Chemical Safety in the Workplace

Guidance Notes on Risk Assessment

and

Fundamentals of Establishing Safety Measures

Occupational Safety and Health Branch
Labour Department

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This guidance notes is prepared by the
Occupational Safety and Health Branch
Labour Department

First edition September 2001

Contents

1 Introduction

1.1 Chemicals are frequently used in workplaces. Quite a number of them are by nature hazardous. Some are hazardous when heated, ground, mixed with other chemicals or exposed to air. If employees do not have adequate knowledge of the hazards and risks involved in the use of chemicals, or in the absence of appropriate safety measures, accidents may occur.

1.2 Under the Occupational Safety and Health Ordinance, the employer of a workplace is required to make necessary arrangements to ensure the safety and health of employees in the use, handling, storage and transport of chemicals. In order to make such arrangements, the employer has to evaluate the work related hazards or potential hazards and develop safety procedures and risk control measures. In other words, the employer needs to identify the hazards and assess the risks involved in undertaking the work, generally known as risk assessment. Based on the results of risk assessment, appropriate safety procedures and safety measures should then be established, implemented and maintained.

1.3 This guidance notes explains the approach in assessing the risks associated with the use of chemicals and the underlying principles in establishing safety measures. It is intended to provide employers, management personnel, professionals, safety personnel and supervising staff with practical guidance for performing risk assessment and establishing safety measures for ensuring the safety and health of employees at work with chemicals. This guidance notes is applicable to workplaces where work involves the handling, use or production of chemicals.

2 Overview of Risk Assessment

Hazards and risks associated with chemical operation

2.1 In chemical safety, the term "hazard" refers to the inherent hazardous properties of a chemical or a chemical operation, while "risk" means the likelihood of the hazardous properties of a chemical or the hazards of a chemical operation causing harm to people and the severity of that harm.

2.2 In this guidance notes, chemical operation refers to any work conducted in a workplace during which chemicals are used, handled or undergoing chemical or physical changes. This embraces a large variety of operations ranging from sophisticated chemical industrial process to preparing a bleaching solution for cleaning purpose, and includes routine maintenance, testing, examination and repair of plant and equipment used in a chemical operation.

2.3 Chemical change involves chemical reactions such as decomposition, combination, neutralisation, oxidation and reduction, etc. This results in transformation of the starting materials (known as reactants) to other substances with different chemical structures and properties (known as products). In physical change, physical forms of the materials change to other forms by operations such as heating, grinding, ultrasonic vibration, dissolution, dilution, etc. Physical forms include gas, vapour, fumes, aerosol, liquid, airborne particulate, dust, powder and solid.

Basic steps in risk assessment

2.4 Risk assessment in chemical safety is an evaluation process to assess the likelihood of the chemical or chemical operation causing harm to people and the severity of that harm. The process provides the necessary information for establishing the appropriate safety measures and procedures.

2.5 In general, risk assessment in chemical safety consists of the following steps:

(a) identifying the chemical hazards;

(b) considering who may be affected, and how;

(c) evaluating the risks arising from the hazards, and considering whether existing safety measures are adequate or more should be done;

(d) recording the findings unless it is easily explicable; and

(e) reviewing the assessment from time to time and revising it if necessary.

Control measures

2.6 *Safety measures*

Based on the results of the risk assessment, the employer should establish, implement and maintain appropriate safety measures to eliminate or reduce the hazards associated with a chemical or chemical operation in ensuring safety and health of the employees. The underlying principles in establishing appropriate safety measures are discussed in the latter part of this guidance notes.

2.7 *Monitoring*

Monitoring provides a means in ensuring that the safety measures taken are adequate in protecting the employees from injuries or ill health. In monitoring, the concentration of the contaminant in the atmosphere is measured and compared with acceptable standards or criteria which are related to the respective lower explosion limit or occupational exposure limit of the chemical concerned, whichever is applicable.

2.8 *Health surveillance*

For those employees who are exposed to certain hazardous chemicals at high levels, regular health surveillance, where applicable to the chemicals in question, can detect early adverse health effects thereby preventing further harm to the employees. Health surveillance includes pre-employment and periodic medical examinations, as well as medical examinations upon resumption of work after prolonged absence because of health reasons, and upon termination of work involving hazardous chemical exposures.

2.9 *Emergency preparedness*

Emergency preparedness is vital, as quick and correct response is necessary in case of emergencies, such as fire, explosion, chemical spillage and leakage to reduce injuries, ill health and other damages. This includes the establishment of emergency response plans, provision and maintenance of emergency equipment as well as regular drills.

2.10 *Information, instruction, training and supervision*

Appropriate hazard and safety information about the chemicals or the chemical operations should be provided to the employees. Instructions regarding safe practices, safe work procedures, emergency procedures should also be given. Training helps employees acquire the necessary attitude, knowledge and skills to work safely and healthily, while supervision helps to ensure that the safety requirements are complied with.

Review of risk assessment

2.11 The risk assessment should be reviewed regularly and whenever there is any indication to suspect that it is no longer valid or where there has been a significant change in the operation to which the assessment relates.

2.12 The assessment may be suspected to be no longer valid as revealed by, for example:

(a) the results of regular performance check of equipment;

(b) the results of monitoring of atmospheric contaminants;

(c) the results of health surveillance; and

(d) new information on relevant health risks.

2.13 Significant changes in the chemical operation include:

(a) change in the chemicals used, including the physical forms and source of the chemicals;

(b) plant modification, including the equipment used in safety measures;

(c) change in work method or procedures; and

(d) change in scale of the operation.

3 Identifying Chemical Hazards

Chemical hazards and the consequences

3.1 Quite a number of the chemicals used in workplaces are hazardous by nature. The hazards may be classified into two categories namely physico-chemical hazards and health hazards. Physico-chemical hazards are those arising from the explosive, flammable or oxidising properties of the chemicals, while health hazards are those arising from the toxic, corrosive, harmful, irritative, carcinogenic or mutagenic effects.

3.2 Some chemicals may not be hazardous by nature. However when they undergo physical or chemical changes during grinding, mixing, heating, dissolution, dilution and other chemical reactions, the processes or the products/by-products may be hazardous. The hazards arise mainly from the formation of hazardous chemicals, evolution of large amount of heat or gaseous products.

3.3 For hazardous chemicals, there are three major routes of entry into the human body:

(a) *Inhalation*
Chemicals that can be inhaled are normally in the form of gas, vapour, fumes, aerosol, airborne particle or dust.

(b) *Skin absorption*
Chemicals can be absorbed through the skin directly or indirectly via the contaminated media such as clothing.

(c) *Ingestion*
Chemicals can be swallowed directly or indirectly via the contaminated media such as fingers.

3.4 In the absence of effective safety measures, the hazards may result in chemical accidents and the consequences may be:

(a) causing fire or explosion;

(b) releasing toxic/harmful gases, vapours, fumes, aerosols, airborne particles;

(c) splashing of hot, corrosive or toxic liquids;

(d) resulting in injuries, ulceration, intoxication or even deaths; or

(e) causing acute or chronic illness or even affecting the health of the next generation.

Hazard identification in chemical safety

3.5 Hazard identification is the initial step in risk assessment. The objective is to identify hazardous chemicals and chemical operations in the workplace. In achieving this objective, the good practice is to:

(a) list out the chemical operations , and prepare a work procedure about each operation; and

(b) list out the chemicals used, or those produced or likely to be produced during the chemical operations.

3.6 Based on the hazard information about the chemicals (refer to paragraphs 3.8 to 3.11) on the list mentioned in paragraph 3.5(b), the hazardous chemicals in the workplace can be identified.

3.7 By going through the work procedures mentioned in paragraph 3.5(a) step by step, the hazards during a chemical operation can be identified. The hazards may be due to:

(a) formation of hazardous chemicals, either as products or by-products;

(b) generation of large amount of heat or gaseous products; or

(c) the physical form of the products or by-products, such as gas, vapour, fumes, aerosol, dust or airborne particulate, that

(i) facilitates entering into the body through inhalation or through skin absorption; or

(ii) results in formation of explosive or flammable mixtures in the air.

Sources of hazard and safety information

3.8 General hazard and safety information about a chemical can be found in the label on the outside of the chemical container. More comprehensive hazard and safety information can be found in the material safety data sheet (MSDS) obtainable from the chemical supplier.

3.9 Hazard and safety information that can be obtained from the label on the chemical container includes:

(a) identity of the chemical — chemical name or common name;

(b) hazard classification and hazard symbol;

(c) particular risks of the chemical; and

(d) safety precautions required of the chemical.

3.10 Hazard and safety information that can be obtained from material safety data sheet includes:

(a) identity and composition of the chemical;

(b) hazard classification;

(c) physical and chemical characteristics;

(d) physico-chemical hazards, including fire-fighting;

(e) stability and reactivity, including combustion products, incompatibles;

(f) health hazards, including primary route of entry, signs and symptoms of exposure, occupational exposure limits, toxicity, monitoring methods;

(g) safety measures, including engineering control, personal protective equipment;

(h) emergency and first aid procedures; and

(i) spill control and disposal.

3.11 Other sources of hazard and safety information on chemicals or chemical operations include chemical safety databanks, chemistry journals, periodicals and handbooks on chemical safety and occupational hygiene.

4 Assessing the Risks of a Chemical Operation

Risk assessment

4.1 Having identified the hazards of the chemicals involved as well as the hazards during a chemical operation, risk assessment is performed for establishing appropriate safety measures and emergency preparedness to ensure safety and health at work. The scale and depth of a risk assessment depend on the hazards of the chemicals and the chemical operation as well as the complexity of the operation.

4.2 Risk assessment should be conducted by a person with the knowledge, experience and training to enable him to assess the risks correctly. That person should have a thorough understanding of the nature of the chemicals and the operation being assessed as well as a good knowledge of the safe practices and precautions required. He should also know when he needs to seek specialist expert advice.

4.3 Information sources mentioned in paragraphs 3.8 to 3.11 will provide useful information in assessing the risks associated with a chemical operation. However, the risks also depend on how the chemical operation is carried out as well as the working environment. Factors listed in paragraphs 4.4 to 4.9 should be carefully considered in evaluating the likelihood of a hazard causing harm to the employees. Some typical questions used in risk assessment of a chemical operation are listed in Appendix I for reference.

Considerations in risk assessment of a chemical operation

4.4 *Physical form of the chemicals*

The physical form of a chemical has a pronounced effect on the extent of the hazards affecting the safety and health of employees. Gases, vapours, fumes, aerosols, dust particles and powders increase the risk of the chemical entering the human body through inhalation and through skin absorption as well as the risks of fire and explosion. It should be noted that aerosol, particulate and powder forms of combustible materials can form explosive/flammable mixture with an oxidizing agent or even with air.

4.5 *Chemical changes*

If a chemical change is involved, the chemical reaction and the products should be investigated. The hazards associated with the chemical reaction as well as hazardous properties of the chemicals involved should be identified. Special attention should be paid to possible side reactions and by-products.

4.6 *Temperature and pressure changes*

Many physical and chemical changes evolve heat, with a rise in temperature. The results may be:

(a) formation of hazardous gases, vapours or fumes;

(b) pressure increase in the container causing explosion;

(c) rapid bubbling causing splashing of hot hazardous fluids; or

(d) increase in reaction rate generating more heat.

These effects are intensified when there is no effective means to dissipate the heat evolved which results in localised heating and superheating in part of the reaction mixture. Moreover, some reactions that evolve heat may only be initiated by raising the temperature, usually by heating. However once initiated, the reaction may auto-accelerate and the reaction rate may become too fast to be under control.

4.7 *Scale of the operation*

Scale of the operation determines the amount of hazardous chemicals involved. In addition, change in scale affects the heating effect of the operation as well as heat dissipation and pressure change in the system.

4.8 *Extent of exposure*

The extent of exposure of employees to the hazardous chemicals is affected by:

(a) frequency and duration of exposure;

(b) rate of generation and concentration of the hazardous chemicals in the atmosphere; and

(c) effectiveness of control and protective measures in minimizing the exposure.

4.9 *Working environment*

The working environment affects the accumulation of hazardous chemicals in the atmosphere as well as the temperature and pressure in the container where the physical or chemical changes take place. If the container cannot withstand the increase in pressure, explosion occurs. Factors to be considered include:

(a) size and shape of the container, especially the headspace in the container and passage for release of pressure;

(b) ventilation of the environment; and

(c) any nearby ignition source, if explosive/flammable mixtures are present.

Special consideration should also be paid to those chemical operations that are sensitive to air, moisture or light.

5 Selecting the Appropriate Safety Measures

Overall strategy

5.1 The objective of safety measures is to eliminate, contain or minimise the risks encountered during a chemical operation in protecting the employees from injury or ill health. The initial step in establishing safety measures is to select the appropriate ones. The primary consideration in the selection is to control the hazards at source and use protective measures only as supplementary means to protect the employees against the hazards.

5.2 The employer should in the first place consider whether those hazardous chemicals and hazardous chemical operations can be eliminated or substituted with less hazardous alternatives. Appropriate control measures should then be considered to effectively control the hazards at source. Regarding control measures, engineering control contains or minimises the hazards, while administrative control helps reducing exposure of individual employee to the hazardous chemicals through arrangement such as rotating shifts, scheduling breaks, etc.

5.3 Protective measures using personal protective equipment protect the employees against the hazards of chemical operation. However, use of personal protective equipment should be a supplement to, and not in lieu of, effective control measures and the equipment selected should be appropriate for the required protection.

Substitution by less hazardous chemicals or operations

5.4 If risk assessment reveals that a chemical or an operation poses risks to the safety and health of employees, the employer should in the first place consider avoiding the use of the chemical or operation. In case this is not reasonably practicable, substituting by less hazardous chemical or operation should be considered.

5.5 The decision for choosing appropriate substitute may not be easy and sometimes it may not be practicable. Nevertheless, in exploring and considering the use of a substitute, it is necessary to compare different alternatives on the basis of the nature of the hazards, i.e. whether they are physico-chemical hazards or health hazards, and consider the risks accordingly.

5.6 In many cases the alternative which removes or lowers a risk may introduce other new risks. In that case, it is necessary to consider which is easier to control. For example, one may need to compare the risks from a toxic chemical with those from a flammable chemical. If the chemical operation takes place in a confined space where presence of ignition source cannot be avoided, there is a risk of starting a fire in a place that is difficult to escape from. It appears that it is more sensible to use a chemical that is not likely to catch fire and to control the risks arising from the toxic chemical by some other means.

5.7 After assessing the risks of all possible alternatives, the employer should be able to decide whether to adopt any of these alternatives as substitute, and how and when the substitute should be introduced. The employer may find it useful to consult his employees in this respect. Nevertheless, the substitute should only be introduced after:

(a) it has been tested, and the plant and equipment have been modified as required; and

(b) the employees are well informed, instructed and trained of the new risks and the corresponding safety measures.

Engineering control measures

5.8 With a view to eliminating or reducing the hazards at source, control measures adopted should be able to prevent accumulation of explosive/flammable mixtures in the atmosphere, to remove hazardous chemicals from affecting the employees or to reduce the hazards of the chemical operation. Engineering control measures include:

(a) workplace ventilation;

(b) temperature control;

(c) stirring facilities;

(d) liquid delivery devices;

(e) appropriate container for the operation;

(f) automation; and

(g) separation of work area.

5.9 *Workplace ventilation*

The primary objective of workplace ventilation is provision of a safe and healthy working environment for the employees, such as to replace stale air and to control airborne contaminants. Major methods of ventilation include:

(a) *General dilution ventilation*

Uncontaminated air is introduced into the work area, either naturally or by mechanical means, and is mixed thoroughly with the impurities in the air before vented out of the workplace. This method is only suitable for replenishing stale air and should be used in conjunction with other effective means of ventilation in order to remove airborne contaminants emitted from chemical operations.

(b) *Local exhaust*

Vapours and particulates are captured and removed by forced air current through a hood near the point of emission before the contaminants disperse into the workplace. This method is generally applied to equipment that cannot be readily enclosed. Typical examples are cooker hoods, canopy hoods over ovens or high temperature furnaces.

(c) *Extraction with partial enclosure*

In this method, the emission source is confined in a partial enclosure in which airflow is created by an extract fan. The airborne contaminants from the emission source are then directed away from the operator, through the extract duct to point of discharge outside the workplace. A typical example is the fume cupboard commonly used in laboratories.

(d) *Total enclosure (glove box)*

Total enclosure provides a high-integrity containment to confine the emission source. It takes the form of a virtually leak-tight box with a viewing window and the work is carried out through gloves fitted to the walls of the enclosure. Glove box should be used for handling very hazardous chemicals as well as for those chemicals or operations that are sensitive to air or moisture.

5.10 *Temperature control*

Some reactions that evolve heat need initial heating (i.e. raising the temperature) to initiate, but once started the reaction may auto-accelerate. Temperature of the reaction mixture should be controlled in order to avoid the reaction going too violently. This lowers the risks of over-pressurization, emitting hazardous vapours and hot hazardous fluids splashing from the container. Means of temperature control ranges from sophisticated automated control devices to simple cooling by water or ice.

5.11 *Stirring facilities*

During the course of a reaction that evolves heat, localized heating and even superheating may occur in part of the reaction mixture. The reaction mixture should be constantly stirred to dissipate the heat throughout the mixture. This lowers the risks of over-pressurization, emitting hazardous vapours and hot hazardous fluids splashing from the container.

5.12 *Liquid delivery device*

Pouring liquid chemicals from one container to another activates vapourisation and aerosol formation. The hazardous chemicals may easily enter the body through inhalation and skin contact. The clothing may be contaminated with the hazardous chemicals. Not only with flammable chemicals, but also with combustible ones, explosion/fire may occur in the presence of an ignition source. Moreover, sucking chemicals by mouth is extremely hazardous and should be prohibited. Appropriate liquid delivery device such as hand pumps should be used in transferring liquid chemicals.

5.13 *Appropriate container for the operation*

If the operation involves heating, or emission of heat or gases/vapours, appropriate container that can withstand the increase in pressure should be used. Factors to be considered in selecting the appropriate container include:

(a) the rate of emitting heat and gases/vapours;

(b) volume of the headspace above the reaction mixture in the container;

(c) passage for release of pressure; and

(d) mechanical strength of the container.

5.14 *Automation*

Automating the operation puts the physical or chemical changes involved in the operation under control. In addition, automation also obviates employees' exposure to hazardous chemicals. Hazardous chemical operations should be automated as far as reasonably practicable.

5.15 *Separation of work area*

The workplace should be divided into various work areas. Hazardous chemical operations should be conducted in the work area where appropriate engineering control measures and safety equipment are available, while incompatible operations are conducted in separate work areas.

Personal protective equipment (PPE)

5.16 The primary objective of using PPE is to protect the employees against the entry of hazardous chemicals into the body through inhalation or through skin contact. It is supplementary to engineering control measures. PPE should be selected appropriate to the hazardous nature of the chemical operation, and should be properly used and maintained. Inappropriate PPE, or PPE improperly used or maintained may do more harm than good. The user may have a false sense of security that may put him at a higher risk of injury or ill health than if no PPE is used.

5.17 Major considerations in selecting the appropriate PPE are the hazards of the operation, physical nature of the chemicals and the routes of entry into the body. Work procedures of the chemical operation should also be considered.

5.18 *Protective clothing*

Protective clothing protects the body or personal clothing from contact with hazardous chemicals and prevents the spread of contamination. It may be in the form of gowns, aprons and overalls made of appropriate materials that are not corroded or damaged by the chemicals involved in the operation. Protective clothing should be inspected for signs of damage before wearing and taken off upon exiting the work area. Contaminated clothing should be properly treated or disposed of as appropriate.

5.19 *Hand and foot protection*

Gloves provide protection to the hands while boots protect the feet from contacting hazardous chemicals and prevent the spread of contamination. Gloves and boots made of appropriate materials should be selected such that they are not corroded or damaged by the chemicals involved in the operation. Gloves and boots should be inspected for signs of damage before use and should be thoroughly cleaned after use.

5.20 *Face and eye protection*

Safety spectacles and goggles provide protection to the eyes from splashing liquid and flying particles. Safety spectacles can be fitted with prescription lenses if required, while clear plastic safety goggles that completely enclose the eyes provides better eye protection. If protection to the face, mouth, nose in addition to the immediate area of the eyes is required, face shield should be used. Contact lenses should be avoided in workplaces where the employees are likely to be exposed to gas, vapour, fumes and dust that are corrosive in nature.

5.21 *Respiratory protective equipment*

Respiratory protective equipment provides protection to the user against airborne particulates, gaseous contaminants and oxygen deficiency. There are three basic classes of respiratory protective equipment:

(a) Air-purifying respirator protects the user from inhaling contaminated air. Its function is to remove airborne particulates and gaseous contaminants using filter, or chemical absorbents in cartridge or canister. It is commonly used in workplaces where the concentration of the air contaminants is not excessive and the duration of exposure is not long. It should not be used in oxygen deficient environment. Air-purifying respirator includes particulate-filter respirators, chemical cartridge respirators and gas masks. The appropriate type should be selected according to the physical state (particulate or gas) and the nature of the contaminants.

(b) Air-supplied respirator provides the user with fresh air through a hose connected to an uncontaminated source. It can be used regardless of the physical state or nature of the contaminants. This includes hose masks with or without blower, airline respirators, abrasive blasting respirators and air-supplied hoods.

(c) Self-contained respirator (breathing apparatus) supplies breathing air to the user from a self-carrying high-pressure cylinder. It provides complete respiratory protection in any concentration of toxic gases and is the equipment of choice for life-threatening situations such as in confined space.

Appropriate respirator should be selected according to the specific working environment. The employee concerned should be physically fit before he can wear the required respirator. Persons suffering from chronic bronchitis or emphysema should consult with doctors before they are employed in work entailing routine use of a respirator.

6 Establishing Safety Measures

Overview

6.1 Having selected the appropriate safety measures, procedures for implementation and maintenance should be established. In general, safety measures should be incorporated into the corresponding work systems and practices, and to be followed by all employees. Some of control measures would best be considered in the design and installation stage of the plant and equipment.

6.2 Major considerations in establishing safety measures against various risks at work with chemicals are discussed in the following sections .

Design and installation of plant and equipment

6.3 Plant and equipment should be designed and installed to eliminate, contain or minimize the risks from chemicals or chemical operations by reducing release of hazardous chemicals and by preventing the spread of fire and explosion in the workplace. Fundamental principles in the design and installation of plant and equipment include:

(a) containment and control of hazards;

(b) avoidance of unnecessary exposure of employees to the hazards;

(c) elimination or control of sources of ignition;

(d) prevention of spread of fire and explosion; and

(e) prevention of spread of hazardous chemicals due to spillage.

6.4 *Containment and control of hazards*

Containment of hazards is a primary consideration during the design of plant and equipment and the procedures to be adopted. It is best achieved by fully enclosing the chemical operation. Full enclosure of an operation is more easily achievable where plant and equipment are automated or operated remotely. In that case, whether the enclosure can withstand the possible increase in pressure should be considered. If full enclosure is not reasonably practicable, other effective means to control the hazards, such as extraction systems and pressure relief facilities should be considered.

6.5 *Avoidance of unnecessary exposure of employees to the hazards*

Work areas, plant and equipment should be so designed and installed as to avoid unnecessary exposure of employees to the hazards. This includes:

(a) separation of work areas such that hazardous chemical operations are isolated from other activities and incompatible chemicals and operations are not put together;

(b) provision of appropriate workplace ventilation;

(c) reduction of the frequency of cleaning of plant and equipment to a minimum; and

(d) procedures that facilitate maintenance and cleaning.

6.6 *Elimination or control of sources of ignition*

When flammable chemicals are involved, the primary consideration in design and installation of plant and equipment is to eliminate flammable mixture in the atmosphere. Nevertheless, if the risk assessment reveals that flammable atmosphere may be produced, sources of ignition must be eliminated or controlled in the work area. Measures to eliminate or control sources of ignition include:

(a) prohibiting naked flame, e.g. setting up and maintenance of "no smoking" zone;

(b) prohibiting use of portable heaters such as oil and gas heaters, radiant electric heaters;

(c) avoiding use of electrical equipment, and if not reasonably practicable the electrical equipment should be explosion-proof; and

(d) preventing accumulation and discharge of static electricity such as avoiding free fall of chemicals during filling of containers, using anti-static electricity additives.

6.7 *Prevention of spread of fire and explosion*

Engineering means to prevent spread of fire and explosion in the workplace include:

(a) design and construction to contain the effects of an explosion;

(b) limitation of the effects of a fire or explosion by means of suitably sized and designed pressure-relief devices;

(c) use of non-combustible or fire-resistant materials;

(d) use of chokes, baffles or similar means to contain the effects of a fire or explosion within areas of the plant;

(e) automatic means of extinguishing or suppressing a fire or explosion, such as sprinkler system, automatically operated inert gas system to suppress explosion.

6.8 *Prevention of spread of hazardous chemicals due to spillage*

For bulk storage areas, a secondary means of containment can be used to prevent the spread of a hazardous chemical due to spillage. The secondary means of containment include:

(a) bund walls for hazardous liquids (a bund wall is a properly designed wall to contain the liquid released from its container);

(b) diversion walls and evaporation areas for heavier-than-air flammable gases with boiling points around ambient temperature (a diversion wall is a low wall adjacent to the chemical container used to divert spilled flammable gas and liquid away from danger areas to an area for safe evaporation); and

(c) containment areas for evaporation of cryogenic liquids.

Work systems and practices

6.9 For each chemical operation, work procedures should be devised and followed by all employees. The work procedures should include:

(a) detailed instructions for undertaking the task;

(b) hazards information about the operation;

(c) hazard control measures; and

(d) use of personal protective equipment.

6.10 Work procedures and safe practices should be documented and made known to employees. Important procedures and practices, such as no smoking, use of personal protective equipment, etc., can be documented in the form of placards or notices and displayed in prominent positions of the work area to arouse employees' attention.

6.11 Before work commencement, it is important to ensure that all safety measures have been adopted. In case of high risk chemical operations, such as operating a production plant, maintenance of the plant and equipment may require entry into confined space. In such case, a formal written procedure referred to as "permit-to-work" system is required. A "permit-to-work" states exactly what work is to be done and when, and which parts are safe. It also includes a checklist of safety requirements for use by the responsible person before commencement and at each stage as well as completion of the work.

Measures for risks of fire and explosion

6.12 Chemical operations that pose risks of fire and explosion include operations during which:

(a) flammable, dangerously reactive or explosive chemicals, or combustible materials in aerosol or airborne particulate forms are involved, either as starting materials, intermediates, products or by-products; or

(b) heat or gaseous products are evolved.

6.13 *Good design and installation practice* include:

(a) installation of appropriate ventilation system to eliminate accumulation of flammable vapours, fumes or dusts in the work area, or to provide the required dry or inert atmosphere for operations involving reactive chemicals;

(b) use of container strong enough to withstand the resulted pressure, or provision of appropriate pressure-relief facilities to prevent pressure built-up in the container;

(c) elimination or control of sources of ignition;

(d) segregation of operations involving flammable chemicals from
- other operations;
- bulk storage of chemicals that may cause hazards in the event of fire;
- fixed sources of ignition; and

(e) provision of adequate means of escape and appropriate monitoring, fire alarm and fire-fighting systems.

6.14 *Safe work systems and practices* include:

(a) use and proper maintenance of the engineering control measures and personal protective equipment;

(b) measures to ensure that appropriate equipment is used for undertaking the operation, such as explosion-proof tools in flammable atmosphere;

(c) good housekeeping and no smoking in the workplace;

(d) exclusion of non-essential access to the work areas where hazardous chemical operations are conducted and reducing the number of employees exposing to the hazards;

(e) minimization of the quantities of chemicals handled, used and kept in the workplace;

(f) separation of incompatible chemicals; and

(g) arrangements for safe disposal of chemicals and immediate cleanup of chemical spills.

6.15 *Personal protective measures* include:

(a) measures to ensure where personal protective equipment and general work clothing are provided they are not liable to increase the possibility of serious burns, such as avoiding those made of synthetic materials that may melt in a fire and thereby causing more serious burns;

(b) provision of appropriate signs and notices to alert employees, such as posting signs of no ignition source; and

(c) adequate preparations for emergencies.

Measures for chemicals injurious to health

6.16 Appropriate measures should be taken to protect employees against the risks of injury or ill health from chemicals injurious to health, including those chemicals classified as toxic, harmful, corrosive, irritant, carcinogenic or mutagenic. In no case should employees be exposed to a hazardous chemical to an extent that exceeds the respective occupational exposure limit.

6.17 *Good design and installation practices* include:

(a) reduction, suppression or enclosure of hazardous gases, vapours, dusts, etc., and limiting area of contamination in the event of spills and leaks, such as totally enclosing the operation and handling systems;

(b) provision of appropriate ventilation systems to prevent accumulation of hazardous chemicals in the workplace atmosphere;

(c) segregation of hazardous processes from other activities; and

(d) provision of appropriate monitoring and alarm systems for the hazardous chemicals.

6.18 *Safe work systems and practices* include:

(a) use and proper maintenance of engineering control measures and personal protective equipment;

(b) good housekeeping in the workplace such as keeping the work area clean and tidy, regular cleaning of contaminated walls, etc.;

(c) exclusion of non-essential access to the work areas where hazardous chemical operations are conducted, and reducing the number of employees exposing to the hazards;

(d) minimization of the duration of exposure of employees to the hazardous chemicals;

(e) minimization of the quantities of chemicals handled, used and kept in the workplace; and

(f) arrangements for safe disposal of chemicals and immediate cleanup of chemical spills.

6.19 *Personal protective measures* include:

(a) provision of appropriate personal protective equipment in supplement to other control measures;

(b) prohibition of eating, drinking and smoking in the work area;

(c) provision of adequate facilities for washing, changing and storage of clothing, including arrangement for laundering and disposing of contaminated clothing;

(d) provision of appropriate signs and notices to alert employees, such as the requirement for personal protective equipment; and

(e) adequate preparations for emergencies.

Appendix I

Considerations in risk assessment of a chemical operation

1. The chemicals involved

- *Are chemical reactions involved?*
  - Is there any side reaction?
  - What are the reactants, products and by-products?
- *What are the hazardous properties of the chemicals?*
- *What are the physical forms of the chemicals?*
  - Are the chemicals easily inhaled?
  - Are flammable/explosive mixtures formed?

2. Characteristics of the operation

- *Is heat generated?*
  - Is there any danger of localized heating or superheating?
  - Does the heat cause vaporisation of the reaction mixture?
- *Are gaseous products or vapours formed?*
- *Will the heat or gases/vapours generated create pressure in the container?*
  - Are the pressure-relief facilities of the container good enough to allow release of excessive pressure?
  - Can the container withstand the excessive pressure?

3. Environmental effect

- *How does temperature affect the reaction?*
  - Does the reaction need to be initiated by rise in temperature?
  - Does the reaction once initiated auto-accelerate so that it may be out of control?
- *Are the reaction, reactants or products sensitive to light?*
  - What are the reactions and products induced by light? Are they hazardous?
- *Are the reactants or products sensitive to heat, air or water?*
  - What are the reactions and products induced by heat, air or water? Are they hazardous?

Useful Information

If you wish to enquire about this guidance notes or require advice on occupational safety and health, please contact the Occupational Safety and Health Branch of the Labour Department through:

Telephone: 2559 2297 (auto-recording after office hours)

Fax : 2915 1410

E-mail : laboureq@labour.gcn.gov.hk

Information on the services offered by the Labour Department and on major labour legislation can also be found by visiting our Homepage on the Internet. Address of our Homepage is http://www.info.gov.hk/labour.

Occupational Safety and Health Branch
Labour Department

9/2001-1-B107