International Labour Office

Preventing major industrial accidents in Asia: A guide

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ILO Regional Office for Asia and the Pacific
Bangkok

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Foreword

In 1984, more than 2,500 people were killed and over 200,000 injured in the Bhopal disaster in India due to the leakage of methyl isocyanate from a chemical plant. Other such major industrial accidents have occurred and today there is global recognition of the need to prevent them.

Over the last 75 years, the ILO has been striving to protect working people. The principles laid down in the ILO Prevention of Major Industrial Accidents Convention, 1993 (No. 174), provides a sound basis for preventing major accidents and protecting workers, the public and the environment. Many countries in Asia and the Pacific have already taken steps to implement the principles.

This booklet presents a practical plan of action for setting up a national major hazard control system. It was first published on the occasion of the 75th anniversary of the International labour Organization in 1994 and was one of a series produced by the ILO Regional Office for Asia and the Pacific.

The publication was prepared under the responsibility of Mr. Seiji Machida, Occupational Safety and Health Technical Specialist, ILO/EASMAT. We would like to mention our special thanks to Mr. Henk Ens, ILO Consultant, who drafted the document. It is reprinted with minor revisions, particularly on OSH statistics.

In the foreword to the first printing we expressed the hope that the booklet would provide a framework of reference and inspire continued efforts to prevent and control major industrial accidents in the region. That wish has apparently been fulfilled since the first printing has already been exhausted. For this reason we have now proceeded to the current second edition.

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Bangkok
June 2000

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1 Background

In 1984, the world was shocked by the industrial disaster in Bhopal, India, when the accidental release of deadly methyl isocyanate killed more than 2,500 people and injured over 200,000, and by the fire and explosion catastrophe in Mexico City which killed more than 500 persons. Measures to prevent major industrial accidents are necessary not only in highly industrialized countries, but also in countries where the infrastructure to prevent and control them has not been adequately developed.

The ILO, in 1985, convened an ad hoc meeting of experts in order to obtain guidance on control of major hazards. To give effect to the meeting's recommendations, the ILO has taken a series of actions resulting in the adoption of the Prevention of Major Industrial Accidents Convention, 1993 (No. 174). The Convention sets standards for the protection of workers, the public, and the environment against major accidents. It applies to installations which produce, process, handle, use, dispose of or store - either permanently or temporarily - hazardous substances exceeding their established threshold quantities. It does not apply to nuclear installations and plants processing radioactive substances, military installations, and transport outside the installation site other than by pipeline. The major elements of this Convention are briefly described in Chapter 3.

This publication draws on and should be read in conjunction with the following ILO publications:

- *Major hazard control: A practical manual,* 1990.
- *Prevention of major industrial accidents: An ILO code of practice,* 1991.

This publication is intended to help ILO member States in Asia and the Pacific to implement the principles of ILO Convention No. 174. It presents a plan of action for establishing a major hazard control system to prevent accidents involving hazardous substances and limit their consequences if they occur.

2 Major industrial accidents: Causes and consequences

During 1980s and 1990s, many Asian countries progressed with industrialization and achieved high economic growth. While several countries are still experiencing economic difficulties since mid-1997, the countries of Asia continue to promote employment generation along with the rapid industrialization and modernization of agriculture. New industries have been set up with new processes, using sophisticated apparatus, creating at the same time new kinds of hazards. If steps are not taken in time, such hazards can develop into major disasters resulting in an enormous number of casualties and extensive damage to property and the surrounding environment.

A data bank on industrial accidents recorded 124 fatal accidents involving hazardous substances in the region. Since more than 65 per cent of them took place in only two countries and none in seven, it appears that many more occurred but went unrecorded. Some of the more severe ones are mentioned in Table 1 (page 3).

Early action should be taken by governments and employers' and workers' organizations to stem the rising number of accidents. In India, the Ministries of Labour and Environment are carrying out an extensive programme and legislation on major hazard control has been introduced. Malaysia has set up a unit for major hazard control within the Ministry of Human Resources. Indonesia and Thailand have taken steps to review the situation and identify major hazard installations. However, efforts have been scattered and unsystematic in most countries. Where a major hazard control system has been initiated, it needs to be improved, expanded, and completed. Major risks are recognized, but preventive laws are generally inadequate to cope with hazards and emergencies. The enforcement efforts of the governmental agencies concerned with the protection of workers, the public, and the environment are not properly coordinated.

Employers, workers, and the public are not fully aware of the damage that hazardous substances can cause. As a result, when a serious accident occurs, those involved are overwhelmed by its immediate effects, unable to grasp the full dimensions of its consequences. After the victims have been attended to and the incident generally brought under control, an assessment has to be made of how to deal with the consequences of the accident and carry on with tasks: repair the damage, restart the plant, prevent a recurrence.

Table 1. Major industrial accidents in Asia

Hazardous substance	Deaths	Injuries	Place and date of accident
Methyl isocyanate	>2 500	>200 000	Bhopal, India, 1984
Gunpowder	9	59	Seoul, Republic of Korea, 1987
Liquefied petroleum gas	35	15	Nagothane, India, 1990
Fireworks	40	60	Sungei Buloh, Malaysia, 1991
Ammonia	7	30	Dhaka, Bangladesh, 1991
Flammable chemicals	5	>200	Bangkok, Thailand, 1991
Gunpowder	63	52	Hubei, China, 1993
Reaction between hydrosulphate and sodium sulphide	15	25	Shenzen, China, 1993
Ethene	9	6	Beijing, China, 1997
Potassium chlorate	35	104	Chiang Mai, Thailand, 1999
Petrol	7	12	Chonburi, Thailand, 1999
Carbonyl chloride (phosgene)	1	101	Rayong, Thailand, 2000

□ Causes

Major accidents may generally be caused by human failures or errors, technical faults or external forces. They almost always result from a number of causes, mainly human failures, not only on the part of the operators immediately concerned, but also maintenance personnel, supervisors, management, and plant and equipment designers and suppliers. Technical failures usually arise from human errors such as poor maintenance, overloading or improper use. Therefore attention should be directed more to preventing human errors and failures at all levels.

◆ *Common cause failures*

Often, one event or condition can lead to a number of faults or failures, called common cause failures. A poorly trained and instructed operator is likely to take wrong action. If a company does not have a well-organized training programme, it is probably because its management does not consider safety a first priority and does not devote adequate time and money to it. Not only operator training and instruction, but also technical safety and maintenance of the installation tend to be neglected.

The most dangerous common cause failures are of an organizational nature: insufficient management commitment to safety, lack of communication between departments, inadequate instruction and information to workers. The higher a common cause failure is located in the management hierarchy, the more harm it can lead to. **Management should be fully committed to plant safety and its commitment made known to all personnel.**

□ Consequences

◆ *Immediate consequences*

The immediate consequences of a major accident may be many dead or injured, heavy damage to installations and buildings, and pollution and damage to the environment. Workers and the installations are mostly affected, but serious accidents can also endanger the nearby population and environment.

◆ *Long-term consequences*

A serious accident has long-term effects at three levels: the enterprise, the people living in the vicinity, and the environment.

The enterprise is affected by:

- adverse public reaction
- unfavourable publicity in the press, radio, and television
- extensive repair or replacement, loss of production, interruption of supply to customers and break in relations with them
- investigations by the judiciary, possibly generating further unfavourable publicity
- lawsuits resulting in severe punishment of the guilty: heavy fines or prison terms
- indemnification of the victims and their relatives
- additional safety measures required by the competent authorities
- increased insurance rates
- expenses for recruitment and training of new personnel.

As a result, the plant may have to be shut down for a long time, perhaps permanently.

People living in the vicinity of the accident may become permanently disabled or emotionally disturbed. Some chemical substances can cause illnesses that manifest themselves long after actual exposure. Besides damage to property near the plant site, the property value itself may decline as people may not want to live near a potentially unsafe area.

Hazardous substances released in the accident may be detrimental to the environment, animals, and vegetation: crops may be spoiled and water supplies polluted, land may not be suitable for cattle-grazing or crop-growing for a long time.

3 Framework for major hazard control system

The purpose of a major hazard control system is to prevent accidents involving hazardous substances and limit their consequences. This requires close collaboration between employers' and workers' organizations and the government. The framework of the system, as laid down in the ILO Prevention of Major Industrial Accidents Convention, 1993 (No. 174), is described below.

□ *National policy*

The ILO member State must formulate, implement, and periodically review national policy to protect workers, the public, and the environment against the risk of major accidents. It must do so in consultation with the most representative organizations of employers and workers and others concerned. Preventive and protective measures should be implemented and the best safety technologies promoted. If necessary, legislation should be modified to include the major hazard control system.

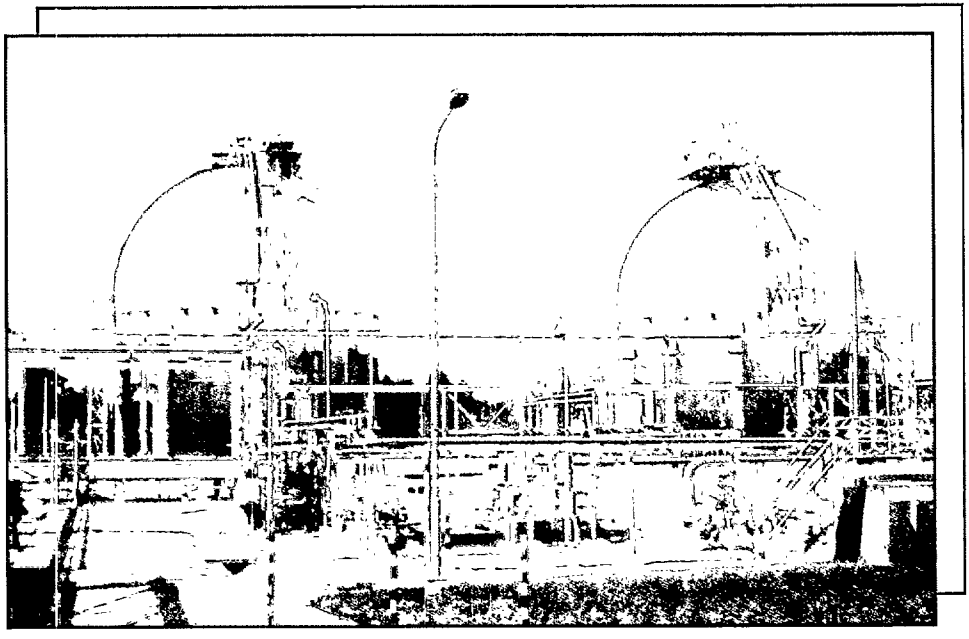
The policy should cover identification of major hazards and their control through preventive measures, mitigation of the effects of accidents, and protection of workers, the public, and the environment from the consequences of accidents. Control of major hazards must be linked to and complement general efforts to improve occupational safety and health. It can be implemented by a practical, step-by-step approach, as outlined in Chapter 4.

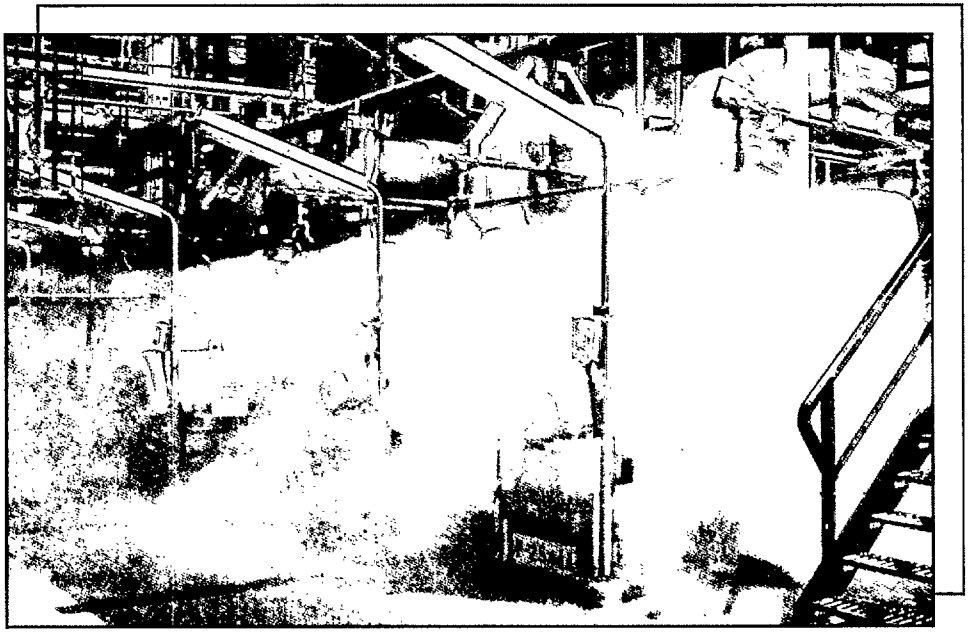
□ *Designation of competent authorities*

The government must designate a competent authority or competent authorities to set up and administer the major hazard control system.

□ *Identification of major hazard installations*

A major hazard installation is one where hazardous substances exceeding their threshold quantities are present. The competent authorities will set up a system for identifying such installations based on a list of hazardous substances and their corresponding threshold quantities established in accordance with national laws and regulations or international standards.





☐ *Responsibilities of employers*

Based on the major hazard control system set up by the competent authorities, employers must identify their major hazard installations and notify the competent authorities.

Employers must establish and maintain a documented system of major hazard control, including an on-site emergency plan (detailed in the ILO code of practice) for each major hazard installation. They must prepare a safety report reflecting the documented system, which should be reviewed, updated, and amended as conditions or circumstances change. The safety report should be made available to the competent authorities.

Employers must inform the competent authorities as soon as a major accident occurs. The accident must be reported in detail, with recommendations on the preventive action to be taken.

☐ *Responsibilities of competent authorities*

The competent authorities will inspect the major hazard installation, ensure compliance with national laws and regulations, and investigate an accident. They have the right to suspend operations that pose imminent threat of a major accident. They will ensure that off-site emergency arrangements are established (described in the ILO code of practice). They will establish a comprehensive siting policy and arrange for appropriate separation of a new major hazard installation from working and residential areas and public facilities, and appropriate measures for existing installations.

☐ *Rights and duties of workers and their representatives*

Workers and their representatives must be informed of the hazards associated with the installation and their likely consequences. They must be advised of orders, instructions and recommendations by the competent authorities. They must be consulted in the preparation of safety reports, accident reports, and emergency plans and procedures, and have access to them.

They must discuss with the employer any hazards they consider can cause a major accident and have the right to notify the competent authorities of such hazards. They must take corrective action and, if necessary, interrupt activities if there is reason to believe that there is imminent danger of a major accident. They must notify their supervisor or raise an alarm before or as soon as possible after taking such action.

They must be regularly instructed and trained in preventive practices and emergency procedures and comply with them.

Setting up major hazard control system: Twenty essential steps

One of the main objectives of setting up a major hazard control system is to ensure that the employer takes all the necessary control measures after assessing hazards and risks in the installations. The employer must systematically collect and document information on the installations and the hazards caused by them, and the measures taken to control the hazards and ensure safe operation. Relevant information should be transmitted or made available to the competent authorities for scrutiny. In the process, lapses and shortcomings in safety functions can be detected by the employer and the competent authorities and remedial measures applied in time.

A major industrial accident can be prevented only if the smaller and more common occupational hazards are already under control. The major hazard control system must be rooted in a system of control and inspection of workplace safety and health. It should therefore be promoted along with efforts to improve safety and health, in general, and chemical safety, in particular.

The organization chart of a major hazard control system is shown in Annex 1.

The system may be set up in a number of steps which need not be consecutive: some can run parallel or overlap, others may relate to activities that should continue throughout the process. In some cases, one or more steps should be completed first before the next step can start, or the outcome of one step may lead to reappraisal of the previous one. A distinction should be made between the different phases and the targets assigned to each of them so that progress can be monitored and evaluated.

It is important to keep the setting-up process moving. If activities in one area cannot proceed, the areas where progress can be made should be concentrated on. If the resources, knowledge or capacity available are insufficient to attain the goals set, efforts must be made to achieve what is possible rather than allow activities to slow down or come to a halt.

Twenty steps in setting up major hazard control system

Step 1: Establish national committee
Step 2: Identify lead agency
Step 3: Review and assess infrastructure
Step 4: Strengthen and coordinate infrastructure
Step 5: Review and assess national legislation
Step 6: Identify competent authorities
Step 7: Establish group of experts and technical advisory unit
Step 8: Establish national list of hazardous substances and threshold quantities
Step 9: Identify major hazard installations
Step 10: Raise awareness
Step 11: Organize training programmes
Step 12: Issue guidelines
Step 13: Strengthen inspection capabilities
Step 14: Promote enterprise action
Step 15: Scrutinize safety report
Step 16: Undertake inspection
Step 17: Establish siting policy
Step 18: Establish off-site emergency plan
Step 19: Establish monitoring system
Step 20: Report and investigate accidents

Step 1: Establish national committee

A national committee should be created to draft national policy on setting up the major hazard control system. It should comprise representatives of the government, employers' and workers' organizations, and other concerned parties. It should preferably be set up by legislation in order to give it as broad a mandate as possible and enable it to include in its work all concerned governmental agencies, such as the ministries of labour, health, environment, industry and interior.

The policy should define the goals to be achieved, the principles and scope of the system, the responsibilities of employers, workers, the government, and concerned competent authorities, and the ways in which the efforts of the competent authorities can be coordinated. It should address all aspects of major hazard control concerning safety and health and protection of workers, the public,

and the environment in accordance with the principles of ILO Convention No. 174.

Step 2: Identify lead agency

An important step is to identify the lead agency responsible for coordinating with the concerned competent authorities for:

- protection of workers, including prevention of major accidents - usually addressed by the labour ministry and its enforcing agency, i.e. the inspectorate
- protection of the public, including organization of the off-site emergency response and siting of major hazard installations - usually the responsibility of the local authorities
- protection of the environment - usually the responsibility of the environmental protection agency.

The lead agency may be an existing or a newly created body within the government structure reporting to one minister, or a body in which several ministries cooperate. As a preliminary arrangement, the government authority responsible for occupational safety and health may serve as lead agency.

The lead agency will take the initiative in establishing the major hazard control system. It will coordinate the drafting of legislative proposals, arrange for consultations with employers' and workers' organizations and others concerned, and follow the proposals through to enactment. It will facilitate continuous exchange of information between the governmental agencies. It will resolve conflicts of interests and differences of opinion between the governmental agencies. Matters it is unable to settle will be brought before the national committee for decision.

Step 3: Review and assess infrastructure

The national committee will review and assess the infrastructure in respect of hazardous industrial operations (including chemicals) and their control. The review should seek answers to the following questions:

- What are the types and sizes of hazardous industries and where are they located?
- What are the main or prevailing major hazards?
- Are safety and health conditions adequate?
- What is the chemical safety situation compared to the requirements of the ILO Chemicals Convention, 1990 (No.170)?
- What is the existing infrastructure in respect of chemical safety (e.g. inspectorate, competent authorities, occupational safety and health institutes, safety councils, technological institutes, universities)?

- To what extent is the management of enterprises committed to safety and how does it make its commitment known?
- Are occupational accidents and diseases reported, registered, and investigated?
- Are safety officers available? What are their qualifications and responsibilities?
- Are there works safety and health committees where workers' representatives can discuss safety issues with the safety officer and other management experts?

The report of the findings and assessment of the review will be discussed in the national committee.

Step 4: Strengthen and coordinate infrastructure

During the review, the national committee will have discovered inadequacies and imperfections in the functioning of the infrastructure. It will propose recommendations for improving the infrastructure and enforcement of legislation, especially in respect of coordination among the competent authorities and the staffing capabilities of the inspection services.

Step 5: Review and assess national legislation

The lead agency will initiate a review and assessment of national legislation and regulations on safety and health in industry, in general, and on the safety of major hazard installations, in particular. The review will include the inspection services of the competent authorities. Answers must be formulated to pertinent questions:

- Does the legislation adequately cover occupational safety and health in hazardous industries?
- Is enforcement of the legislation supported by adequate inspection services by the competent authorities?
- Are the inspection services properly organized and coordinated?
- Is the legislation enforced by different competent authorities and, if so, are there overlapping responsibilities or areas not covered?
- How can the activities of the competent authorities be coordinated?
- Does the legislative system have provisions for accommodating the major hazard control system?

Where appropriate, the lead agency, in consultation with the competent authorities, will draft proposals for improvements in the legislation on occupational safety and health and chemical safety. The proposals will be discussed with employers' and workers' organizations and others concerned.

If the legislation does not contain provisions for accommodating the major hazard control system, the lead agency will draft proposals to modify it or to introduce new legislation on major hazard control, indicating which competent authorities will be responsible for its enforcement.

The legislative provisions for a major hazard control system are given in Annex 2.

Step 6: Identify competent authorities

A competent authority or several competent authorities must be identified to enforce the major hazard control legislation. They must liaise closely with each other under the guidance of the lead agency.

Major hazard control covers three aspects: occupational safety and health (prevention and control of major accidents), public safety (off-site emergency preparedness, siting, and licensing), and environmental protection. The competent authorities will usually be the three or more agencies concerned with these aspects, each attached to its own ministry.

Step 7: Establish group of experts and technical advisory unit

◆ *Group of experts*

In setting up the major hazard control system, the competent authorities may have to answer questions and resolve problems for which they do not have sufficient expertise. They would need to call upon a group of experts for advice. The group of experts may be set up and financed by a competent authority or jointly by several competent authorities.

The group of experts will advise on specific matters and draft guidelines, codes of practice, and other documents on implementation of the major hazard control legislation.

The experts may be drawn from governmental agencies, industry, universities, technological institutes, and safety councils. They may be appointed or nominated by the institutions in which they work or may be approached directly by the competent authorities.

◆ *Technical advisory unit*

A technical advisory unit needs to be set up within the competent authorities to provide them with technical support and specialized information. It will advise inspectors, management, and workers on implementation of the major hazard control legislation. It may be also called upon to advise the decision-making authorities and the national committee.

Personnel of the unit may be recruited from among senior inspectors familiar with industrial conditions and occupational safety and health, or from industry. They should receive further training in all areas of major hazard control.

Ideally, the unit should have specialists in areas such as chemical engineering, hazard and operability study (HAZOP), safety management, occupational safety and health, explosion protection, assessment of the effects of accidental releases of hazardous substances, and risk assessment. Such specialists may not be available at the time of setting up the major hazard control system. Nevertheless, the system should be organized to function as efficiently as possible by utilizing the capabilities available in the country and making the employer (not the government) responsible for plant safety.

Initially, major hazard control will not be a full-time concern for the specialists; they may be engaged part-time or required to spare time from their current work.

For specific purposes, the competent authorities may need to contract the services of external advisers or consultants.

The unit will conduct lectures and training courses on major hazard control.

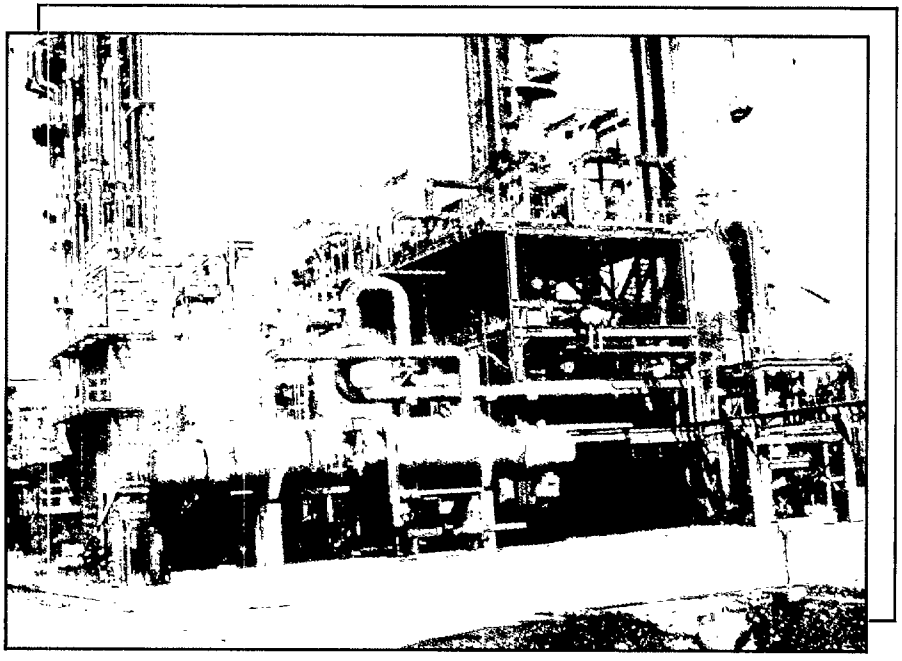
The unit should have access to international knowledge on chemical safety, hazardous substances, and major hazard control.

The unit should establish links with international databases on hazardous substances, major hazard installations, and major accidents, as well as with other databases in the country, such as the National Centre of the ILO International Occupational Safety and Health Information Centre (CIS).

Step 8: Establish national list of hazardous substances and threshold quantities

A major hazard installation is an installation where one or more hazardous substances exceeding their threshold quantities are present. In order to identify the major hazard installations in the country, the competent authorities must establish a national list of hazardous substances with their corresponding threshold quantities. The list should be concise and convenient to use.

The list largely determines the scope of the major hazard control system. Each country must decide on which hazardous substances are to be included and what their threshold quantities would be. It can prepare a list according to its particular needs or use one established elsewhere. The ILO publication, *Major hazard control: A practical manual,* lists 180 hazardous substances with their threshold quantities. Initially, the list should include only the substances present in substantial quantities and most relevant to the country. Other substances can be added later. If possible, threshold quantities should be assigned to categories of substances rather than to individual substances.



Threshold quantities may be set according to local conditions. To start with, the quantities should be high enough to limit the scope of the major hazard control system to larger installations. Later, they may be reduced to extend the system to smaller installations.

The competent authorities must set up a panel of experts to periodically review the list of hazardous substances and their corresponding threshold quantities based on latest technology and industrial development. The panel of experts may develop guidelines to systematically set new threshold quantities for existing and additional substances.

As major accidents are caused mainly by only a few of the substances, a short list of 19 chemicals is also given in the ILO manual. Initially, it may be practical to use the short list, adding other substances later, as needed. An even shorter list of five substances may be used (Table 2, page 16).

Details of hazardous substances and their properties are given in Annex 3.

Step 9: Identify major hazard installations

Identification of major hazard installations in a country would mean locating and registering the installations where one or more hazardous substances exceeding their threshold quantities are present. The competent authorities can identify such installations before the major hazard control legislation is enacted, but identification can be finalized only after the list of hazardous substances and their threshold quantities is made legally binding.

Major hazard installations are most commonly petrochemical works and refineries, chemical works and production plants,

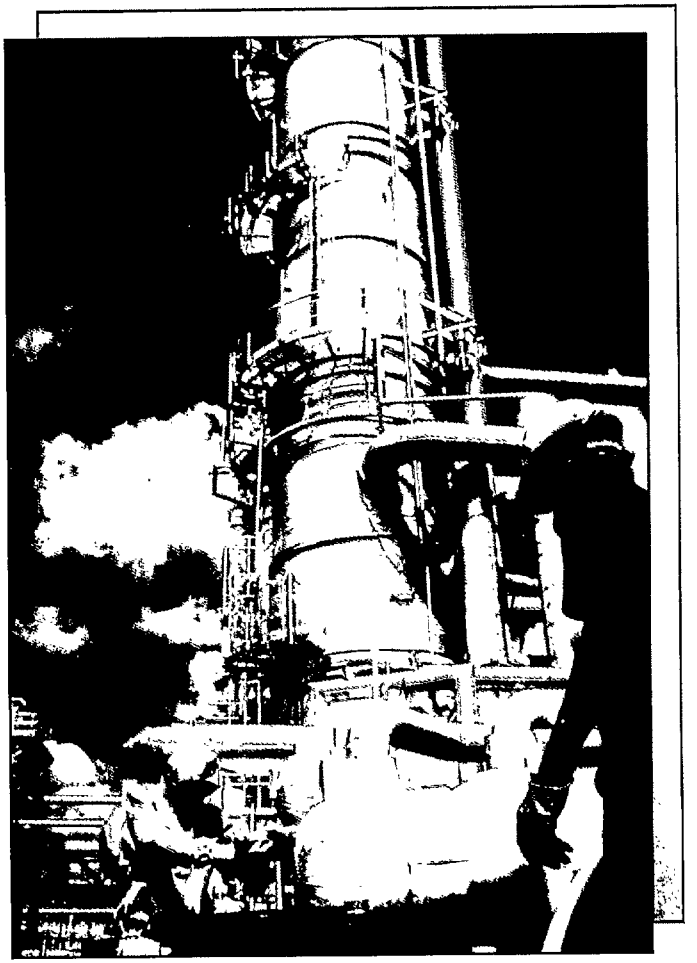


Table 2. Short list of hazardous substances and threshold quantities

Hazardous substance	Description	Threshold quantity
LPG	Liquefied petroleum gas, mixture of butane and propane	200 tons
LNG	Liquefied natural gas, deeply refrigerated methane	200 tons
Petroleum products	Petrol, aviation fuel, crude oil, diesel fuel	50 000 tons
Cl_2	Chlorine	25 tons
NH_3	Ammonia	500 tons

liquefied petroleum gas stores and terminals, chemical stores and distribution centres, large fertilizer stores, explosives factories, and works in which chlorine is used in bulk. Local inspectors of the competent authorities are familiar with these installations and their knowledge may be tapped as a first step in identifying them. Additional information on their location may be obtained from organizations such as chambers of commerce, trade associations, and trade unions.

The competent authorities can ask the management of the companies likely to have major hazard installations for information on their activities. The information may be used to establish or modify the list of hazardous substances and their threshold quantities. In order to determine whether a plant is a major hazard installation or not, the total storage capacity of the dangerous substance must be considered, not the inventory figure or consumption at a given time.

When the major hazard control legislation is in place, the management of the company must on its own initiative check the list of hazardous substances and the threshold quantities, identify its major hazard installations, and notify the competent authorities.

Step 10: Raise awareness

Hazards can be controlled only when all concerned are aware of them, the need to control them, and the ways of doing so. Management and workers in the installations and people living nearby must be informed about the processes carried out

in the plant, the hazardous substances and their characteristics, the hazards involved in the processes (if things go wrong, what can happen), and the protective measures they themselves can take.

Management must be convinced that hazard analysis and open information on hazards will not adversely affect the company if it clearly demonstrates that it considers the safety of its personnel and installations a priority matter.

Workers must be made to realize that accidents can be avoided through proper information, instruction, training, and discipline, and that they must comply with all safety regulations.

For management and workers to be aware of the hazards and the need to control them, they should know about accidents in similar installations, their causes and how they could have been avoided, and the possible consequences of such accidents if they were to occur in their installations.

The competent authorities may inform the public through the press, radio or other media about the specific accidents that they have investigated, explaining their causes and how they could have been prevented.

Articles on accident investigation in technical publications written by safety officers, government inspectors, and technical experts create awareness of the hazards. These publications should be accessible to all concerned. Reference libraries on chemical safety and prevention of major industrial accidents should be available and kept up-to-date.

Step 11: Organize training programmes

The competent authorities must organize training courses on the major hazard control system in cooperation with major hazard industries, professional institutions, employers' and workers' organizations, safety councils, occupational safety and health institutes, technological institutes, and universities.

A general, basic course should be provided for those directly involved: safety officers and managers of major hazard installations, Inspectors of the competent authorities responsible for enforcing the legislation, specialists of the technical advisory unit, occupational safety and health inspectors. It should be organized by professional training institutes. Instructors should be recruited from governmental agencies, industry, employers' and workers' organizations, safety and health institutes, universities, professional organizations, research laboratories, medical institutions, and insurance companies. Optimal use should be made of the existing training facilities.

Inspectors must also receive training in special skills and techniques for inspecting major hazard installations, scrutinizing safety reports, and investigating accidents. Courses should be held at local schools and institutions, or instruction should be given by specialists of the technical advisory unit. If possible, fellowships abroad should be arranged.

Specialists of the technical advisory unit need to be familiar with conditions and safety problems in chemical factories. To equip them with this knowledge, they should attend part of the basic training course for inspectors and join the training course for inspectors on inspection of major hazard installations and investigation of accidents.

Step 12: Issue guidelines

As soon as the legislation on the major hazard control system is enacted, the lead agency will inform all concerned. The competent authorities must draft guidelines on aspects such as identification and notification of major hazard installations, writing of safety reports, hazard assessment, and emergency preparedness. Guidelines may be newly drafted or they may be based on other countries' guidelines. Their contents should be examined by the group of experts.

Step 13: Strengthen inspection capabilities

When the major hazard control system is first set up, each major hazard installation will have to be inspected several times. Once the system is fully operational, the installation should be inspected at least once a year or every two years.

Inspectors of the competent authorities must be capable of scrutinizing a safety report and understanding from it the installation processes, the hazards involved, and the technical and organizational measures taken to control the hazards. They must be able to conclude from it whether the management of the company is sufficiently committed to safety, whether the powers and responsibilities in the company are delegated in a way to ensure safe operations, whether the hazards have been properly identified and assessed, and whether the preventive measures taken are adequate to ensure safe operation. They must be able to formulate recommendations and demands for rewriting of the safety report, additional information, and safety measures, and discuss them with the management.

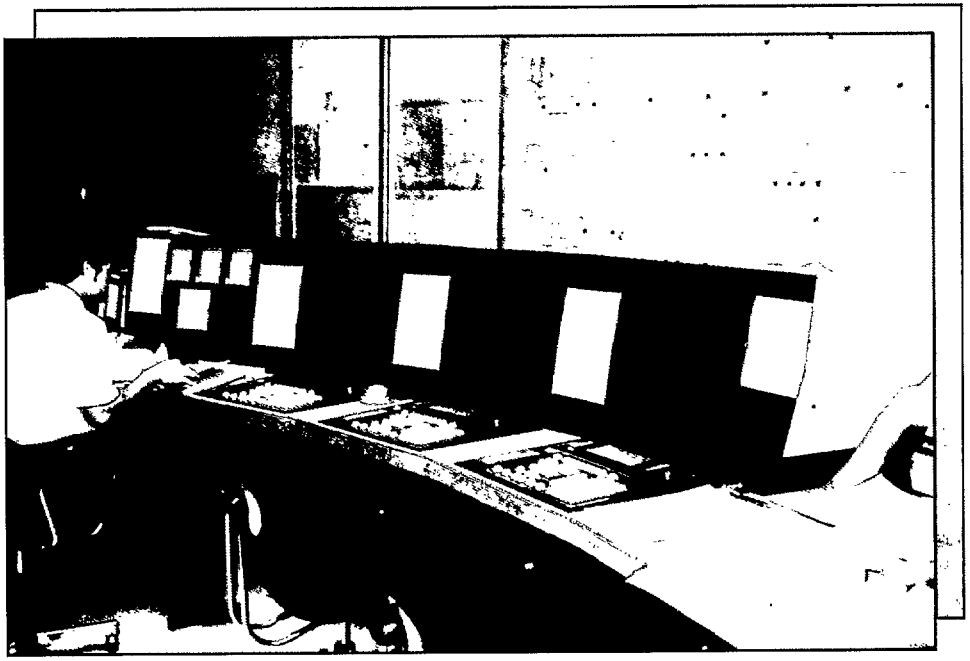
Inspectors must be capable of investigating different kinds of accidents. From scanty and sometimes distorted evidence, they must be able to draw valid conclusions as to the causes of the accident and how a recurrence can be prevented.

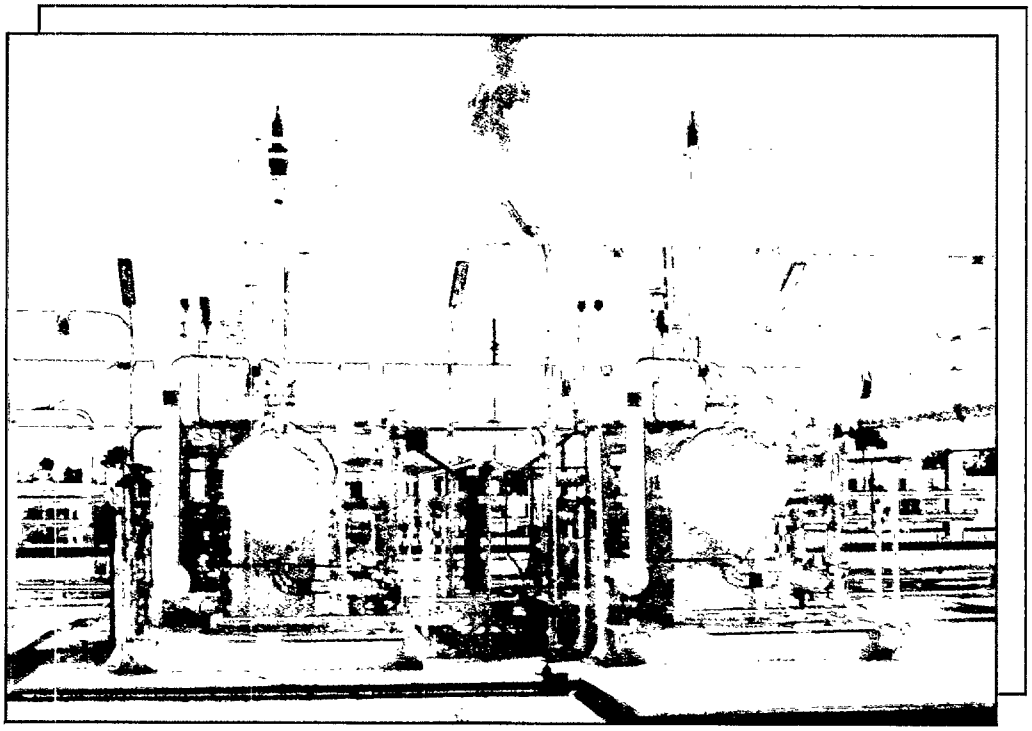
Inspectors need not have specialized knowledge about subjects such as risk calculations, hazard analysis, and dispersion calculations. Specialists of the technical advisory unit will assist them in this respect. If the specialists are not available, the company safety personnel who prepared the report must explain these subjects to the inspector.

Besides their basic engineering qualifications, inspectors should receive induction training in factory inspection and training in safety engineering. They should preferably have some years of experience in industry.

Step 14: Promote enterprise action

Employers must set up a documented system of major hazard control (Annex 4), recording all safety measures in their operations, to ensure that relevant information can be retrieved when needed. Information from the documented system should be condensed and included in the safety report.





In principle, the safety report should be written by company personnel. It should begin with an introduction on the company's safety policy written by top management. Subsequent sections should be written preferably by company officers responsible for the subjects concerned. In the process, they may discover faults in the safety systems which they will be in the best position to correct. Parts of the report may also be written by the safety officer.

The safety report or parts of it may sometimes have to be written by an external expert. However, safe operation of the plant requires that knowledge of the hazards and safety measures is always available within the company. Contracting out the safety report to an external expert has certain disadvantages: it may turn out to be more expensive than estimated as the external expert may not have in-depth knowledge of the company and the plant and will have to

spend more time and energy securing all the information needed; the knowledge gained by the external expert will not remain with the company; the competent authorities will not discuss the safety report with the external expert who has no direct responsibility for the installation.

The competent authorities can guide management and workers on the requirements of the major hazard control legislation, particularly in respect of the safety report. The local inspector and one or more specialists from the technical advisory unit can answer their questions. Specialists of the technical advisory unit, through lectures and discussions, can provide them with information on implementation of new legislation or regulations on major hazard control, methods of identifying and analysing hazards, control measures, on-site emergency plan, and writing of safety reports. The lectures should be supported by printed information in the national language.

Annex 5 describes the contents of the safety report.

Step 15: Scrutinize safety report

The safety report must be scrutinized by the competent authorities, preferably by the local inspector, who has first-hand knowledge of the installation, and one or more specialists of the technical advisory unit familiar with hazard analysis and assessment and the safety reports of other installations.

The safety report should be checked on three counts:

- Does it adequately describe the hazardous substances, installation, processes, and safety organization?
- Does it properly identify, analyse, and assess the hazards and the measures taken to deal with them?
- Does it show that the hazards have been adequately dealt with and operations are safe as a result?

If the descriptive part of the safety report is found inadequate, the competent authorities will reject it and request the company to rewrite it. The competent authorities must state in what respect it is inadequate. If it is incomplete, the competent authorities will request the company to provide additional information, specifying the information needed. However, if it is generally unsatisfactory, the competent authorities will explain in what respect it is lacking so that it can be rewritten.

Hazard identification, analysis, and assessment must show that the management is aware of the hazards involved in the operations. Depending on the type, size, and complexity of the installation, different methods of analysis may be used, ranging

from written statements by company experts and records of past operations to complex risk analysis programmes. If the competent authorities are not satisfied with the risk assessment, they may ask the employer to conduct systematic and detailed studies (such as the HAZOP study) of the possible hazards on one or more parts of the installation. The HAZOP study is conducted by a multidisciplinary team of experts familiar with all aspects of the installation's operations. If the competent authorities are not satisfied with the measures taken to control the hazards, they may demand that additional measures be instituted. If they are satisfied that the safety report describes a safe installation, the veracity of the report must be confirmed by inspection of the installation.

Step 16: Undertake inspection

In normal factory inspection, the conditions and situation are checked against precise and detailed regulations and requirements with which the inspector is thoroughly familiar. In the case of major hazard installations, however, there are no detailed regulations to follow. Inspection is carried out to verify whether the plant is being operated according to the standards set by the management in the safety report.

The inspector will announce the visit in advance and, if possible, discuss the aspects to be inspected with management and workers' representatives before entering the plant. The inspector may be accompanied and assisted by one or more specialists from the technical advisory unit involved in scrutinizing the safety report.

The inspection procedures are given in Annex 6.

Step 17: Establish siting policy

According to ILO Convention No. 174, the competent authorities must establish a comprehensive siting policy and arrange for appropriate separation of proposed new major hazard installations from working and residential areas and public facilities, and appropriate measures for existing installations. This is to be undertaken in close coordination and cooperation with all the bodies and authorities involved in land use and siting of industrial installations. The local government bodies play an important role in the siting and licensing of major hazard industries. The competent authorities must therefore issue guidelines to the local authorities based on the national siting policy.

New major hazard installations must be located at an adequate distance from populated areas. Installations too close to populated areas must be relocated, if possible. No settlements should be allowed to come up next to installations which for safety reasons were built at a distance from populated areas.

Step 18: Establish off-site emergency plan

The off-site emergency plan is a key element of the major hazard control system and follows logically from the analysis that provided the basis for the on-site emergency plan. The two plans should therefore complement each other.

The competent authorities must ensure that the off-site emergency plan and procedures for protecting the public and the environment outside the site of the major hazard installation are established, updated, and coordinated with all concerned. They should clarify by means of policy, regulation or legislation whether it is the employer's or the local authorities' responsibility to prepare the plan.

Where several major hazard installations are located close to each other, they may be covered by one plan. The plan will be prepared by the local authorities or in cooperation with the employer.

The plan must be based on the hazards identified by the management of the installation, as indicated in the documented system of major hazard control and described and assessed in the safety report. Where more than one hazard have been identified, the plan must take all of them into account. It must include the equipment immediately available, not those to be provided at a future date. It must be modified and updated whenever important aspects of the hazards and the capability of dealing with them change. It must be based on facts and realities and be certain to work when put into action.

All authorities and bodies to be counted on in the event of an accident, such as the fire brigade, ambulance, medical services, hospitals, and police, must be involved in preparing the plan, and its final version must be discussed with and communicated to them.

The plan must be easy to understand and clearly define the responsibilities and communication between all parties. It must indicate the organizations and persons concerned: names, addresses, telephone numbers. It must be made available to all who have a role in it.

The important organizational aspects the plan must cover are:

- the tasks and responsibilities of all concerned persons and services
- the ways a major accident can be detected, reported, and communicated to those who must act on it
- establishment of an emergency control centre
- communication and coordination among the public emergency services concerned

- communication and coordination between the company emergency services and the public emergency services
- procedure for warning the population
- procedure for gaining access to the accident site and keeping roads to the site clear of obstruction by spectators
- information to the public: who will respond to the press, radio, and television
- when and how to end the emergency.

Further information on emergency planning is available in the ILO code of practice.

Step 19: Establish monitoring system

The response to an emergency must be made immediately after the accident. This is possible if the accident - which often results from the accidental release of a large quantity of hazardous substance - is promptly detected and reported. If no automatic detection apparatus is in place, it may take a long time before an alarm is raised. Persons in the immediate vicinity of the release are likely to be incapacitated by it and unable to raise the alarm. Besides, no clear information on the location, nature, and extent of the release can be obtained by human observation.

To ensure prompt and adequate emergency response, employers should instal sensors for hazardous substances in the proximity of the places where releases might occur. Their readings should be transmitted to the emergency control centre from where a number of instruments can be monitored. There should be 24 hours' surveillance of the readings. The system should ensure that all persons involved in emergency procedures are immediately aware of the alarm.

The monitoring system should be installed as early as possible so that reference data can be established on the conditions that existed before the accident or before the installation became operational. Such data are necessary for the correct setting of alarms.

The monitoring system should be directed towards dealing with major accidents as well as environmental pollution. The competent authorities in charge of these activities should liaise closely with each other. Agreement must be reached on: what must be measured, where, how often, and with what accuracy; how data should be recorded and in what form they should be kept; who should take action on and have access to recorded data; who will fund the monitoring service and supply personnel.

As new industries are set up and experience and expertise grow with time, the monitoring service will need to be improved

and expanded: more sampling and sensing equipment would need to be added, more chemicals may require to be included in the sampling, and more information may need to be obtained on other industrial operations in the area. This will make it possible to detect, almost instantaneously, any abnormal release and trace it back to its source.

When setting up the monitoring system, it is advisable to monitor not only the release of pollutants and hazardous chemicals into the air, but also the discharge of chemicals into the effluent from the installations.

The telephone number of the emergency control centre may be made known to the public. Information on releases of hazardous substances or accidents should be reported to the centre.

Step 20: Report and investigate accidents

The employer must report a major accident to the competent authorities, investigate its causes, and make recommendations to prevent a recurrence.

The competent authorities will check whether the hazards that caused the accident were correctly identified and assessed in the safety report and whether the provisions to deal with them were inadequate or inactivated and, if so, why. To assess whether the action proposed by the employer will be sufficient to prevent a recurrence, the competent authorities will have to conduct their own independent investigation. The investigation will be carried out by the local inspector, assisted by one or more specialists from the technical advisory unit. They should build up and maintain their capability for investigating not only major accidents, but also the smaller ones which are likely to occur more frequently.

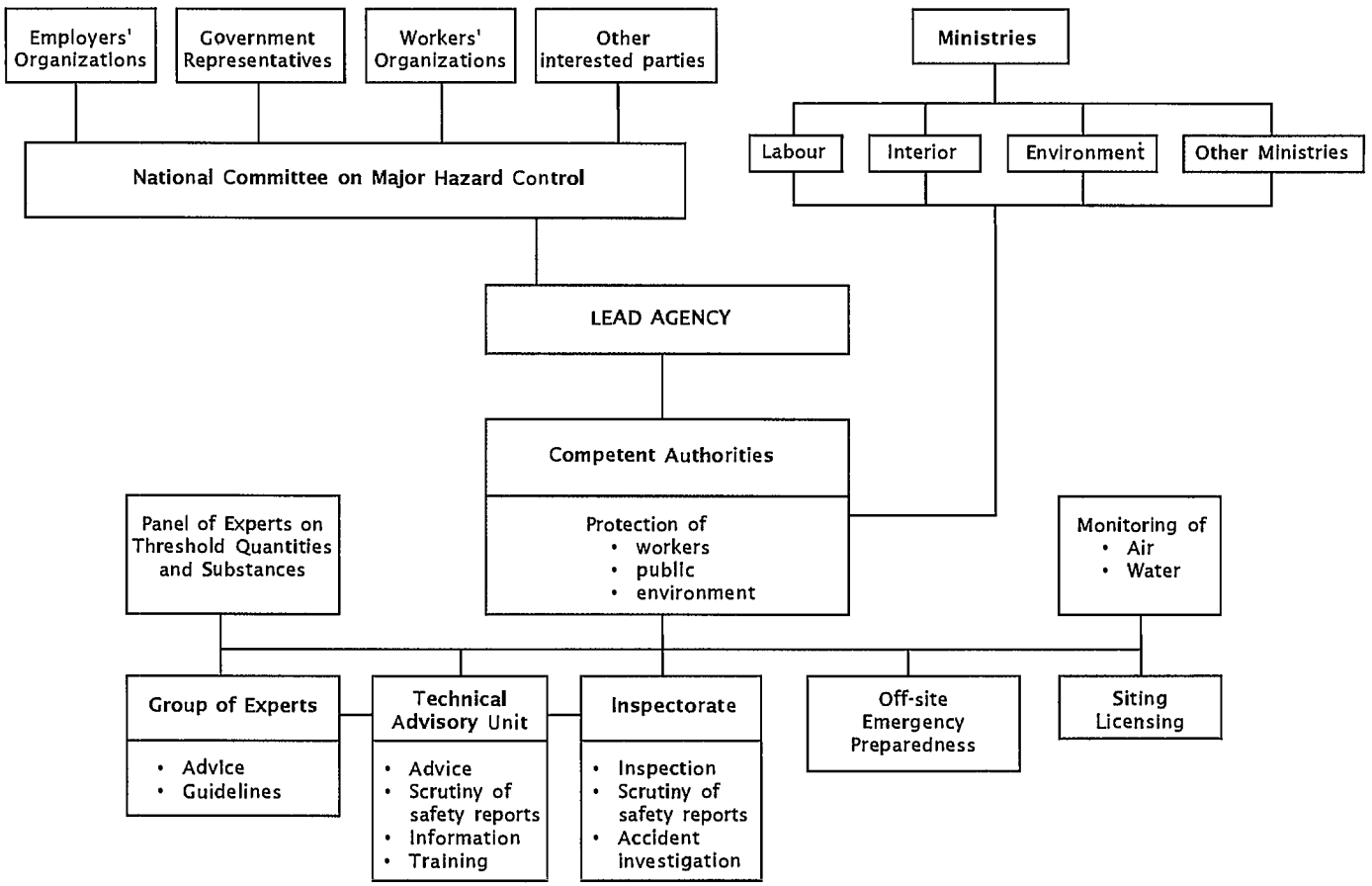
Criteria must be established for accidents that have to be reported by the employer to the competent authorities: what constitutes a major accident to be reported and investigated by the employer, what constitutes a "near miss" and should, as such, be analysed by the employer.

The competent authorities will set up a data bank of accidents in major hazard installations. This is usually undertaken by the technical advisory unit.

Annex 7 describes accident investigation and reporting.

Annex 1

Organization chart of Major hazard control system



Annex 2

Legislative provisions for major hazard control system

National legislation for a major hazard control system must provide for:

- a clear statement that the employer will ensure the safety of the plant, workers, people in the vicinity of the plant, and the environment
- designation of a competent authority or competent authorities to implement the system
- establishment of criteria for identification of major hazard installations by the competent authorities
- obligation of the employer to identify such installations and notify the competent authorities
- obligation of the employer to set up and maintain a documented system of major hazard control and prepare a safety report
- obligation of the employer to make available to the competent authorities all information required to assess the safety of the installations
- obligation of the employer to carry out the technical and organizational measures required by the competent authorities to ensure safety of the installations
- obligation of the employer to report to the competent authorities all major accidents and investigate their causes
- rights and duties of workers and their representatives
- powers of the competent authorities to inspect major hazard installations
- obligation of the competent authorities to ensure that on-site and off-site emergency plans for protection of workers, the public, and the environment outside the installations have been established and are kept up-to-date
- obligation of the competent authorities to establish a siting policy.

Annex 3

Hazardous substances

The threshold quantity of a hazardous substance depends on the nature of the hazards it causes and its physical, chemical, and toxicological properties.

□ *Nature of hazards*

Hazardous substances may present hazards of flammability, toxicity or explosivity.

A **flammable substance**, when ignited, will burn in ambient air, causing injury by radiation or transmission of heat, destruction of property by overheating, and ignition of other substances which, themselves, are not considered to be hazardous. Flammable substances in the form of vapour or mist mixed with air may form explosive clouds. Explosions of large vapour clouds may cause shock waves of great destructive power.

If a **toxic substance** enters the human body through the nose, mouth or skin, it may cause harm in different ways. Each toxic substance acts in its own specific way.

An **explosive substance**, when exposed to heat or shock, may explode without needing to come into contact with oxygen from the ambient air. The resultant shock waves can cause human injury, destruction of property, and further explosions.

□ *Physical properties*

Hazardous substances may be gases, liquids or solids.

Gases can spread easily and, if flammable, may mix with the surrounding air to become explosive. If heavier than ambient air, they form clouds that stay close to the ground; if lighter than ambient air, they lift off and disperse more rapidly. The most important physical property is their density relative to that of ambient air.

Liquids may evaporate and give off dangerous fumes. As long as a flammable or toxic substance is in liquid form it cannot explode or enter the human body by respiration. Non-vaporizing liquids are much less

dangerous than gases or liquefied gases. The important physical properties are atmospheric boiling point, viscosity, specific weight (lighter or heavier than water), and vapour pressure. Generally, substances stored as liquids, which become gases when released under atmospheric conditions (liquefied gases), can be very dangerous when they mix with ambient air to form large clouds. Substances stored in gas form are seldom present in very large quantities.

Solids can be inhaled or react violently only if they are in finely powdered form and mix with air to form a dust cloud borne by the wind. Substances in the form of solid blocks or gravel seldom cause major accidents. The relevant physical properties are the size and shape of particles and specific weight.

☐ *Chemical properties*

The most important chemical properties of hazardous substances are flammability and reactivity. Once ignited, all flammable substances present similar hazards. For a specific study and analysis of the properties, further data would be required on the flashpoint, ignition temperature, explosion limit, ignition energy, and heat of combustion. Such data are not required for determining threshold quantities. The reactivity should be taken into account to avoid contact with reactive substances, including the selection of fire-fighting agents.

☐ *Toxicological properties*

The toxicological properties of hazardous substances are difficult to quantify, determine, and take into account. Each toxic substance poses specific threats to the human body, but it is difficult to obtain accurate data on them. Data are usually ascertained from experiments on rats. The toxicological properties are characterized by the results of such experiments in the form of "LC 50 values" (Lethal Concentration 50 per cent). The LC 50 value of a gas is the concentration in mg/l which kills 50 per cent of a number of rats inhaling it for four hours.

☐ *Important hazardous substances*

The hazardous substances that have caused most of the major accidents are flammable substances (liquefied petroleum gas, liquefied natural gas, petroleum products) and toxic substances (chlorine, ammonia).

Liquefied petroleum gas (LPG) is a mixture consisting mainly of propane (C_3H_8) and butane (C_4H_{10}). It is stored and transported at ambient temperature in pressurized tanks ranging in size from 5 kg bottles for household use to spheres of up to 5,000 kilolitres at pressures between 8 and 17 bars, depending on the constitution of the mixture and temperature. When refrigerated, it can be kept at lower pressures. Large quantities may

be stored under atmospheric pressure in tanks cooled to temperatures below -40°C.

Liquefied natural gas consists mainly of methane (CH_4). It is stored under atmospheric pressure in very large refrigerated tanks (100,000 kilolitres or more) at temperatures below -160°C.

Petroleum products include crude oil, naphtha, petrol, aviation turbine fuel, diesel oil, and fuel oil. In refineries and petrochemical factories, very large quantities of different petroleum products may be present, mostly in cylindrical tanks under atmospheric pressure at ambient temperature. The larger tanks are usually floating-roof tanks.

Chlorine (Cl_2) is a toxic gas produced in large quantities by electrolysis of sodium chloride (common salt). It is used for bleaching and production of plastics. It is heavier than air. It is stored and transported in liquefied form in pressurized tanks at ambient temperature or refrigerated at -30°C under atmospheric pressure. It is most commonly transported in one-ton, cylindrical containers. Pressures are similar to those of LPG.

Ammonia (NH_3) is a toxic gas that can be ignited under certain circumstances. It is used in very large quantities in fertilizer production and in smaller quantities for refrigeration purposes. As a gas at ambient temperature, it is lighter than air, but when released at low temperature or cooled down by evaporation it may form toxic clouds that are heavier than the surrounding air and cling to the ground. It is stored and transported in liquefied form either under atmospheric pressure at temperatures around -40°C or under pressure at ambient temperature. Pressures are similar to those of LPG.

Annex 4

Documented system of major hazard control

An important obligation placed on employers by the ILO Prevention of Major Industrial Accidents Convention, 1993 (No. 174), is that they must establish and maintain a documented system of major hazard control for each major hazard installation. The documented system must contain information on:

- identification and analysis of hazards and assessment of risks
- technical measures to control identified hazards in respect of design, safety systems, construction, choice of chemicals, operations, maintenance, and systematic inspection
- organizational measures to control identified hazards in regard to training and instruction of personnel, personal protective equipment, staffing levels, hours of work, definition of responsibilities, and controls on outside contractors and temporary workers on the installation site
- emergency plans and procedures, including preparation of on-site emergency plan and procedures, with periodic testing, evaluation, and revision; provision of information on hazards and on on-site emergency plan to the authorities responsible for preparing the off-site emergency plan, and consultations with them
- measures to limit the consequences of major accidents
- consultations with workers and their representatives
- improvements in the major hazard control system (compiling and analysing information on accidents and "near misses", discussing the results of the analysis with workers and their representatives, recording relevant data and analyses).

☐ *Purpose*

The documented system requires that all important aspects of major hazard control, including the decision-making process, be recorded and documented. It consists of a large number of files containing

records of past decisions and the reasons and arguments for the decisions, which can be retrieved, when needed (for instance, when installation modifications are discussed or accidents are investigated). The purpose is to increase management's awareness of the hazards involved in the processes and operations and ensure better supervision by it. All documents on safety management must be readily available for future reference to enable the company to follow a consistent safety policy.

◆ *Awareness raising*

Managers have to verify all provisions in the plant before documenting them and making themselves responsible for their correctness. In the process, they become aware of the potential hazards in the plant processes and weaknesses and omissions in safety organization measures. This results in more attention being paid to safety by top management and better supervision of safety measures at all levels of the organization.

◆ *Supervision*

Both the management and the competent authorities must supervise the safety of the operations. In the absence of detailed legal requirements and regulations, inspectors would need to refer to the safety report and the documented system. They do not need to have detailed, specialized knowledge of all aspects of the operations. They should limit themselves to checking whether the actual conditions and provisions in the plant correspond with what is noted in the safety report and the documented system.

□ *Confidentiality*

Some of the information in the documented system may be of a confidential nature (details of process control, process conditions, work methods) which if disclosed to competitors might be detrimental to the company. Management cannot give this as a reason for refusing access to such essential information to the competent authorities. Inspectors of the competent authorities must have access to this information to enable them to check whether the employer has fully complied with the obligation to set up the documented system. However, they must be placed under oath not to divulge the information to third parties.

Annex 5

Safety report

The ILO Prevention of Major Industrial Accidents Convention, 1993 (No. 174), requires that employers of major hazard installations draw up safety reports based on the documented system of major hazard control (Annex 4). The safety report must remain in the installation as a reference document of the company.

The purpose of the safety report is to provide information on the hazards associated with the installation and the measures taken to control them. Workers and their representatives must have access to it. It may be used to inform other concerned parties, such as the fire and rescue authorities, police, local government authorities, medical services, environmental protection authorities, and the public living or working near the plant site. It can also be used to inform customers and suppliers or for public information purposes. It must be submitted or made available to the competent authorities.

In view of the purpose and wide distribution of the safety report, management may be reluctant to include confidential information in it. The competent authorities must therefore have access also to the documented system of major hazard control which includes all relevant safety information. If denied access to the documented system, the competent authorities would be unable to assess the adequacy of the major hazard control system and verify that the safety report is based on the requirements of that system.

□ *Contents*

The safety report should contain the following information:

- an introduction to the company's activities, particularly regarding the specific site and installation, including a statement on management's commitment to safety
- the reasons for identifying the plant as a major hazard installation
- descriptions of the installations and processes, hazardous substances and their characteristics, and safety organization

- hazard identification, analysis, and assessment
- provisions for controlling the hazards and the measures taken
- emergency plans.

□ *Management's commitment to safety*

The top management of the company must express clearly and publicly its commitment to the safety of workers, the plant, and the environment. This statement must guide decision making at all levels.

□ *Descriptions*

◆ *Installations, processes, and hazardous substances*

The safety report should describe the installations, processes, and hazardous substances in a clear and concise way so that technically trained inspectors without specialized knowledge can comprehend the processes and the potential hazards and methods of controlling them. Proper descriptions are also necessary for understanding hazard analysis and assessment and the adequacy of the measures taken to control the hazards. The safety report should not contain detailed technical information, such as process and instrumentation diagrams or reports of hazard and operability studies (HAZOP), which are incuded in the documented system of major hazard control.

Descriptions of the installations and processes may be written separately or combined. For batch processes, where a number of processes are carried out in the same installation, it is logical to describe the installation first and then the processes using hazardous substances. Where the installation is designed and built exclusively for one continuous process, the descriptions of the installation and processes should be combined.

◆ *Safety organization*

The description of safety organization must include allocation of duties and responsibilities, place of the safety officer in the safety organization, training and instruction of personnel, consultations with and information to workers, safety committee, workers' council, updating of operating instructions and manuals, maintenance of installations, inspection and testing, emergency plans, and accident reporting and investigation.

□ *Hazard identification, analysis, and assessment*

The safety report must mention the methods employed in identifying, analysing, and assessing hazards, and the control measures taken based on hazard assessment. Often, it describes the mea-

sures taken to ensure plant safety, but not the hazards that exist. Employers are inclined to state that no hazards remain as adequate control measures have been taken. The competent authorities need to know what the hazards are in order to verify the adequacy of control measures. The safety report must always indicate what could happen if the measures were not taken and everything went wrong.

Hazard assessment has been traditionally carried out based on the knowledge and experience gained with similar installations. The knowledge and experience are seldom recorded systematically, being obtained through trial and error and "sound engineering practice". These methods are no longer acceptable for major hazard installations.

◆ *Existing major hazard installation*

When the major hazard installation was built, hazard assessments by the employers should have been included in the safety report. If there are no records of hazard assessments, management must carry out its own assessments based on its present knowledge and operating experience.

Where records of hazard assessments exist, they may be referred to in respect of operating experience: number of operating hours; criteria for events (personal injury, man-hours lost, property damage); description of accidents, their causes, and consequences; and measures taken to prevent a recurrence of the events.

Where the competent authorities find the hazard assessments insufficient to ensure safe operations, they may require new assessments to be made on the installation units (parts of the installation) considered to be most dangerous. Generally, the hazard and operability study (HAZOP) is the most suitable type of analysis as it gives insights into the nature, magnitude and causes of potential hazards and the measures necessary for their prevention or reduction.

◆ *New major hazard installation*

For a new major hazard installation, more detailed and systematic studies are required since no operating experience is available. Any one of a number of procedures and methods may be used, provided it leads to a clear understanding of the nature and magnitude of the hazards, and the measures by which they can be controlled and the remaining risks rendered acceptable. Some of the more commonly used methods are given here:

Index systems, such as the Dow Fire and Explosion Index and the Mond Index, indicate the magnitude of the risks caused by different installation units. Taking into consideration the properties of the hazardous substances, the quantities of the substances that might cause an accident, and the operating conditions, the installation units

can be classified into groups according to the increasing magnitude of the hazard. Preventive measures can then be directed towards the installation units presenting the greatest hazards.

Fault tree analysis can be used when it is known that one specific, unwanted occurrence - called top event - is the all-important risk and all other hazards can be disregarded. Going back in time from the top event, an analysis is made of all the conditions that can lead to the event. For each condition, the probability of occurrence is calculated or assumed. From this the probability of the top event can be calculated. Besides the top event probability, the analysis results also show which conditions contribute most to the risk. By taking measures to reduce the probabilities associated with these conditions, the total risk may be reduced to an acceptable level.

Event tree analysis is the opposite of fault tree analysis. Starting from one specific fault or failure - the initial event - and going forward in time, an analysis is made of the effects and consequences of the event under all conceivable conditions. Assigning probabilities to all conditions enables calculation of the probabilities of all possible final events. The final events may range from those having no influence on the plant processes to those leading to a major accident. Event tree analysis can be used to design measures for reducing the probabilities of an initial event or subsequent sequential events leading to a major accident.

The **hazard and operability study** (HAZOP) is a systematic and detailed study of an installation by a group of experts. Each element of the installation is scrutinized and all possible malfunctions of the elements and their causes and consequences are analysed using guide words. The study results in a report recommending specific improvements in the safety of the installation. It may be carried out for large or small installation units. It is usually conducted at the early stages of design of the installation and repeated during construction, after start-up of the plant, and at regular intervals during its operation. Details of HAZOP studies are given in the ILO publication, *Major hazard control: A practical manual.*

□ *Hazard control measures*

The adequacy and appropriateness of control measures can be assessed in relation to the hazards. The description of the hazards should therefore precede the description of the control measures.

Major hazards should be controlled through organizational and technical measures. As safety problems are often of an organizational nature, organizational measures must take priority. They include introduction of a work permit system, drills and exercises, instruction and training of operating personnel, inspection and maintenance procedures, recording and reporting procedures, and consultations with workers. Technical measures include detection and alarm systems, physical separation of instal-

lation units that might interact dangerously with each other, and automatic shutdown system, flare system, scrubber system, and fire-fighting system.

□ *Emergency plans*

Emergency plans should be established to deal with the consequences of major accidents. It is often impossible to assess the magnitude of an accident at the moment it occurs. Besides, the emergency organization services for a major accident are also part of the normal plant organization services required to respond to smaller accidents.

◆ *Incidents*

A chemical factory is operated according to standards prescribed in detail in its operating manuals. Any situation deviating from the standards is called an incident.

Small incidents like the malfunctioning of instruments, simple failure of apparatus, variations in process conditions beyond operational limits, errors or omissions of operators, and non-compliance with product standards can be corrected by operating staff. Such incidents should be recorded in the log book of the watch and investigated by the supervisor as part of normal operations.

For large incidents like machinery breakdowns, leaks and spillages, and accidental slips or falls of operators, the assistance of regular works services such as maintenance personnel or first-aid staff is required. These incidents may cause physical injury, property damage, and loss of working time and production. They must be registered more formally and investigated thoroughly.

◆ *Works emergency services*

If the incident goes beyond the capacity of the regular production and maintenance services, the works emergency services (fire brigade, ambulance) are called in to assist. The operating manuals and general instructions indicate how these services can be called in. The works emergency services have their own instructions on how to proceed and whom to contact.

◆ *On-site emergency plan*

The works emergency services should be able to deal with all local incidents, even quite serious ones. Standard operating procedures are no longer valid for major incidents such as large releases of hazardous substances, explosions or large fires, or if an incident started locally escalates. An on-site emergency plan must be prepared to deal with such situations. It will be activated when normal production routines are interrupted to such an extent that decisions beyond the scope of operating

manuals must be taken. The normal plant organization then ceases to function and an emergency organization comes into action.

The emergency organization and its workings are described in the emergency plan. It should contain procedures for evacuating workers, including a system of accounting for them outside the endangered area, method of requesting outside assistance (medical, rescue, fire or environmental protection specialists), the role of selected plant officials and workers during an emergency, and the location, use, and maintenance of all emergency equipment.

Annex 6

Inspection

A major hazard installation is generally a very complex installation where precisely controlled processes are carried out according to specific standards and procedures established by the management or designer of the installation and processes, which are recorded in operating manuals and company standards. These standards are usually not mentioned in national legislation or regulations. In the case of conventional industrial operations, the competent authorities usually provide precise guidelines and regulations on basic occupational safety and health standards.

Major hazard installations are built to different standards - often foreign standards. Technological developments require modifications in installations and processes and in safety requirements, as a result of which operating manuals have to be constantly updated. It is impossible for inspectors of the competent authorities to be conversant with all these standards, judge which one to apply to which part of the installation, and verify whether they have been complied with. Inspectors can only check whether the major hazard installation is built, operated, and maintained in accordance with the design specifications and operating manuals, as well as to general industry safety standards.

□ *Preparations for inspection*

The inspector must study all available information on the installation before the actual inspection visit. The safety report in which the management has laid down the standards to which the plant is built and operated is an essential part of such information. Additional information may be obtained from the operating licence, documented system of major hazard control, and preliminary discussions with the management.

Reference can also be made to previous inspection records, company correspondence on safety matters, and records of accidents and measures taken as a consequence.

The first important aspect to check is the extent of management's commitment to safety. Is there a written safety policy state-

ment by top management and has it been made known to all employees? The inspector will check conditions in the installation against the policy statement.

The inspector also needs to ascertain information on technical and organizational aspects: nature, quantities, and hazard potential of the substances used; storage capacities of hazardous substances and conditions under which they are kept; processes carried out, instrumentation, and safety provisions; emergency control systems (fire detection, alarm and extinguishing system, flare system, pressure relief system, vent scrubber system, containment system); personal protective measures; organization of safety department and emergency response.

□ *Inspection*

As a rule, the inspector will inform the management of the plant in advance of a planned inspection visit. On arrival at the installation, the inspector may collect further information from the management, safety officer and workers' representatives. The inspector should take the initiative in deciding which parts of the installation will be visited and in what order. Whenever the inspector finds it necessary to alter the itinerary, changes must be made.

During the visit, the inspector will be accompanied by a company employee, usually the safety officer, who will explain the safety regulations. A representative of the workers' organization may also accompany the inspector. The inspector must comply with safety regulations, such as wearing a safety helmet, shoes, and other protective clothing. If access to parts of the operation is denied for safety reasons, the inspector must make sure that unsafe operations are not being carried out there.

On the first visit, the inspector will concentrate on the essential parts of the installation and the parts where major accidents are most likely to occur: control room, storage area, loading installation, fire station, emission prevention systems.

Housekeeping is an indicator of management's commitment to safety. The inspector will make a quick round of the central production area to check on housekeeping. A disorderly and poorly maintained installation can never be safe. The inspector will also inspect outlying parts of the plant site which the management and safety officers are apt to visit infrequently, particularly storage areas of hazardous substances and emission prevention systems.

The inspector will check whether the safety measures mentioned in the safety report are available and operational: safety relief devices, personal protective apparatus, fire-fighting system, emergency exits, showers, alarm systems for excessive temperature, pressure, and gas concentration. The inspector will check whether the installation is on automatic control (as it should be) or

has reverted to manual control, whether any safety measures have been bypassed or discontinued, and whether all instruments are functioning. Apparatus or instruments that are fitted must function. Supervisors may explain that instruments not in use are no longer necessary or that they are spare instruments. The inspector should not accept such explanations. If for any reason an instrument becomes superfluous, it should be removed immediately, not left unused. If the safety report mentions that a spare instrument is provided, the instrument must be in working order and functioning: it is part of the hazard assessment on which plant safety is based. If one non-functioning instrument is acceptable, there is no reason why other defective ones will not be, and operating standards can deteriorate until the stage is set for a major accident.

□ *Reporting*

At the end of the visit, the inspector will provide a summary of findings to company representatives. The inspector's recommendations will be confirmed later in writing. The inspection report will be written soon after the inspection visit. Any shortcomings will be notified to the company for remedial action. Corrective action must be directed towards the basic causes of shortcomings.

If just a few items in the installation are found to be not functioning properly, the safety officer or department supervisor should be informed. The safety officer or department supervisor will not only ensure that the deficiencies are rectified, but also check similar apparatus which were not inspected in order to take remedial measures. However, if several deficiencies are noticed, it would appear that the safety officer or the department supervisor is not serious about plant safety. The inspector's report should then be addressed directly to the management for action. But should the general standards of housekeeping and safety show that the management itself is not sufficiently committed to safety, the inspector will report this to a superior so that the Chief Inspector or the Director-General of Inspection can take up the matter with top management.

Annex 7

Accident investigation by competent authorities

An accident in a major hazard installation must be reported by the employer to the competent authorities. Usually the report is made to a local office, initially by telephone, and confirmed later in writing. The competent authorities will organize investigation of the accident, if necessary.

☐ *Purpose*

Major accidents are recorded and investigated by the competent authorities in order to ascertain whether adequate measures have been taken by the employer to prevent a recurrence. The team of investigators include inspectors and specialists. Other governmental authorities may wish to know the causes of accidents in order to prosecute those guilty of causing it or determine the liability for compensation. Sometimes the competent authorities may be required to transmit the outcome of their investigations to these authorities.

☐ *Causes of accidents*

Few accidents are attributed to a single cause. Modern installations and processes are designed and built so that no single failure or operating error can cause an accident. The investigation must establish all the causes of the accident and its consequences.

The direct errors, mistakes, faults or failures that caused the accident may themselves have been caused or made possible by unsafe operating methods, situations or conditions that existed long before the accident. Similar accidents can be prevented by exposing these underlying faults in the organization and operation of the plant. To do so a distinction should be made between token faults (the directly manifest, specific causes of the accident) and type faults (the underlying, latent causes of the accident that may have been present long before it occurred, usually related to organizational factors). The investigation should go beyond the token faults and establish any type faults. By eliminating type faults, it is possible to prevent similar accidents in future.

☐ *Method of investigation*

For effective preventive measures to be taken, the investigators must

establish the following:

- facts: what happened, when, where, in what sequence, and what actually the persons concerned did
- circumstances: weather, lighting, temperature, noise, dust
- conditions: operating pressures, organizational arrangements, maintenance, housekeeping.

The investigators should introduce themselves to the management, clarify their mandate, intentions, and method of working, and advise whom they wish to meet and the purpose of their report. They should find out whether other investigations are also being conducted. If possible, arrangements should be made for cooperation among all parties involved in the investigation. If a common report can be prepared with the consensus of all investigators, it will be much more valuable than several separate, possibly contradictory ones.

The investigators should reach the accident scene as quickly as possible and record all relevant facts and circumstances observed (position of equipment, materials, persons, physical objects; extent of damage; tracks, marks or other traces left by moving parts).

The investigators should make sketches and tables of dimensions and distances of the accident site, to be later worked out as technical drawings. They should note in the technical drawings all the safety measures needed. If possible, they should take photographs from all angles and ensure that the photographs show objects of known dimensions. Samples should be taken of the substances involved in the accident and evidence that may disappear should be impounded.

The investigators should interview the victims, eye witnesses, those who may have noticed something specific during the accident, and those who may have knowledge about the circumstances, operations, conditions, work methods or other relevant aspects. Six key questions should be asked: who, what, where, when, how, why. The investigators should try to put the interviewees at ease. The interviewees should be explained the purpose of the investigation and, if possible, reassured that their testimony will not be used against them or their colleagues. They should not be interrupted or influenced in their thinking. They should be allowed to express their feelings and ask for clarifications and further details. The investigators should make notes of the discussions. A tape recorder can be used, but never without their agreement. The tape recording cannot replace handwritten notes.

□ *Analysis of data*

All data on the investigation should be analysed soon after collection. To begin with, they should be put in chronological order and related to each other. If

necessary, additional information should be gathered to establish the sequence of events that led to the accident. On the basis of the chronological framework, one or more theories about the sequence of events should be formulated. Each sequence and hypothesis must be checked carefully against all evidence for contradictions or support. There may be several sequences of events, but not enough evidence to prove beyond doubt the actual cause of the accident. If the investigation reveals more than one cause, measures must be taken to prevent each one of them.

□ *Accident report*

The report must contain:

- a short description of what happened (not the investigation or the conclusions drawn from it)
- a chronological account of the events leading up to the accident (not details of the investigation)
- a structured account of the investigation, collection of facts, and conclusions
- relevant facts and analyses
- a short, clear summary of the conclusions and recommendations
- sketches, charts, and diagrams to support and clarify the report
- supporting material (such as accident report forms) which clarify or illustrate important aspects of the accident (as annexes).

The report should be concise, well-written, and clear as it will provide the basis for future preventive measures.