

Workplace Safety and Health Guidelines

Management of Hazardous Chemicals Programme



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1. Introduction

Chemicals are used extensively in industry. Many useful products such as paints, plastics, adhesives, detergents and pharmaceuticals are derived from chemicals. However, it is important to exercise caution in the usage of chemicals. Some chemicals are inherently dangerous that need to be stored in special containers to avoid contact with air. Others may appear harmless but can cause injury almost immediately upon contact. For many toxic chemicals, the health effects may take a long period of time to develop.

Hazardous chemicals in the workplace are categorised into three different types:

- Physical hazards (e.g., flammable, explosive, and reactive);
- Health hazards (e.g., toxic, corrosive, narcotic, irritating and carcinogenic); and
- Environmental hazards (e.g., aquatic toxicity and ozone depleting).

In Singapore, hazardous chemicals are regulated by different authorities. The National Environment Agency (NEA) licenses the import, storage, usage and disposal of prescribed hazardous substances that can pose environmental health problems. The Singapore Civil Defence Force (SCDF) controls the transport and storage of petroleum and bulk flammable substances while the Singapore Police Force regulates explosives and their precursors for security reasons.

Safeguarding persons against hazardous chemicals at workplace falls under the purview of the Workplace Safety and Health (General Provisions) Regulations. Under the law, all hazardous substances used in a workplace are required to be placed under the control of a competent person who has adequate knowledge of the properties of the substances and its dangers. These substances should be kept, stored, used, handled or disposed properly so that it will not pose a risk to the health and safety of any person at work. The law also requires hazard communication through the use of warning signs, container labelling and safety data sheets.



Figure 1: Chemical Barrels.

In addition, practicable measures are mandatory to control toxic airborne contaminants and specify the permissible exposure limits (PEL) for 700 toxic substances. Regular workplace monitoring is required to ensure that workers are not exposed to toxic substances above the PEL. Pre-employment and periodic medical examinations are necessary if workers are exposed to 17 prescribed toxic substances under the Workplace Safety and Health (Medical Examinations) Regulations.

Although different authorities regulate different aspects of hazardous chemicals, the objective of the regulation is the same i.e., to prevent accidents or incidents that can result in deaths, injuries or illnesses, property loss and damage to the environment. An integrated approach is therefore needed to manage hazardous chemicals at both the plant and national levels.

Accidents or incidents can happen at any stage in the life cycle of the chemicals, namely, manufacturing, transportation, storage, handling, usage and disposal if the chemicals are not managed properly. Many accidents happened due to the lack of safety and supervisory measures and/ or information and training about the hazards associated with the chemicals and its processes. To be protected against hazardous chemicals at workplace, an effective Management of Hazardous Chemicals Programme needs to be established and implemented.

The risks posed by hazardous chemicals can be eliminated or minimised if appropriate control measures are taken. The Workplace Safety and Health (WSH) Guidelines on Management of Hazardous Chemicals Programme provides guidance on establishing and implementing a comprehensive programme to manage hazardous chemicals at the workplace. The objective of the guideline is to ensure safe use of hazardous chemicals, prevent accidents or exposure incidents involving hazardous chemicals, and minimise the consequences should such an accident or incident occur.

This set of guidelines addresses the key elements in managing hazardous chemicals in their production, storage, transport, usage, handling and disposal stages. It applies to all workplaces that use, produce, store, transport or handle hazardous chemicals. The Management of Hazardous Chemicals Programme should be an integral part of the Safety and Health Management System which is mandatory for workplaces such as petrochemical and pharmaceutical plants, semiconductor wafer manufacturing, and bulk storage of hazardous chemicals premises.

Conforming to the guidelines presented in this publication does not mean compliance with the relevant provisions of the legislation. The legislative provisions stipulated by the regulatory authorities shall take precedence over any part of this publication.

2. Objective of Management of Hazardous Chemicals Programme

The main objective of the Management of Hazardous Chemicals Programme is to prevent and control chemical hazards at workplace, and safeguard the health and safety of persons against chemical hazards within the plant.

The Management of Hazardous Chemicals Programme enhances chemical safety and prevents chemical-related injuries, illnesses or diseases at the workplace.

3. Requirements and Coverage of Management of Hazardous Chemicals Programme

A Management of Hazardous Chemicals Programme is required if any hazardous chemical is used or handled at a workplace. Hazardous chemicals can be classified under the following categories:

- Corrosive substances
- Flammable substances
- Explosives
- Oxidising substances
- Pyrophoric substances
- Gases under pressure
- Organic peroxides
- Self-heating substances
- Self-reactive substances
- Substances which when in contact with water, emit flammable gases
- Toxic substances
- Mutagens
- Carcinogens
- Teratogens
- Sensitizers
- Irritants
- Substances hazardous to aquatic environment

The Management of Hazardous Chemicals Programme must cover the safety and health aspects throughout the life cycle of the hazardous chemicals that are used or produced in a plant, transportation, storage, handling, usage and disposal of the chemicals.

A workplace which uses or handles any hazardous chemical may choose to implement the relevant elements or components of the Management of Hazardous Chemicals Programme depending on the nature of its work, operation or process carried on, and the hazardous chemical(s) used or handled. As a minimum requirement, the programme should cover risk assessment and hazard communication through safety data sheets and labelling as these are essential for chemical safety management.

For workplaces such as petrochemical and pharmaceutical plants, semiconductor wafer manufacturing, and bulk storage of hazardous chemicals premises that are required to implement a Safety and Health Management System, the Management of Hazardous Chemicals Programme should be an integral part of the Safety and Health Management System.

4. Establishment of Management of Hazardous Chemicals Programme

A team should be formed to establish and implement the Management of Hazardous Chemicals Programme. The composition and size of the team should be proportionate to the size of the company and the risk of exposure to hazardous chemicals. The team could comprise safety and health, procurement, operation and relevant technical personnel.

A senior management staff should take charge of and lead the programme. He/ she should formulate chemical management policy for the plant and delegate the responsibility of various elements or components of the programme to competent persons within the plant.

The person-in-charge should establish practicable links with internal or external parties such as competent authorities, industrial hygienists, occupational health specialists, safety and health consultants, laboratory and other service providers. In establishing and implementing the programme, the person-in-charge should arrange meetings or discussions to promote collaboration of efforts between management and employees.

The person-in-charge should coordinate the programme, monitor the progress, assess the performance, evaluate the effectiveness, review the programme at regular intervals, and ensure that the objectives are met.

5. Elements of Management of Hazardous Chemicals Programme

Where toxic, corrosive, explosive, flammable, reactive, oxidising or other hazardous chemicals are used, handled or produced, a Management of Hazardous Chemicals Programme should be established and implemented to safeguard the safety and health of persons who are at risk of exposure to these chemicals and protect the environment.

The Management of Hazardous Chemicals Programme should form part of the workplace safety and health management system. It should cover all stages in the life cycle of the chemicals i.e., during manufacturing, transport, storage, use, handling and disposal. The programme should include the objectives, targets, record-keeping process and written safe work procedures. A senior management staff should oversee the programme to ensure its effectiveness.

The programme should also include the key elements from section 5.1 to 5.12. Individual elements could be delegated to a competent person who has adequate knowledge in managing hazardous chemicals. It is essential to identify the key persons in the early stages of developing the programme, so that they are involved from the start.

5.1 Policy and Strategy

The top management should issue a statement on hazardous chemical management policy. The policy should state explicitly the responsibility and commitment of management to ensure the safe use of chemicals, and the protection of employees against chemical hazards. The management should also outline a broad strategy on managing hazardous chemicals and include the duties and responsibilities of employees.

5.2 Selection and Procurement

A proper chemical selection and procurement procedure should be established with clearly defined requirements. All new processes and chemicals should be evaluated for hazards before acquisition or purchase. This is to minimise the introduction of additional hazards into the workplace.

Information on protection against safety and health hazards should be obtained from suppliers and other sources. Safer chemicals and processes should be considered more favourably.

Factors or information to be considered when selecting a safer chemical include flammability (flash point), fire or explosion rating, toxicity (lethal dose or concentration), health effects, routes of exposure, vapour pressure and permissible exposure level of the chemical. Much of the information can be found in the safety data sheets (SDS) of the chemical. In general, chemicals with a higher Globally Harmonised System (GHS) of Classification and Labelling of Chemicals* hazard category number are less hazardous than those with a lower hazard category number within the same GHS hazard class.

Refer to the simple flowchart below for selection of chemicals.

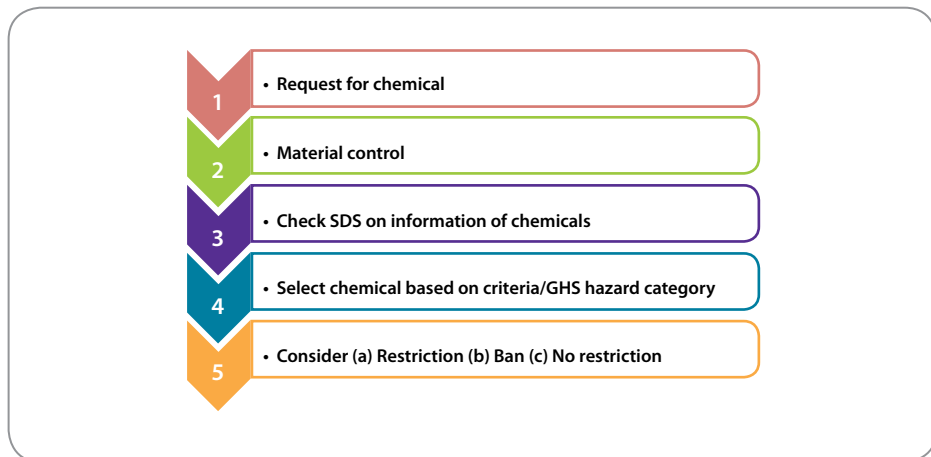


Table 1: Flowchart for selecting chemicals.

*The Globally Harmonised System (GHS) of Classification and Labelling of Chemicals is developed by the United Nations. It is a hazard communication system through standardised chemical hazard classification, container labelling and SDS.

5.3 Register of Chemicals and Safety Data Sheets

A register of all hazardous chemicals which are produced, stored, used or handled should be kept. The register should contain information on the inventory (i.e., amount stored), supplier of each chemical, application and location of the chemicals, and movement of the chemicals. It should also indicate the persons who are at risk or liable to chemical exposure. The register should be kept updated when chemicals are no longer used or new chemicals are introduced.

Safety data sheets (SDS) are the main communication tool between the chemical suppliers and the end users. The SDS of all hazardous chemicals listed in the register should be obtained from the respective suppliers and compiled. The SDS should contain the following key information:

- identity of the substance;
- safety and health information pertaining to the substance;
- composition of and ingredients used in the substance;
- first aid measures;
- fire fighting measures;
- accidental release measures;
- precautions to be taken for safe handling;
- exposure controls and personal protection needed;
- physical and chemical properties;

- stability and reactivity of the substance;
- toxicological information;
- ecological information;
- disposal considerations;
- transport information; and
- regulatory information.

Management should study the information in the SDS and take necessary measures to ensure the safe use of the hazardous chemicals. SDS should be available to persons who are exposed or liable to exposure of hazardous chemicals. Copies of SDS should also be located near the work station and kept in the office.

Refer to **Annex A** for more information on the SDS.

5.4 Labelling and Warning Signs

All packaged containers containing hazardous chemicals should be labelled in accordance with the GHS. Refer to **Annex B** for a summary of GHS hazard classes.

The label should indicate the identity of the chemical, its hazards and the precautions to take. Persons who are required to handle chemicals should be aware of the hazards and the precautionary measures. Warning signs or notices specifying the nature of the danger of the hazardous chemicals should be prominently displayed in areas where such substances are used or handled. These warning labels should be available in various languages that can be understood by the workers.

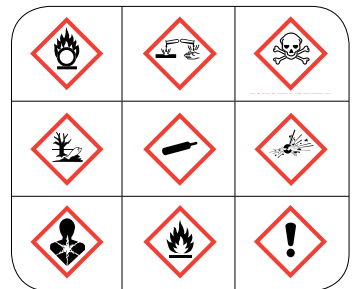


Figure 2: Symbols of GHS for Classification and Labelling of Chemicals.

Refer to **Annex C** for more details on labelling.

5.5 Storage and Transportation

5.5.1 Storage

The hazards in chemical storage include catastrophic failure of a tank, leaks or fugitive emissions from storage containers. A proper system of storage should be established taking into consideration the properties of the chemicals, any form of incompatibility, quantity to store, operational and environmental conditions.

Different chemicals may require different storage containers. Bulk storage of hazardous chemicals often requires adequate tank separation, and diking or curbing to contain potential spill. Hazardous chemicals should be stored away from heat and direct sunlight, and the containers should be properly labelled. Gas cylinders should be securely strapped or chained to a wall or bench. Poisonous chemicals should be locked up and only the authorised person has access to the key.

Chemical containers should be covered when not in use to prevent evaporation and accumulation of harmful vapours in the storage area.

Design of storage facilities should be based on statutory requirements, safety data or other technical information. International or national standards should be followed where applicable. Flammable liquids should be stored in a fire-retardant cabinet which has a proper warning label. If the liquids are stored in a room, there should be adequate ventilation to prevent the accumulation of vapour. Large amounts of liquids should be stored in bigger rooms.



Figure 3: Chemical containers properly stored and labelled.

5.5.2 Transportation

An accident during the transport of hazardous chemicals can have catastrophic consequences such as fire, explosion and toxic release. Whenever hazardous chemicals are transported within or outside a company, precautionary measures should be taken to ensure that the potential risks are communicated to persons who will come into contact with the chemicals during transportation.

This can be accomplished through marking and labelling of packages or containers to indicate the hazards of the consignment. The relevant information can be included in the transport documents, and by placing or sticking placards on the transport units i.e., vehicles and containers. These labels should conform to the Singapore Standard SS 586 : 2008 Specification for Hazard Communication for Hazardous Chemicals and Dangerous Goods Part 1 on Transport and Storage of Dangerous Goods.

In addition, the vehicles should be equipped with appropriate fire fighting appliances and drivers should be trained in the safe transport of Dangerous Goods as well as in dealing with emergency situations.

Loading, unloading and transfer operations are prone to accidents, and should be managed properly. Control measures should be implemented to reduce the risks. Safe work procedures should also be established and carried out in order to avoid unnecessary risks.

Refer to **Annex D** for more information on transport of Dangerous Goods.



Figure 4: An example of a proper label

5.6 Risk Assessment and Control

Management must ensure that a risk assessment (RA) is conducted before the use of any hazardous chemical. The RA should include work on any process, plant, vessel or machinery that is liable to produce or give off any hazardous chemical. The RA should cover:

- identification of the safety and health hazard events;
- determination of the degree of exposure to the hazardous chemicals or the frequency or likelihood of occurrence of the events; and
- analysis of the possible effects of exposure to the hazardous chemicals or the consequences of the events.

A documented RA should be kept and reviewed every three years or when there is a significant change in the work process, or there is reason to suspect that the assessment is no longer valid.

If the RA reveals that the risk is not acceptable, control or preventive measures should be implemented to reduce the risk. The hierarchy of control is as follows: hazard elimination, process or chemical substitution, engineering control (e.g., process modification, containment, automation, local exhaust ventilation), administrative measures (e.g., safe work practices, reduction of exposure duration) and personal protection.

Refer to **Annex E** for more information on RA.

Developers of industries using or storing large quantities of hazardous substances are required to conduct a Quantitative Risk Assessment (QRA). The QRA is required to establish health and safety zones to prevent knock-on effects of neighbouring hazardous installations and protect the public from fire, explosion, toxic fumes dispersal hazards, detrimental effects on health, and chemical contamination.

For more information on QRA, please refer to the Pollution Control Department (PCD) Guidelines for Quantitative Risk Assessment (QRA) Study which is available at: http://app2.nea.gov.sg/haz_sub.aspx

5.7 Safe Work Procedures and Personal Protective Equipment

Any work involving hazardous chemicals should be established and documented through written procedures. The procedures should cover dispensing, transferring, using and disposing of the hazardous chemicals.

During the manufacturing process of the chemicals, written procedures should be put in place for the start up, during routine operation, at shut down and maintenance work.

The safe work procedures should include the safety and health precautions which are to be taken during the course of work, and the use of personal protective appliances.

Personal protective equipment (PPE) include respirators, safety glasses, face shields, overalls, aprons, gloves and boots. Fit tests should be conducted for respirators used by the workers, and the fit test certificates should be kept. Workers should also conduct fit checks (positive or negative pressure fit checks) on their respirators before using them. It is a good practice to perform leak tests on PPE such as gloves to check for holes before use.

PPE should be selected properly, used correctly or comfortably fitted and maintained regularly to ensure effective protection. A suitable PPE programme should be implemented with taking the preceding elements (i.e., selection, issue, fitting and maintenance) into consideration.

Refer to **Annex F** for more information on PPE.



Figure 5: Personal Protective Equipment such as respirator, apron and gloves.

5.8 Workplace Monitoring and Medical Surveillance

Monitoring of the work environment provides basic information on the extent and magnitude of the hazards, and exposure to the workforce. It also reveals which workers are most at risk or areas of the workplace that contain high levels of airborne contaminants.

Regular monitoring by a competent person should be carried out in areas where hazardous chemicals are used or given off. Appropriate monitoring strategies should be established and followed. The monitoring data should be interpreted correctly and the records should be kept.

Regular medical surveillance helps to detect early signs of overexposure to toxic chemicals which have suitable biological indicators for exposure assessment. A medical surveillance programme should be established where appropriate. Employees exposed to such chemicals should be identified for regular medical examinations. The results of examinations should be evaluated and medical records such as medical examination and laboratory reports should be kept. Competent advice should be sought if necessary.

Refer to **Annex G** for more details on workplace monitoring and medical surveillance.

5.9 Information and Training

Employees who handle hazardous chemicals or may be affected by them should be informed of the hazards and procedures for safe handling, minimising exposure and first aid. They should be trained before being assigned to work with such chemicals. The training programme should be established to ensure that the safe handling procedures are both known and understood by all concerned.

Information on hazardous chemicals and safe handling procedures should be disseminated regularly to employees through group and individual training, SDS and other aids.

A properly conducted training programme will ensure that the workers learn how to read the SDS, understand the information provided in the SDS and chemical labels, where to find important information, understand the risks of exposure and ways to protect themselves. When workers gain adequate knowledge and can comprehend easily, they are able to carry out proper work practices in the workplace.

Refer to **Annex H** for more information on training.

5.10 Emergency Planning and First Aid Procedures

Emergency planning is needed to respond to chemical accidents such as fires, explosions, spills, leaks or release of hazardous chemicals as well as release from pipelines and transport vehicles. Emergency procedures should be established so that the source of release can be promptly rectified, and the area of contamination can be contained and decontaminated properly. The procedures should also indicate how contaminated materials should be safely disposed of. Emergency drills should be conducted at suitable intervals to ensure that all employees are trained to take necessary actions during an emergency.

A first aid programme must ensure that emergency treatment for victims of chemical poisoning or excessive exposure to toxic chemicals is in place. This should cover first aid facilities, first aid personnel and types of first aid treatment.

Refer to **Annex I** for more information on emergency planning and first aid procedures.

5.11 Waste Disposal

Chemical waste can be classified as liquids, sludge, solids or mixed waste. Waste chemicals are recycled, incinerated, buried or made to undergo a physical and chemical transformation (i.e., neutralisation and separation) or biological treatment. Improper handling of waste may cause pollution and endanger the safety and health of the workers.

Operations that generate hazardous waste should be governed by a hazardous waste management system. This should include proper labelling of waste according to the national or international codes, proper waste storage and treatment facilities, proper waste transport and disposal facilities e.g., by licensed or toxic waste collectors, and proper emergency action plan to deal with any accidental release of hazardous waste.

Refer to **Annex J** for more details on waste disposal.

5.12 Contract Work

Where contract work involving hazardous chemicals is carried out, the management should set up a system to ensure that such work is carried out safely within the plant.

Criteria should be established for the selection of contractors based on their safety and health awareness, management and performance. Clear communication between the management and contractors should be established; and duties, responsibilities, authority and reporting relationships should be defined.

The management and contractor should establish a safe work procedure to ensure the safety and health of both employees and contract workers. Training and health educational programmes on health hazards and prevention measures should be developed for both contract workers and supervisors before they start work.

Rules could be set to penalise errant and recalcitrant contractors and contract workers, and incentive or award can be given to those who excel in safety and health performance.

6. Management of Hazardous Chemicals Programme Review and Audit

The management should conduct a review of its Management of Hazardous Chemicals Programme annually to ensure that it is relevant and up-to-date.

The programme should be subjected to regular audits to ensure that it has been implemented effectively.

The management should also implement the recommendations of the review and audit to help improve and enhance the programme.

A checklist summarising the Management of Hazardous Chemicals Programme is appended in **Annex K**.

7. Annexes

Annex A: Safety Data Sheets

- Each hazardous chemical used should have safety data sheets (SDS) containing the information in paragraph A1.
- Chemical manufacturers or suppliers should prepare or provide SDS for all hazardous chemicals they produce or supply. They should ensure that the information contained in the SDS is adequate, accurate and up-to-date.
- Chemical suppliers should provide workplace occupiers and employers with SDS at the first time when the hazardous chemical is supplied to the factories and on request.
- Workplace occupiers and employers should obtain an SDS for each hazardous chemical used. They should assess all relevant information provided on the SDS and take necessary measures to ensure safe use of chemicals in the workplace.
- Workplace occupiers and employers should not purchase any proprietary chemicals which are sold under a commercial name without a SDS.
- Workplace occupiers and employers should not accept incomplete SDS, but instead, they should request for full information from the suppliers. If necessary, they should approach other suppliers who are able to provide the chemicals with complete SDS information.
- Workplace occupiers and employers should maintain a collection of the SDS of all hazardous chemicals used in the factories. They should not withhold any information or alter the SDS, unless an SDS is labelled in a foreign language which needs to be translated to English or other languages understood by the workers.
- Workplace occupiers and employers should ensure that SDS is easily accessible to persons who are exposed or likely to be exposed to hazardous chemicals.
- Persons who handle any hazardous chemicals, or may be exposed to or affected by these chemicals should be informed of the hazards and procedures for safe handling, usage, storage, transport and disposal.

A1. A summary of safety data sheets key information

Minimum information for an SDS	
1. Identification	<ul style="list-style-type: none"> • Product identifier • Other means of identification • Recommended use of the chemical and restrictions on use • Supplier's details (including name, address, phone number etc) • Emergency phone number
2. Hazards identification	<ul style="list-style-type: none"> • GHS classification of the substance/ mixture and any national or regional information • GHS label elements, including precautionary statements (Hazard symbols may be provided as a graphical reproduction of the symbols in black and white or the name of the symbol e.g., flame, skull and crossbones.) • Other hazards which do not result in classification (e.g., dust explosion hazard) or are not covered by the GHS
3. Composition/ information on ingredients	<p>Substance</p> <ul style="list-style-type: none"> • Chemical identity • Common name, synonyms, etc • CAS number, EC number, etc • Impurities and stabilising additives which are themselves classified and which contribute to the classification of the substance <p>Mixture</p> <ul style="list-style-type: none"> • Chemical identity and concentration or concentration ranges of all ingredients which are hazardous within the meaning of the GHS and are present above their cut-off levels <p><small>NOTE - For information on ingredients, please refer to the rules on Confidential Business Information in SS 586 Part 3.</small></p>
4. First aid measures	<ul style="list-style-type: none"> • Description of necessary measures, subdivided according to the different routes of exposure, i.e., inhalation, skin and eye contact, and ingestion • Most important symptoms/ effects, acute and delayed • Indication of immediate medical attention and special treatment needed, if necessary

5. Fire-fighting measures	<ul style="list-style-type: none"> • Suitable (and unsuitable) extinguishing media • Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products) • Special protective actions for fire fighters
6. Accidental release measures	<ul style="list-style-type: none"> • Personal precautions, protective equipment and emergency procedures • Environmental precautions • Methods and materials for containment and cleaning up
7. Handling and storage	<ul style="list-style-type: none"> • Precautions for safe handling • Conditions for safe storage, including any incompatibilities
8. Exposure controls/ personal protection	<ul style="list-style-type: none"> • Control parameters e.g., occupational exposure limit values or biological limit values • Appropriate engineering controls • Individual protection measures, such as personal protective equipment
9. Physical and chemical properties	<ul style="list-style-type: none"> • Appearance (physical state, colour, etc) • Odour • Odour threshold • pH • Melting point/ freezing point • Initial boiling point and boiling range • Flash point • Evaporation rate • Flammability (solid, gas) • Upper/ lower flammability or explosive limits • Vapour pressure • Vapour density • Relative density • Solubility • Partition coefficient: n-octanol/ water • Auto-ignition temperature • Decomposition temperature • Viscosity

10. Stability and reactivity	<ul style="list-style-type: none"> • Chemical stability • Possibility of hazardous reactions • Conditions to avoid (e.g., static discharge, shock or vibration) • Incompatible materials • Hazardous decomposition products
11. Toxicological information	<p>Concise but complete and comprehensible description of the various toxicological (health) effects and the available data used to identify those effects, include:</p> <ul style="list-style-type: none"> • Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact) • Symptoms related to the physical, chemical and toxicological characteristics • Delayed and immediate effects and also chronic effects from short- and long-term exposure • Numerical measures of toxicity (such as acute toxicity estimates)
12. Ecological information	<ul style="list-style-type: none"> • Toxicity (aquatic and terrestrial, where available) • Persistence and degradability • Bioaccumulative potential • Mobility in soil • Other adverse effects
13. Disposal considerations	<ul style="list-style-type: none"> • Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging
14. Transport information	<ul style="list-style-type: none"> • UN number • UN proper shipping name • Transport hazard class(es) • Packing group, if applicable • Marine pollutant (Yes/ No) • Transport in bulk (according to Annex II of Marpol 73/78 and IBC code) • Special precautions which a user needs to be aware of or needs to comply with in connection with transport or conveyance either within or outside their premises

15. Regulatory information	<ul style="list-style-type: none">• Safety, health and environmental regulations specific for the product in question
16. Other information including information on preparation and revision of the SDS	

For more information on SDS, please refer to Singapore Standard SS 586 : 2008 Specification for Hazard Communication for Hazardous Chemicals and Dangerous Goods Part 3 Preparation of Safety Data Sheets (SDS).

Annex B: Summary of Globally Harmonised System Hazard Classes

Hazard Types	Hazard Classes	Hazard Categories
Physical Hazard	<ul style="list-style-type: none"> Explosives 	Division 1.1 to 1.6
	<ul style="list-style-type: none"> Flammable gases 	Categories 1 and 2
	<ul style="list-style-type: none"> Flammable aerosols 	Categories 1 and 2
	<ul style="list-style-type: none"> Oxidising gases 	Category 1
	<ul style="list-style-type: none"> Gases under pressure 	Compressed gas; liquefied gas; refrigerated liquefied gas; dissolved gas
	<ul style="list-style-type: none"> Flammable liquids 	Categories 1 to 4
	<ul style="list-style-type: none"> Flammable solids 	Categories 1 and 2
	<ul style="list-style-type: none"> Self-reactive substances 	Types A to F
	<ul style="list-style-type: none"> Pyrophoric liquids 	Category 1
	<ul style="list-style-type: none"> Pyrophoric solids 	Category 1
	<ul style="list-style-type: none"> Self-heating substances 	Categories 1 and 2
	<ul style="list-style-type: none"> Substances which on contact with water, emit flammable gases 	Categories 1 to 3
	<ul style="list-style-type: none"> Oxidising liquids 	Categories 1 to 3
	<ul style="list-style-type: none"> Oxidising solids 	Categories 1 to 3
	<ul style="list-style-type: none"> Organic peroxides 	Types A to F
	<ul style="list-style-type: none"> Corrosive to metals 	Category 1

Hazard Types	Hazard Classes	Hazard Categories
Health Hazard	<ul style="list-style-type: none"> Acute toxicity (oral, dermal and inhalation) 	Categories 1 to 5
	<ul style="list-style-type: none"> Skin corrosion/ irritation 	Categories 1A, 1B, 1C and 2
	<ul style="list-style-type: none"> Serious eye damage/ eye irritation 	Categories 1 and 2A
	<ul style="list-style-type: none"> Respiratory sensitizer 	Category 1
	<ul style="list-style-type: none"> Skin sensitizer 	Category 1
	<ul style="list-style-type: none"> Mutagenicity 	Categories 1A, 1B and 2
	<ul style="list-style-type: none"> Carcinogenicity 	Categories 1A, 1B and 2
	<ul style="list-style-type: none"> Toxic to reproduction 	Categories 1A, 1B and 2
	<ul style="list-style-type: none"> Specific Target organ toxicity following single exposure 	Categories 1 and 2
	<ul style="list-style-type: none"> Specific Target organ toxicity following repeat exposure 	Categories 1 and 2
	<ul style="list-style-type: none"> Aspiration hazard 	Categories 1 and 2
Environmental Hazard	<ul style="list-style-type: none"> Acute hazards to the aquatic environment 	Category 1
	<ul style="list-style-type: none"> Chronic hazards to the aquatic environment 	Categories 1 and 2

Please refer to this link for the 2007 revised version of the entire GHS document:
http://www.unece.org/trans/danger/publi/ghs/ghs_rev02/02files_e.html

Annex C: Container Labelling





The objective of labelling is to enable users of chemicals to know the chemicals that they are handling, hazards involved and precautionary measures to take.

- Suppliers of chemicals should ensure that all containers of toxic and hazardous chemicals that they supply are properly labelled.
- The label should indicate the chemical name, ingredients where appropriate, symbols (hazard pictograms), signal words (danger or warning), hazard statements (hazard or risk phrases), precautionary statements (precaution or safety phrases), and supplier identification. Please refer to section C1 of Annex C for a sample of GHS label.
- If a toxic or hazardous chemical is decanted or transferred from its original container to a new one, the container to which the chemical is decanted should also be properly labelled.
- Always check the label before handling any chemical. If a chemical container does not have a label, do not handle it until it is properly labelled.
- All torn, damaged or misplaced labels should be replaced.
- Always check the SDS if you have any doubts about a hazardous chemical after reading the label.

In addition to the hazard (risk) and precautionary (safety) phrases commonly used in EU Labelling which can be found in section C2, other codes like HAZCHEM emergency action code may be included in the labels.

For more information on container labelling, please refer to Singapore Standard SS 586 : 2008 Specification for Hazard Communication for Hazardous Chemicals and Dangerous Goods Part 2 : Globally Harmonised System of Classification and Labelling of Chemicals – Singapore's Adaptations.

C1. A Sample of a GHS Label

EPICHLHYDRIN	Epichlohydrin 1-Chloro-2,3-epoxypropane CAS No. 106-89-8 UN No. 2023		
			
DANGER			
Hazard or Risk Statements: <ul style="list-style-type: none">• Flammable liquid and vapour.• Toxic if swallowed.• Toxic in contact with skin.• Fatal if inhaled.• Causes severe skin burns and eye damage.• May cause allergy or asthma symptoms or breathing difficulties if inhaled.• May cause an allergic skin reaction.• Suspected of causing genetic defects.• May cause cancer.• Suspected of damaging fertility or the unborn child.• Causes damage to respiratory organs, liver, kidney, heart, central nervous system through prolonged or repeated exposure.			
Precautionary or Safety Statements: <ul style="list-style-type: none">• Do not handle until all safety precautions have been read and understood.• Wear protective gloves/ protective clothing/ eye protection/ face protection.• Keep away from heat, sparks, open flames or hot surfaces. No smoking.• Take precautionary measures against static discharge.• Do not breathe dust, fume, gas, mist, vapours or spray.• Use only outdoors or in a well-ventilated area.			
<i>Container remains hazardous when empty. Continue to observe all precautions. For further information on this product, refer to Manufacturer's Safety Data Sheet.</i>			
United Nations Chemical Company Ltd. 1-1, Peace Avenue, Jurong Island Annex A, Singapore Tel. 65 61234567, Fax. 65 61234566			

C2. Hazard (Risk) Phrases and Precautionary (Safety) Phrases commonly used in EU Labelling

Hazard (Risk) Phrases for Labelling

The following are hazard or risk phrases that can be used for labelling of containers of hazardous chemicals. Identifying four hazard phrases to describe the risks should suffice.

- R1 Explosive when dry
- R2 Risk of explosion by shock, friction, fire or other sources of ignition
- R3 Extreme risk of explosion by shock, friction, fire or other sources of ignition
- R4 Forms very sensitive explosive metallic compounds
- R5 Heating may cause an explosion
- R6 Explosive with or without contact with air
- R7 May cause fire
- R8 Contact with combustible material may cause fire
- R9 Explosive when mixed with combustible material
- R10 Flammable
- R11 Highly flammable
- R12 Extremely flammable
- R13 Extremely flammable liquefied gas
- R14 Reacts violently with water
- R15 Contact with water liberates highly flammable gases
- R16 Explosive when mixed with oxidising substances
- R17 Spontaneously flammable in air
- R18 May form flammable or explosive vapour-air mixture in use
- R19 May form explosive peroxides
- R20 Harmful by inhalation
- R21 Harmful in contact with skin
- R22 Harmful if swallowed
- R23 Toxic by inhalation
- R24 Toxic in contact with skin
- R25 Toxic if swallowed
- R26 Very toxic by inhalation
- R27 Very toxic in contact with skin
- R28 Very toxic if swallowed
- R29 Contact with water liberates toxic gases
- R30 Can become highly flammable in use
- R31 Contact with acids liberates toxic gases
- R32 Contact with acids liberates very toxic gases
- R33 Danger of cumulative effects
- R34 Causes burn
- R35 Causes severe burn
- R36 Irritating to eyes
- R37 Irritating to respiratory system
- R38 Irritating to skin
- R39 Danger of very serious irreversible effects

- R40 Possible risks of irreversible effects
- R41 Risk of serious damage to eyes
- R42 May cause sensitisation by inhalation
- R43 May cause sensitisation by skin contact
- R44 Risk of explosion if heated under confinement
- R45 May cause cancer
- R46 May cause heritable genetic damage
- R47 May cause birth defects
- R48 Danger of serious damage to health by prolonged exposure
- R49 May cause cancer by inhalation
- R50 Very toxic to aquatic organisms
- R51 Toxic to aquatic organisms
- R52 Harmful to aquatic organisms
- R53 May cause long-term adverse effects in the aquatic environment
- R54 Toxic to flora
- R55 Toxic to fauna
- R56 Toxic to soil organisms
- R57 Toxic to bees
- R58 May cause long-term adverse effects in the environment
- R59 Dangerous to the ozone layer
- R60 May impair fertility
- R61 May cause harm to the unborn child
- R62 Possible risk of impaired fertility
- R63 Possible risk of harm to the unborn child
- R64 May cause harm to breastfed babies
- R65 Harmful: May cause lung damage if swallowed

Precautionary (Safety) Phrases for Labelling

The following are precaution or safety phrases that can be used for labelling of containers of hazardous substances. Four precaution phrases should suffice to put together the most appropriate safety advice.

- S1 Keep locked up
- S2 Keep out of reach of
- S3 Keep in a cool place
- S4 Keep away from living quarters
- S5 Keep contents under (appropriate liquid to be specified by the manufacturer)
- S6 Keep under (inert gas to be specified by the manufacturer)
- S7 Keep container tightly closed
- S8 Keep container dry
- S9 Keep container in a well-ventilated place
- S12 Do not keep container sealed
- S13 Keep away from food, drink and animal feeding stuffs
- S14 Keep away from (incompatible materials to be indicated by the manufacturer)
- S15 Keep away from heat
- S16 Keep away from sources of ignition – no smoking
- S17 Keep away from combustible material

- S18 Handle and open container with care
- S20 Do not eat or drink when using
- S21 Do not smoke when using
- S22 Do not breathe dust
- S23 Do not breathe gas/ vapour/ fumes/ spray mist (appropriate wording to be specified by the manufacturer)
- S24 Avoid contact with skin
- S25 Avoid contact with eyes
- S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
- S27 Take off immediately all contaminated clothing
- S28 In case of contact with skin, wash immediately with plenty of (to be specified by the manufacturer)
- S29 Do not empty into drains
- S30 Never add water to this product
- S33 Take precautionary measures against static discharges
- S34 Avoid shock and friction
- S35 Dispose this material and its container in a safe way
- S36 Wear suitable protective clothing
- S37 Wear suitable gloves
- S38 Wear suitable respiratory protection equipment if ventilation is insufficient
- S39 Wear eye/face protection equipment
- S40 Use (to be specified by the manufacturer) to clean the floor and all objects contaminated by this material
- S41 In case of fire or explosion, do not breathe fumes
- S42 Wear suitable respiratory protection equipment (appropriate wording to be specified by the manufacturer) during fumigation or spraying
- S43 In case of fire, use (appropriate fire-fighting equipment to be specified by the manufacturer)
- S45 In case of accident or if you feel unwell, seek medical advice immediately
- S46 If swallowed, seek medical advice immediately and show this container or label
- S47 Keep at temperature not exceeding °C (to be specified by the manufacturer)
- S48 Keep wetted with (appropriate material to be specified by the manufacturer)
- S49 Keep only in the original container
- S50 Do not mix with (to be specified by the manufacturer)
- S51 Use only in well-ventilated areas
- S52 Not recommended for interior use on large surface areas
- S53 Avoid exposure – obtain special instructions before use
- S56 Dispose this material and its container at special waste collection point
- S57 Use appropriate container to avoid environmental contamination
- S58 To be disposed off as hazardous waste
- S59 Refer to manufacturer or supplier for information on recovery or recycling
- S60 This material and its container must be disposed off as hazardous waste
- S61 Avoid release to the environment – refer to special instructions / SDS
- S62 If swallowed, do not induce vomiting: seek medical advice immediately and show this container or label

Annex D: Transport of Dangerous Goods

Classes of Dangerous Goods

Dangerous Goods can be explosive, flammable, toxic, radioactive, corrosive or harmful to humans, animals or the environment. Dangerous Goods are classified by the United Nations Model Regulations on the Transport of Dangerous Goods (UNRTDG) into 9 classes below.

Class	Dangerous Goods
1	Explosives
2	Gases <ul style="list-style-type: none">• Flammable gases• Non-flammable, non-toxic gases• Toxic gases
3	Flammable Liquids
4	Flammable Solids <ul style="list-style-type: none">• Flammable solids• Substances liable to spontaneous combustion• Substances which in contact with water, emit flammable gases
5	Oxidising Substances; Organic Peroxides <ul style="list-style-type: none">• Oxidising substances• Organic peroxides
6	Toxic (Poisonous) Substances <ul style="list-style-type: none">• Toxic substances• Infectious substances
7	Radioactive Materials
8	Corrosive Substances
9	Miscellaneous Dangerous Substances

For packing purposes, Dangerous Goods are divided into three groups based on the degree or severity of the danger they present:

- Packing Group I – Higher danger
- Packing Group II – Medium danger
- Packing Group III – Lower danger

Dangerous Situations

An accident occurring during transport of Dangerous Goods can cause extensive damage and have serious consequences. A risk of an accident is present when:

- load shifts during transport;
- package or container of Dangerous Goods runs loose because it is not properly secured;
- vehicles carrying Dangerous Goods are left to stand unattended; and
- spillage is not promptly or properly cleaned.

There is always a risk of spillage during transportation and handling of Dangerous Goods. Spillage can happen in the following situations:

- when there is a vehicle or road accident;
- goods are not packed properly;
- defective valves that cannot be tightened completely;
- handling of goods e.g., during unloading, unloading and transfer operations without referring to the contents; and
- when the load or vehicle is burning.

Common hazards in the handling of Dangerous Goods include:

- burns from chemical fire;
- explosion due to flammable chemicals or explosives;
- exposure to toxic chemicals; and
- damage to the environment.

Mixing of incompatible chemicals can produce heat to cause fire or explosion and can release dangerous gases.

Documentation for Transport

A transport document should be prepared for the transportation of Dangerous Goods. The document should contain:

- appropriate shipping name;
- class and assigned category as appropriate;
- UN number and the assigned packing group as appropriate;
- total quantity of Dangerous Goods (by mass, volume as appropriate); and
- name and address of the consignor and the consignee.

If dangerous waste is transported for disposal, the proper shipping name should be preceded by the word "WASTE".

In addition, a declaration or certificate indicating that the consignment is accepted for transportation, and the goods are packed, marked and labelled properly.

Vehicle Requirements

Each vehicle carrying Dangerous Goods should be equipped with:

- placards according to the transported goods;
- fire-fighting appliances suitable for the type of load;
- tool kit for emergency repairs of vehicle;
- at least one scotch (mechanical brake);
- two independent amber lights; and
- protective equipment (PPE, absorbing material for spills, etc).

Responsibilities

The responsibilities of the consignor are to see that:

- goods are correctly classified;
- limitations on transport of certain goods are observed;
- goods are properly marked and packed; and
- appropriate documents are attached to the goods.

The responsibilities of the transporter are to:

- equip the vehicle with the necessary equipment;
- see that the drivers and workers are trained; and
- plan the transport:
 - routes to avoid dense population areas;
 - observe time restrictions on transportation; and
 - arrange supervision during parking.

The Driver is responsible for:

- having the proper licenses and training;
- having the necessary transport/shipping document;
- checking the vehicle, tank, valves/ hoses, earthing strap touching the ground, and fire fighting equipment;
- accepting only marked/ labelled and undamaged packages and containers;
- adhering to speed limit, approved routes and hours of transport; and
- following instructions given e.g., use of personal protective equipment as necessary.

Common Rules for Transportation

- Do not leave vehicle carrying Dangerous Goods unattended.
- Do not take passengers.
- Do not smoke inside the vehicle or during loading operation.
- Do not keep engines running when they are not needed for loading.
- Do not use open flames in areas where there are Dangerous Goods.
- Read the transport documents before loading – master the loading and know what to do in case of spill.
- Make sure the labels are placed on the vehicle and the Dangerous Goods.
- Separate Dangerous Goods from other goods that are transported in the same vehicle.
- Make sure the load cannot move during transport.
- Ensure that the necessary equipment for unloading and transport safety e.g., grounding cables and personal protective equipment are available.
- Do not accept damaged goods or leaking packages or containers for transport.
- Do not open packages or containers of Dangerous Goods.

For more details on transport of Dangerous Goods, please refer to Singapore Standard SS 586 : 2008 Specification for Hazard Communication for Hazardous Chemicals and Dangerous Goods Part 1 : Transport and Storage of Dangerous Goods.

For more details on transport of petroleum and flammable materials, please refer to SCDF website at www.scdf.gov.sg

Annex E: Risk Assessment

Risk assessment (RA) is an evaluation of how hazardous chemicals are used or handled at work and the safety and health risks involved. It should also cover risk of loss of containment which poses a threat to the workplace, community and environment. The objective of an RA is to enable decisions to be made on appropriate preventive and control measures to minimise the risks.

Hazard and Risk

The “hazard” presented by a chemical is its potential to cause harm. For example, flammable chemicals can cause fire and explosion, while toxic chemicals like cyanides can cause death if ingested.

The “risk” posed by a chemical is the likelihood that it will cause illness or harm people in the actual conditions of its use. The risk depends on many factors such as the severity of the hazard, the exposure level which depends on the amount used, the manner of usage and the control measures, the duration and frequency of exposure.

Risk Assessment Team

Employers are responsible for risk assessment. They may form a team to do the assessment or they may engage external safety and health specialist or consultant.

A thorough knowledge of the work is essential when carrying out an RA. Therefore, employees who are familiar with the work should be involved even if an outside specialist is engaged in the assessment.

The team should be given resources to gather information, work with relevant people, examine records and visit the workplace. There should be a competent person e.g., a Workplace Safety and Health Officer to coordinate the assessment.

Hazardous Chemicals Identification

Hazardous chemicals can be identified by:

- referring to the inventory list and chemical register which lists all the chemicals used or produced in the workplace;
- checking all locations where chemicals are stored or used;
- considering what substances may be produced during any work process;
- considering which substances that can be given off from work as dusts, fumes or vapours; and
- considering which chemicals may leak or be spilled during any work activity.

Having identified the chemicals present, it is necessary to determine if they are hazardous. The primary source of information will be the safety data sheets (SDS) provided by the chemical supplier and the labels on chemical containers.

For chemicals or substances used or generated in the workplace for which a SDS is not available, it will be necessary to obtain safety and health information from other sources. In addition, where the processes are complex, it is necessary to obtain more information from technical reference sources, codes of practice, guidelines and computerised databases.

Assessing the Risks

As part of the RA, walkthrough inspections should be conducted to observe the work activities and the associated hazards. During the inspection, these factors should be checked.

- Are hazardous chemicals stored properly?
- Are containers labelled correctly?
- Are there any engineering controls in place?
- Are ventilation systems effective and maintained?
- Are employees trained in and to follow safe work procedures?
- Are work practices in place to ensure safe handling of hazardous chemicals?
- Are suitable personal protective clothing and equipment used and maintained?
- Are good housekeeping practices in place?
- Are emergency procedures and equipment in place?

To determine whether there are significant risks from the hazardous chemicals identified, these factors should be considered.

- How much of the chemical is in use or produced by the work activity?
- Is the chemical released or emitted into the workplace?
- Are persons exposed to the chemicals through inhalation, skin contact, or ingestion?
- Who could be exposed to the chemicals?
- What measures are taken to prevent or control exposure?
- Are the control measures effective, properly used and maintained?
- Are there any risks associated with the storage, transport and disposal of the chemical?
- Are there any risks of fire or explosion from the chemical?

For the persons who might be exposed to the chemical, estimate the degree of exposure, taking into account the level, duration and frequency of exposure and the routes of exposure. To estimate the degree of exposure to airborne substances, workplace monitoring can be undertaken by a competent person.

If the assessment shows that hazardous chemicals are effectively controlled and there is no significant risk to the safety and health of persons in the workplace, the assessment is complete and no further measures may be required.

Annex F: Personal Protective Equipment

The use of personal protective equipment (PPE) is appropriate in circumstances where:

- it is not feasible to control the hazard by more suitable means such as engineering control or administrative measures e.g., during maintenance or repair work;
- emergency situations require personnel to come into direct contact with high concentrations of chemicals; or
- it is used as an interim measure while more effective solutions are being devised or in the process of implementation.

The use of PPE does not eliminate or reduce the hazard. Hence, the wearer may be exposed to a hazardous situation if the PPE fails. In some cases, PPE may be cumbersome and interfere with safe and effective performance of the task. Given the shortcomings, PPE should always be regarded as the last line of defence.

PPE include items of clothing such as overalls, gloves, boots and aprons, and equipments such as respirators, safety glasses and face shields.

Personal Protective Equipment Programme

Given that PPE is the last line of defence, a comprehensive PPE programme is required to ensure that workers are protected when PPE is used. There are four key elements in a PPE programme.

- **Selection**

- The equipment should meet the basic criterion of providing adequate protection to cope with the particular hazard against which it is being applied. It is important to take into account factors such as the nature of the hazard, the circumstances of the task to be performed, acceptable level of exposure and performance requirement of the device.

- **Fitting**

- Correct fit and comfort are essential if the expected degree of protection is to be achieved.
- For most items of PPE, a range of sizes is needed to accommodate the full range of shapes and measurements of users. This is often the only method to ensure that each user is supplied with equipment that fits him or her correctly.
- If the wearer finds the PPE uncomfortable, it should be removed at least after the hazard has been eliminated.

- **Maintenance and Storage**

- Poorly maintained equipment may result in serious health consequences. Some large organisations use specialised contract or in-house services to collect, clean, repair and re-issue items of PPE.

- **Education and Training**

- It is important that users are trained to use their equipment correctly. Instructions should cover topics such as the need for the device, its design features, applications and limitations.

Annex G: Workplace Monitoring and Medical Surveillance

Workplace Monitoring

- Assessing possible health risks resulting from work activities
- Assessing the need for and effectiveness of exposure control measures
- Determining compliance with permissible exposure levels (PEL) of toxic substances
- Assessing the effect of changes in processes, materials or controls
- Identifying hazardous areas or work tasks that give rise to the most exposure
- Investigating complaints concerning alleged health effects
- Reassuring employees who may be exposed to toxic airborne contaminants

The method of airborne contaminant sampling can be indirect via laboratory analysis or direct reading instruments may be used depending on the chemical being monitored.

Sampling Strategies

Air sampling strategies in terms of the locations, duration and frequency of sampling, and the number of samples should fulfil the requirements that will be significant to represent workers' exposures or environmental conditions. The measurements taken must be efficient, accurate and economical.

Location of Sampling

The choice of monitoring locations depends on the objective of sampling or the type of information required.

If the objective of monitoring is to determine a worker's exposure level, it is necessary to conduct personal monitoring by attaching the monitoring device as close as possible to the worker's breathing zone.

If the objective is to assess the contaminant concentration at selected locations or to evaluate the adequacy or effectiveness of engineering control measures, area monitoring is required by setting the sampling equipment in a fixed position in the work area.

Frequency of Sampling

The frequency of air monitoring depends on the exposure level:

- where workers are exposed to contaminants of less than 10% of the PEL, no air monitoring is required unless there is a change in the process;
- where workers are exposed to contaminants between 10% and 50% of the PEL, monitoring should be carried out at least once a year;
- where the exposure is between 50% and 100% of the PEL, monitoring should be conducted at least once every six months; or

- where the exposure exceeds PEL, monitoring should be done at least once every three months until the exposure is reduced to below the PEL by appropriate control measures.

What to Sample

More than one chemical is commonly used in most workplaces. Therefore, workers can be exposed to more than one hazard. For practical reasons, it may not be possible to sample every chemical. The type of chemicals to be sampled will depend on two factors.

- The risk to the workers – depending on which chemicals are likely to be released into the atmosphere. This will in turn depend on the kind of operations (manual or closed) and physical properties of the chemicals (e.g., vapour pressure of an organic solvent).
- The toxicity or health effects of the chemicals.

Permissible Exposure Limits (PEL)

When assessing risks of exposure to contaminants in working environment, the results of air sampling or concentration measurements are compared with their PEL. Two types of PEL used are:

- PEL (Long Term) is the maximum time-weighted average (TWA) concentration of a toxic substance to which persons may be exposed over an 8-hour workday or a 40-hour workweek; and
- PEL (Short Term) is the maximum TWA concentration to which persons may be exposed over a period of 15 minutes during the workday.

To determine compliance with PEL, sample(s) should be collected to cover the period which the exposure standard is defined i.e., a 15-minute sampling period to evaluate compliance with PEL (Short Term) and an 8-hour monitoring period to determine compliance with PEL (Long Term).

For airborne contaminants having both PEL (Long Term) and PEL (Short Term), the long-term full-shift sample(s) should be supplemented by short-term grab sample(s) to monitor the peaks if there are wide fluctuations in the air levels.

The PEL of some common toxic substances are in the First Schedule of the Workplace Safety and Health (General Provisions) Regulations. The concentration units of PEL are ppm and mg/m³.

The following formula can be used to convert mg/m³ to ppm at Standard Temperature (25°C) and Pressure (760 mmHg).

$$\text{ppm} = (\text{mg/m}^3)(24.5) / (\text{Molecular weight})$$

For work shift more than eight hours, some steps need to be taken to adjust the PEL so that it can be compared against the concentration of the contaminant. The user can choose either of the following methods.

- OSHA model
Adjustments of Permissible Exposure Limits:
Adjusted PEL = 8hr PEL x Daily Reduction Factor
Daily Reduction Factor = $8/h$ (where h = hours worked per day)
- Brief & Scala model (a more conservative model)
Adjustments of Permissible Exposure Limits:
Adjusted PEL = 8hr PEL x Daily Reduction Factor
Daily Reduction Factor = $\{8/h \times (24-h/16)\}$ (where h = hours worked per day)

For more information, please refer to MOM Guidelines on Sampling Strategy and Submission of Toxic Substances Monitoring Report.

Medical Surveillance

The primary objective of medical surveillance through biological monitoring and medical examinations is to ensure that current or past exposures to chemicals are not harmful to the worker's health. This is done by detecting excessive exposure before obvious health effects occur.

Biological monitoring is useful in assessing the overall exposure of a worker to a chemical. This can be done by monitoring:

- amount of a chemical that has been absorbed by the worker; and/ or
- health effects of the absorbed chemical on the worker.

Biological monitoring involves measuring the level of an appropriate determinant in biological samples such as blood or urine collected from the worker at the specified time. The determinant can be the chemical of interest or its metabolite(s). It can also be a characteristic reversible biochemical change induced by the chemical.

Interpretation of Results

The biological threshold limit value (BTLV) represents the maximum concentrations of the toxic substance or its metabolites in the biological sample which would not be associated with significant risk to the worker's health. These limits generally represent the biological equivalent of the established permissible exposure levels for air contaminants.

All results exceeding the BTLV should be verified by a repeated test as soon as possible. Workers with test results higher than the recommended BTLV should be removed from further exposure to the hazard until subsequent follow up results are below the BTLV and there are no other abnormalities. The cause of the high values should be determined and appropriate adequate preventive measures should be taken to improve the work practices and conditions at the workplace.

The frequency and type of biological monitoring or tests for the more commonly used chemicals can be found in the Guidelines for Designated Workplace Doctors.

Annex H: Training

All persons who work with hazardous chemicals should receive information and training on:

- legal requirements on the control of hazardous chemicals;
- company policy on hazardous chemical hazard control;
- chemical safety and health rules and regulations;
- simple RA;
- hazards and necessary precautions to take based on the information that can be found on the SDS of respective hazardous chemicals;
- safe work procedures;
- PPE including topics on selection, fitting, use and maintenance; and
- procedures for emergency response.

Training should be conducted at least once a year and:

- for each new employee before starting a job;
- for each new hazardous chemical introduced; and
- when new information about any hazardous chemical used becomes available.

All induction and training should be properly recorded and documented.

Annex I: Emergency Planning and First Aid Procedures

Emergency Planning

Emergency planning is a backup to the preventive measures for managing chemical hazards. Occupiers of workplace where hazardous chemicals are used should assess:

- what could happen to cause an emergency situation;
- what dangers could arise to people as a result of these emergencies; and
- how these could be mitigated by planned remedial and rescue measures.

An emergency plan should be formulated based on the particular hazards associated with the chemicals used or processes involved. The plan should contain:

- an assessment of the nature and size of the events;
- actions to be taken on-site, where appropriate:
 - first-aid arrangements
 - fire-fighting procedures
 - rescue and evacuation arrangements
 - decontamination procedures
- setting up and operating an emergency control centre to co-ordinate rescue and mitigation activities; and
- liaising with relevant authorities including emergency services.

First Aid Procedures

The standard emergency treatments for victims involved in chemical accidents are:

Splashes on the skin

- Remove contaminated clothing and flush with water for at least 10 minutes
- Seek medical help

Splashes in the eyes

- Flush the eyes with water for several minutes
- Seek medical treatment

Inhalation of gases or vapours

- Remove casualty to a safe area
- Apply cardiac pulmonary resuscitation (CPR) if breathing has stopped
- Send for medical aid immediately

Ingestion of poisonous chemical

- Wash the mouth with water
- Do not induce vomiting
- Remove victim to hospital

In all cases of splashes, inhalation and ingestion of toxic or corrosive chemicals, first aid information should be available to the first aiders and medical personnel for proper treatment. This information is usually found in the SDS of the chemicals.

Annex J: Waste Disposal

A hazardous waste is a substance that has no economic use and that, if disposed of untreated to the environment will be potentially harmful to human beings or the environment, by means of its chemical and physical properties.

The sources of hazardous waste or waste products are from the following industries.

- Chemical, petrochemical and petroleum
- Leather
- Metal fabrication
- Mining
- Paper and paper products
- Plastics
- Printing
- Refining
- Rubber
- Textiles

Hazardous wastes may be classified by their constituent and physical state.

Type of Waste	Typical Examples
<p>Solid</p> <ul style="list-style-type: none"> • Contaminated clay, sand, oil • Halogenated organic solids • Metallic dusts and shavings • Non-halogenated organic solids • Non-metallic inorganic dusts 	<ul style="list-style-type: none"> • Clay filters, spilled material • Polyvinyl chloride • Primary metal dusts and metal machinery waste, emission control dusts from lead and steel industries • Polyethylene, cyclic intermediates • Precipitator or bag house wastes
<p>Liquids</p> <ul style="list-style-type: none"> • Cyanide and metal liquids • Halogenated solvents • Metal-containing liquids • Non-halogenated solvents • Non-metallic inorganic liquids • Other organic liquids • Polychlorinated biphenyls (PCB) 	<ul style="list-style-type: none"> • Neutralised acid or basic wastes with cyanide salts • Spent carbon tetrachloride, chloroform, trichloroethylene • Metal-finishing solutions (acidic or alkaline) • Spent acetone, methyl ethyl ketone • Acidic or basic solutions without metals • Aqueous organic solutions from cleaning or degreasing operations • Transformer fluids
<p>Sludge</p> <ul style="list-style-type: none"> • Cyanide and metal sludge • Dye and paint sludge • Halogenated organic sludge • Metal-containing sludge • Non-halogenated organic sludge • Non-metallic inorganic sludge • Oily sludge 	<ul style="list-style-type: none"> • Metal heat treating sludge • Heavy metal and solvent sludge • Halogenated still bottoms • Electroplating or chrome pigments, waste water treatment sludge • Still bottoms without halogens • Lime sludge, sulphur sludge • Tank bottoms, oil/water separation sludge
<p>Mixed</p> <ul style="list-style-type: none"> • Explosives • Pesticides, herbicides • Resins • Miscellaneous wastes 	<ul style="list-style-type: none"> • TNT, wastewater treatment sludge from explosives production • Pesticides, dioxins and other production wastes • Phenols, epoxy, polyester • Laboratory waste chemicals, equipment containers, unspecified wastes

Treatment and Disposal

The main alternatives for treatment and storage or disposal are:

- acid regeneration;
- biological treatment;
- deep-well injection e.g., injection of liquid wastes into wells or salt domes;
- incineration with or without energy recovery;
- isolated storage e.g., in specially constructed salt mine cavity;
- land farming i.e., spreading of discards onto land;
- landfill or placement of wastes into a site which receives normal refuse;
- land treatment – bio-degradation of liquid or sludge in soils;
- oil refining;
- physico-chemical treatment e.g., neutralisation;
- recycling/ reclamation e.g., of ferrous and/ or non-ferrous metals; and
- solvent regeneration/ reclamation.

Precautionary Measures

Exposure to toxic chemicals, fire and explosions, toxic chemical release and spills are common in hazardous waste treatment facilities. Precautionary measures should be taken to prevent chemical accidents.

- Establish and implement safe work procedures for all waste treatment work
- Prohibit smoking in areas where flammable chemicals are present
- Install local exhaust ventilation system to remove hazardous airborne contaminants at the source of generation e.g. reactors, mixers, neutralisation tanks
- Do not mix waste or treat waste with another waste, unless the constituents in the waste are known; if necessary, conduct laboratory testing to ascertain the hazardous substances before treatment.
- Install fixed piping for dosing of acids, alkalis, oxidisers or reducers
- Use pumps whenever possible to transfer liquid wastes
- Segregate chromic acid waste and cyanide waste
- Store oxidising agents and reducing agents separately as they are incompatible
- Use appropriate mechanical lifting or handling devices for transferring of heavy waste containers
- Wear appropriate PPE when handling hazardous wastes e.g. impervious gloves, face-shield, eye goggles, coveralls and boots
- Cover all waste containers, pits and tanks when not in use
- Provide adequate general ventilation at all work areas

Annex K: Checklist for Management of Hazardous Chemicals Programme (MHCP)

Policy and Strategy		Yes	No
1	Is there a policy established for management of hazardous chemicals?		
2	Is there a broad strategy on managing hazardous chemicals?		
3	Are the duties and responsibilities of employees clearly stipulated?		
Selection and Procurement		Yes	No
4	Is there a proper approval procedure and detailed selection criteria established for chemical selection and procurement?		
5	Is information on the protection against safety and health hazards of each chemical obtained from suppliers?		
Register of Chemicals and Safety Data Sheets (SDS)		Yes	No
6	Is there a register of all hazardous chemicals produced, stored, used or handled in the workplace?		
7	Does the register contain information on the inventory, supplier, application, location and movement of these chemicals, as well as the persons at risk?		
8	Is the register updated periodically?		
9	Are copies of SDS of all hazardous chemicals listed in the register obtained from the respective suppliers and compiled?		
10	Is the information in the SDS studied and necessary measures taken to ensure the safe use of the chemicals?		
11	Is the SDS available to persons who are exposed or liable to exposure of hazardous chemical?		
Labelling and Warning Signs		Yes	No
12	Are all chemical containers labelled in accordance with GHS?		
13	Are there warning signs or notices specifying the nature of the hazardous chemicals and the risks involved?		
14	Are the labels and warning signs legible, prominently displayed and in languages understood by workers?		
15	Appropriate steps are taken to include or exclude workers in the MHCP whose exposures have changed significantly.		

Storage and Transportation		Yes	No
16	Is a proper system of storage of hazardous chemicals established?		
17	Are poisonous chemicals locked up, and only the authorised person has the key?		
18	Are adequate measures taken to ensure that potential risks are communicated properly to all who may come into contact with the chemicals during transportation?		
19	Are precautionary measures taken to ensure that emergency situations during transportation, loading and unloading of chemicals are adequately dealt with?		
Risk Assessment and Control		Yes	No
20	Is a risk assessment conducted for work on any process, plant, vessel or machinery that is liable to produce or give off any hazardous chemical?		
21	Are the risk assessment worksheets reviewed every 3 years or immediately if there has been a significant change to the process?		
22	Are control measures implemented to reduce any unacceptable risk?		
23	Do the control measures follow the hierarchy of control (hazard elimination, process or chemical substitution, engineering control, administrative measures and personal protection)?		
Safe Work Procedures and Personal Protective Equipment		Yes	No
24	Are safe work procedures on any work involving hazardous chemicals established and documented?		
25	Is there a suitable personal protective equipment programme implemented to ensure that the employees are effectively protected?		
Workplace Monitoring and Medical Surveillance		Yes	No
26	Is monitoring of areas where hazardous chemicals are used or given off is carried out by a competent person regularly?		
27	Are results of the monitoring correctly interpreted and records properly kept?		
28	Is a medical surveillance programme established where appropriate?		
29	Are results of the medical examinations evaluated and medical records properly kept?		

Information and Training		Yes	No
30	Is there a training programme to ensure that the safe handling procedures and SDS of chemicals are known and understood by all concerned?		
31	Are employees trained prior to their first assignment working with hazardous chemicals?		
32	Are hazardous chemicals put under the control of a competent person who understands how to handle and manage the chemicals?		
Emergency Planning and First Aid Procedures		Yes	No
33	Are emergency procedures established to cope with chemical accidents such as fires, explosions, spills, leaks or release of hazardous chemicals?		
34	Are emergency drills conducted at suitable intervals?		
35	Is there a first aid programme to ensure that provisions for emergency treatment of victims of chemical poisoning or excessive exposure to toxic chemicals are available?		
Waste Disposal		Yes	No
36	Is there a hazardous waste management system which includes proper labelling of waste, waste storage and treatment facilities, waste transport and disposal facilities emergency action plan?		
Contract Work		Yes	No
37	Is there an established criteria for the selection of contractors based on their safety and health awareness, management and performance?		
38	Are the safe work procedures and training of contractors developed together with the contractors?		
Programme Review and Audit		Yes	No
39	Is the Management of Hazardous Chemicals Programme reviewed annually?		
40	Is the programme audited regularly? Are recommendations arising from the review implemented to improve the programme?		

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