
9	METHYL ISOCYANATE F, T TOLUIDINE, ALL ISOMERS T
10	ANILINE T BENZIDINE T PICRIC ACID E, T ZINC PHOSPHIDE T

Group 5 Carcinogens

1	BENZENE F, T
2	ASBESTOS
3	VINYL CHLORIDE F, T DIELDRIN T
4	ALDRIN T CARBON TETRACHLORIDE T
5	LINDANE T
6	MUSTARD GAS T AFLATOXINES T CHLOROFORM XN
7	ACRYLONITRILE F, T POLYCYCLIC AROMATIC HYDRO- T
8	ARSENIC AND INORGANIC COMPOUNDS T POLYCHLORINATED BIPHENYLS XN
9	O-DIAZOMETHANE C, T POTASSIUM DICHROMATE XI
10.	DIMETHYLSULPHATE T EPICHLOROHYDRIN T ETHYLCARBAMATE T N-NITROSOAMINES N-NITROSODIPHENYLAMINE XN N-NITROSO-N-METHYL-(4-HYDROXYBUTYL)-AMINE XN 1,1,2,2-TETRACHLOROETHANE T

Notes:

C = Corrosive
E = Explosive
F = Flammable
O = Oxidizing
T = Toxic
Xi = Irritant
Xn = Harmful

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Appendix H

Hazardous Substances in the World Bank List But Not in the PSA list

1 1,1-bis (tert-butylperoxy) cyclohexane
2 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin
3 1,3,5-triamino-2,4,6-trinitrobenzene
4 1,3-propanesultone
5 1-guanyl-4-nitrosaminoguanyl-1-tetrazene

6 1-propen-2-chloro-1,3-diol diacetate
7 1-tri (cyclohexyl) stannyl-1h-1,2,4-triazole
8 2,2',4,4',6,6'-hexanitrostilbene
9 2,2-bis (tert-butylperoxy) butane
10 2,2-dihydroperoxypropane

11 2,2-dyhydroperoxypropane
12 2,3,7,8-tetrachlorodibenzo-p-dioxin (tcdd)
13 2,4,6-trinitroanisole
14 2,4,6-trinitrophenetole
15 2,4,6-trinitrotoluene

16 2-naphthylamine
17 3,3,6,6,9,9-hexamethyl-1,2,4,5-tetroxacyclononane
18 4,4' - methylenebis (2-chloroaniline)
19 4-(chloroformyl) morpholine
20 4-aminodiphenyl

21 4-fluoro-2-hydroxybutyric acid
22 4-fluoro-2-hydroxybutyric acid, amids
23 4-fluoro-2-hydroxybutyric acid, esters
24 4-fluoro-2-hydroxybutyric acid, salts
25 4-fluorobutyric acid

26 4-fluorobutyric acid, amides
27 4-fluorobutyric acid, esters
28 4-fluorobutyric acid, salts
29 4-fluorocrotonic acid
30 4-fluorocrotonic acid, amides

31 4-fluorocrotonic acid, esters
32 4-fluorocrotonic acid, salts
33 acetone cyanohydrin (2-cyanopropan-2-ol)
34 acrolein (2-propenal)
35 allyl alcohol (2-propen-1-ol)

36 allylamine
37 amiton
38 ammonia
39 ammonium nitrate
40 anabasine

Hazardous Substances in the World Bank List But Not in the PSA list

41 arsine (arsenic hybride)
42 barium azide
43 benzidine
44 benzidine salts
45 beryllium (powders, compunds)

46 bis (2,4,6-trinitrophenyl) amine
47 bis (2-chloroethyl) sulphide
48 bis (chloromethyl) ether
49 bromine
50 carbon disulphide

51 cellulose nitrate
52 chlorine
53 chloromethyl methyl ether
54 chlorotrinitrobenzene
55 cobalt (powders, compounds)

56 crimidine
57 cyanthoate
58 cyclotetramethylenetetranitramine
59 cyclotrimethylenetrinitramine
60 di-isobutyryl peroxide

61 di-n-propyl peroxydicarbonate
62 di-sec-butyl peroxydicarbonate
63 diazondinitrophenol
64 dibenzyl peroxydicarbonate
65 diethyl peroxydicarbonate

66 diethylene glycol dinitrate
67 dimethyl phosphoramidocyanidic acid
68 dimethylcarbamoyl chloride
69 dimethylnitrosamine
70 dinitrophenol, salts

71 ethyl nitrate
72 ethylene glycol dinitrate
73 ethylene oxide
74 ethyleneimine
75 fensulfothion

76 fluenetil
77 fluoroacetic acid
78 fluoroacetic acid, amides
79 fluoroacetic acid, esters
80 fluoroacetic acid, salts

Hazardous Substances in the World Bank List
But Not in the PSA list

81 formaldehyde (concentration > 90%)
82 glycolonitrile (hydroxyacetonitrile)
83 hexamethylphosphoramide
84 hydrazine nitrate
85 hydrogen cyanide

86 hydrogen fluoride
87 hydrogen selenide
88 hydrogen sulphide
89 isobenzan
90 isodrin

91 juglone (5-hydroxynaphthalene-1,4-dione)
92 lead azide
93 lead styphnate (lead 2,4,6-trinitroresorcinoxide)
94 mercury fulminate- n-methyl-n,2,4,6-tetranitroaniline
95 methyl ethyl ketone peroxide

96 methyl isocyanate
97 nickel (powders, compounds)
98 nickel tetracarbonyl
99 nitrocellulose compounds
100 nitrogen oxides

101 nitroglycerine
102 oo-diethyl s-ethylsulphinylmethyl phosphorotioate
103 oo-diethyl s-ethylthiomethyl phosphorothioate
104 oo-diethyl s-isopropylthiomethyl phosphorodithioate
105 oo-diethyl s-propylthiomethyl phosphorodithioate

106 oxydisulfoton
107 oxygen difluoride
108 pentaborane
109 pentaerythritol tetranitrate
110 peracetic acid

111 phosacetim
112 phosgene (carbonyl chloride)
113 phosphine (hydrogen phosphide)
114 picric acid (2,4,6-trinitrophenol)
115 promurit 1-(3,4-dichlorophenyl)-3-triazenethiocarboxamide

116 propylene oxide
117 propyleneimine
118 pyrazoxon
119 selenium hexafluoride
120 sodium picramate

Appendix I

Material Safety Data Sheet

1. PRODUCT DATA.

1.1 TRADE NAME: Parathion พาราไธออน

USES : pesticide on crops, vegetables, ornamentals ยาปราบศัตรูพืช

1.3 MANUFACTURER/IMPORTER:

NAME : แองโกร เคมิคอล AGRO Chemical Industries Co. Ltd.

STREET: 169 กาญจนบุรี - ถนนไทยโยค

CITY : กาญจนบุรี

CODE :

TEL # : 3923298 กท.สนง.ใหญ่, TELEX:

2. PRODUCT CLASSIFICATION.

2.1 UN #: 2783 2.2 EEC #: 015-034-00-1

2.3 CARCINOGENIC SUBSTANCES: no evidence

2.4 WARNING LABELS: R 26 27 28 ; S 1 13 28 45

3. HAZARDOUS INGREDIENTS:

3.1 SUBSTANCES	%	HAZARDS PROPERTY, LD50, TLV
(C2H5O)2 PSOC6H4 NO2	100	synonyms: ethyl parathion or O,O-Diethyl-O,p-nitrophenyl phosphorothioate Threshold Limit Value in Thailand: 0.11 mg/m3

4. CHEMICAL AND PHYSICAL DATA:

4.1 BOILING POINT (DEG. C): 375 C (760 mm Hg)

4.2 MELTING POINT (DEG. C): 6 C (pure), 0 C (technical)

4.3 VAPOUR PRESSURE (KPA) : 0.004

4.4 SOLUBILITY IN WATER : 0.00002 g/100g water at 20 C

4.5 SPECIFIC GRAVITY : 1.27

4.6 EVAPORATING RATE (BUTYL ACETATE = 1): n/a

4.7 PH-VALUE :

4.8 APPEARANCE, COLOUR AND ODOR:

yellow to dark brown liquid, characteristic odor like garlic

5. FIRE AND EXPLOSION HAZARD DATA.

5.1 FLASH POINT: not combustible
5.2 FLAMABLE LIMITS: LEL: - UEL: -
5.3 AUTOIGNITION TEMPERATURE:
5.4 CHEMICAL REACTIVITY:
temperatures above 100 C may cause decomposition so that containers burst

MATERIALS TO AVOID: contact with strong oxidizers may cause fire and explosion
HAZARDOUS DECOMPOSITION PRODUCTS:
toxic gases and vapors as nitrogen oxides, S, P, CO_2

6. HEALTH HAZARD DATA.

6.1 WAYS OF EXPOSURE:
Parathion can affect the body if it is inhaled, comes in contact with eyes or skin or if swallowed. It may enter the body through the skin
6.2 LOCAL EFFECTS (SKIN, EYES, MUCOUS MEMBRANES):
Skin: sweating, twitching in affected areas within 15 min. to 4 hours.

6.3 EFFECTS OF OVER-EXPOSURE (SHORT TERM):
After inhalation: tightness of chest, wheezing, bluish skin discoloration, small pupils, aching eyes, blurring vision, tearing, headache, watering of the mouth. Severe intoxicat: weakness, paralysis, breathing stopped. Dizziness or coma
6.4 EFFECTS OF OVER-EXPOSURE (LONG TERM):
Repeated exposure may increase susceptibility to the effects of this and related chemicals. Repeated low exposures may result in the onset of symptoms

7. SAFETY PRECAUTIONS.

7.1 TECHNICAL SAFETY MEASURES:
Process enclosure

FIRE AND EXPLOSION PREVENTION:
not combustible
VENTILATION:
general dilution ventilation, local exhaust ventilation
RESPIRATORY PROTECTION TYPE:
chemical organic vapor cartridge respirator or air supply r.
PROTECTION:
HAND : gloves must be worn
EYE : face shield or goggles should be worn where spills can occur
OTHER:

7.2 SAFETY PRECAUTIONS:
FIRST AID:
Eye: Wash eyes with large amount of water lifting lids occasionally
Skin: Wash immediately with soap and water, remove contaminated cloth
Breathing: Move person to fresh air at once, perform artificial respir ation if breathing has stopped, keep warm and rest. Swallowed: if pers on is conscious give water and get him vomiting it. Get medical help

8. SPECIAL INSTRUCTIONS. -

8.1 HANDLING AND STORING:
persons not wearing protective equipment to be restricted
8.2 CORROSIVENESS:

8.3 SPILL AND LEAK PROCEDURES:
1. Ventilate area of spill or leak 2. Collect for reclamation or absorb in vermiculite, sand, earth or similar

8.4 ENVIRONMENTAL HAZARDS:
major hazard quantity 100 kg, initial: 1000 kg Group I

8.5 DESTROYING AND DISPOSAL METHODS:
Parathion may be disposed of by absorbing it in vermiculite , dry sand, earth or a similar material and disposing in sealed containers in a secured sanitary landfill

8.6 INSTRUCTIONS IN CASE OF FIRE:

ADDITIONAL INFORMATION AVAILABLE FROM:
NICE/Department of Labour, Thaling Chan,BKK, 424-8001/4

SIGNATURE:................................

ATTACHMENT:

Cas No. 563882 ; NICE Group 1 initial quantity: 1 tonne

NICE CHEMLAB No. 0704 , 0705,

Survey PCF database No. 0081

Appendix J
List of Participants
Seminar "Strategy for Major Accident Prevention in the Chemical Industry"
TDRI Office, January 22, 1986.

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Plant Administrative Manager
Union Carbide Co.,Ltd.

19. Anuwat Chansooksai
Personnel Manager
Chia Tai Co.,Ltd.

20. Vinai Surapolchai
Administrative Manager
Thai Asahi Caustic Soda Co.,Ltd.

21. Manee Kaewta
Senior Production Manager
Thai Asahi Caustic Soda Co.,Ltd

22. Sriprapai Sivilai
Technical Officer
Employer Confederation of Thailand

23. Thanavit Supavanich
    Director
    Medical Division
    Petroleum Authority of Thailand

24. Panus Thai-Luan
    Secretary-General
    National Congress of Thai Labour

25. Jukka Takala
    Chief Technical Adviser
    International Labour Organisation (ILO)

26. Janice Jensen
    Consultant
    USAID

27. Dr. Eddie Hum
    Deputy Head
    Carl Duisberg Gesellschaft (CDG)
    South East Asia Program Office

Secretariat

Thailand Development Research Institute

28. Prof. Dr. Anat Arbhabhirama
    President

29. Dr. Dhira Phantumvanit
    Associate Director
    Natural Resources and Environment Programme (NRE)

30. Dr. Yothin Unkulvasapaul
    Research Fellow, NRE

31. Adis Israngkul
    Research Associate, NRE

32. Suthawan Sathirathai
    Research Associate, NRE

33. Chuchitt Sombunthawong
    Secretary

National Institute for the Improvement of Working Conditions and Environment (NICE)

34. Dr. Chaiyuth Chavalitnitikul
    Director

35. Vilert Jetiyanuwatr
    Safety Officer

36. Sumalee Chanachanmongkol
    Safety Officer