

Chemical Safety in the Workplace

Guidance Notes on Chemical Safety in Textile Finishing



Occupational Safety and Health Branch
Labour Department

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CONTENTS

1	Preface	1
2	Typical Processes in Textile Finishing	2
2.1	Introduction	2
2.2	Preparation	3
2.3	Dyeing	3
2.4	Printing	4
2.5	After-finishing (or finishing)	4
3	The Chemical Hazards	5
3.1	The hazards of chemicals used in textile finishing	5
3.2	The hazards of dyestuffs	5
3.3	The hazards of non-dyestuffs	6
3.4	Other hazards	8
4	Chemical Safety Programme	10
4.1	Overview	10
4.2	Major elements	10
5	Risk Assessment	12
5.1	Overview	12
5.2	Risk assessment on textile finishing	13
6	Safety Measures	16
6.1	Overall strategy on establishing safety measures	16
6.2	Ventilation	17
6.3	Process or equipment modification	18
6.4	Personal protective equipment (PPE)	19
6.5	Monitoring and health surveillance	21
6.6	Some practical safety precautions	23

7	Emergency Preparedness	29
7.1	Overview	29
7.2	Emergency planning	30
7.3	Emergency equipment	31
8	Hazard Communication	32
8.1	Employers' responsibility	32
8.2	Sources of hazard information	32
8.3	Means of hazard communication	32
	Appendix I	37
	References	37
	Enquiries	38

1 Preface

The textile finishing industry utilizes a broad range of chemical substances for its preparation, colouration and the after-finishing processes. Many of these chemicals have different levels of health and physico-chemical hazards. The risk of injury or ill-health upon exposure at work depends on whether there are adequate safety measures in place.

Under the *Occupational Safety and Health Ordinance (Cap. 509)*, employers of a workplace are required to ensure safety and health of their employees in connection with the use, handling, storage, transport and disposal of chemicals. This can be achieved through implementing a chemical safety programme, which essentially comprises such elements as risk assessment of chemicals and processes, preventive and protective measures, hazard communication and training of staff.

This Guidance Notes is intended to provide employers, management personnel, professionals, safety personnel, supervisors and employees engaged in textile finishing with detailed information on how to develop an effective chemical safety programme for textile finishing. As every workplace has its own uniqueness, employers should develop their own programmes that best suit their workplaces with due consideration for the processes being carried out, the chemicals used, the working environment, the safety measures in place and the levels of training and experience of their employees.

2 Typical Processes in Textile Finishing

2.1 Introduction

2.1.1 Textile finishing, which renders the newly constructed fabric suitable for its intended end use, generally includes the following processes:

- (a) preparation;
- (b) colouration which may either be dyeing or printing; and
- (c) after-finishing (or finishing).

2.1.2 The colouration process (dyeing in particular) may not necessarily follow the fabric manufacturing process. The substrates to be dyed can be garments, fabrics, yarns (in various forms, such as hank, cheese or cone, or slasher) or even fibres. Textiles are dyed using a wide range of dyestuffs, techniques and equipment. The machines and processes adopted depend on the form and the nature of the substrates as well as whether the dyeing is a continuous process or a batch-wise one. In terms of chemical hazards, wet processing is the most significant textile finishing operation, and the methods used vary greatly depending on end-products and applications, site-specific manufacturing practices and fibre types. Natural fibres typically require more processing steps in preparation than man-made fibres. Most woollen and acrylic yarns are dyed in hank forms. Man-made and cotton yarns are dyed in package (such as cones or cheeses). Cotton warp yarns for denim manufacturing, however, are slasher-dyed.

2.2 Preparation

2.2.1 “Preparation” here means the pre-treatment processes to completely remove oils, dirt, soil and other additives from the raw fabrics prior to the colouration process. The processes can range from a mild wash (for synthetic fibres such as polyester or nylon yarns), cleaning with surfactant (for woollen substrates) to very drastic treatment using caustic soda at elevated temperatures (for cotton, jutes and other natural cellulosic fibres). Bleaching may be necessary for white textile substrates or textile substrates to be dyed in very light colours. Fluorescent brightening agents (which may be regarded as ‘colourless dyes’ absorbing ultraviolet radiation and re-emitting blue light) are often added for white substrates.

2.3 Dyeing

2.3.1 “Dyeing” is the homogenous colouration of textile substrates using dyes, which are substantive colourants for the substrate, and other necessary chemical auxiliaries, such as surfactants, to improve wetting, dispersing, levelling or other desirable dyeing properties.

2.3.2 Different types of dyes are applied by different means. For example, direct dyes are water soluble and can be applied directly. However, vat dyes and sulphur dyes (which are all water insoluble) have to be converted (or reduced) to their ‘leuco’ (which are water soluble and substantive) forms, using sodium hydrosulphite (also called ‘hydros’, or sodium dithionite) and sodium sulphide respectively, in strongly alkaline conditions. Chrome mordant dyes, normally applied for wool, have to be treated with dichromate in their application. Reactive dyes react with fibres more readily in alkaline conditions. The application of disperse dyes for polyester fibres in aqueous system requires an operating temperature at 130°C, and thus necessitates the use of pressurized equipment.

2.4 Printing

- 2.4.1 “Printing” is the non-homogenous colouration of textile substrates. Technologically speaking, it is essentially a localized application of colourants on substrates. To enable sharp definition of the printed patterns, textile printing invariably requires the use of thickeners such as alginates and starch for water-soluble dyes.
- 2.4.2 Textile printing commonly utilizes non-substantive insoluble colourants (or pigments). The pigments are held on the substrate surface by a binder. To reduce poor fabric handle, an oil-in-water emulsion (which has practically no solid content) is used as thickener. The oil phase is usually a petroleum distillate, such as white spirit, which is highly flammable.

2.5 After-finishing (or finishing)

- 2.5.1 “After-finishing” refers to the treatment of textile substrates to impart desirable properties (other than colouration), such as wash-and-wear finish, anti-shrink finish, water-repelling finish and flame-retarding finish. It is often simply called “finishing” and thus may cause confusion with its another meaning that carries a broader implication.
- 2.5.2 The application of resin for wash-and-wear finishes for cloth is one of the most common after-finishing processes. Typically this kind of resin is based on methylated cyclic urea polymerizing by condensation. Formaldehyde will be liberated during curing stage and storage.

3 The Chemical Hazards

3.1 The hazards of chemicals used in textile finishing

3.1.1 Many chemicals used in textile finishing pose health and physical-chemical hazards. As some processes are operated at elevated temperatures, fire and explosion may occur.

3.2 The hazards of dyestuffs

3.2.1 Many textile dyes have complex chemical structures, and there is a large range of such products in commercial use. Their impacts on health (such as toxicity and carcinogenicity) and safety thus vary considerably. Dyes that have not been associated with any adverse health effects in light of current medical knowledge should also be handled with care as they may pose health hazards that have not yet been known. It should be prudent to minimize exposure to dyes of all types. It is also essential to read the material safety data sheet (MSDS) supplied with each product.

3.2.2 The following dyes are known to be hazardous to health:

- (a) Certain reactive dyes are recognized as respiratory sensitizers. Inhaling such dyes can cause occupational asthma. Once a person is sensitized, re-exposure to even very small amounts of the same dye may result in allergic symptoms, such as wheezing, chest tightness and breathlessness.
- (b) Certain reactive, vat and disperse dyes are recognized as skin sensitizers.
- (c) Certain azo dyes are known to be carcinogenic.

3.3 The hazards of non-dyestuffs

3.3.1 The textile finishing also uses many hazardous chemicals other than those for dyeing. It is not possible for this Guidance Notes to elaborate all these chemicals individually but they can be broadly grouped into oxidising agents, reducing agents, corrosives, irritants and flammables.

3.3.2 Oxidizing agents used in textile finishing are mainly bleaching agents such as hydrogen peroxide, sodium hypochlorite and sodium dichlorocyanurate. Violent reactions may be caused by uncontrollable decomposition of such chemicals. For example, if the chemical reaction during peroxide bleaching is not strictly controlled, a rapid evolution of oxygen can be caused by decomposition of hydrogen peroxide. The volume of oxygen thus produced may exceed the capacity of the relief devices causing the vessel to fail catastrophically. Mixing oxidizing agents with incompatible substances such as reducing agents will generate a lot of heat and toxic gases, or lead to explosion. Moreover, precautions must be taken to prevent occurrence of the following hazardous reactions between:

- (a) sodium hypochlorite and acid;
- (b) sodium peroxide and sodium hydrosulphite.

- 3.3.3 Reducing agents like sodium hydrosulphite are used in reducing bleach bath, in stripping (i.e. removal of a dye from a substrate) and in applying vat dyes. Other reducing agents are thiourea dioxide, sodium formaldehyde sulfoxylate (trade name "Formosul" or "Rongalite"), sodium bisulphite and sodium metabisulphite. Sodium bisulphite, when contaminated with acid, gives rise to hazardous fumes of sulphur dioxide. Sodium hydrosulphite, when contaminated with water, generates considerable amount of heat and may even ignite spontaneously.
- 3.3.4 In textile finishing, strong acids and alkalis, such as sulphuric acid and caustic soda, are commonly used. These are very corrosive chemicals that can cause serious burns and react dangerously with other chemicals.
- 3.3.5 The dyeing and after-finishing processes involve many chemicals that are irritating to eyes, skin and respiratory tract. These include formaldehyde-based resins, ammonia, dilute acetic acid, aqueous ammonia, some shrink-resist chemicals and optical whiteners, soda ash, various bleaches and acrylate (for preparation of screens).
- 3.3.6 When flat or rotary screens are made or repaired at the printing workshops, solvent vapour hazards can be caused by the use of volatile adhesives and varnishes. If epoxy adhesive is used to secure rotary screens to their end rings there is a skin contact risk until the adhesive is fully cured.
- 3.3.7 Screen inks may contain such solvents as aliphatic and aromatic hydrocarbons (e.g. white spirit, trimethylbenzenes), ketones (e.g. cyclohexanone), alcohols (e.g. diacetone alcohol) and certain glycol ethers and their esters (e.g. 1-methoxy-2-propanol and 2-butoxyethyl acetate). There has been particular concern about the health effects of some glycol ethers and their acetate derivatives.

3.3.8 The risk of absorption of a solvent into the body depends on the particular chemical, its concentration, and frequency, duration and mode of exposure. Short term health effects range from loss of concentration, mild headaches and nausea, to more severe headaches, vomiting or even unconsciousness. In the long term, kidney and liver damage may result from such absorption.

3.4 Other hazards

3.4.1 The use of pressure equipment for high temperature operation can be found in:

- (a) scouring by kier – although the use of kier for scouring tends to be replaced by continuous preparation ranges, both pressure and open or atmospheric kiers are still found in use for the scouring and bleaching of fabrics. The main hazards include scalding by hot liquor or steam when a person is inside the kier, or the danger of falling into the kier.
- (b) dyeing by high temperature dyeing machines – the substrates requiring dyeing at high temperature of 130°C are usually poly(ethylene terephthalate) (PET) or its blends. The high temperature dyeing machines include package dyeing machine for yarns (mostly cheese or cones), jet dyeing machine for knitted goods and high pressure jigger for woven fabrics.

3.4.2 Explosion of pressure equipment may result in serious accidents. These equipment are under the control of the *Boilers and Pressure Vessels Ordinance* and its subsidiary legislation. Here are some examples of the risks:

- (a) Pressure vessels or components such as opening covers may fail under pressure, due to mechanical failure or faulty closing.
- (b) Vessels may fail during bleaching operations using hydrogen peroxide as a result of decomposition of the peroxide leading to the rapid evolution of oxygen beyond the capacity of the relief devices.

- (c) Operators may be engulfed with steam, boiling liquid, or hot water, when:
 - (i) temperature of dyeing liquor is at or above 100°C and a lid or sample chamber is opened, allowing liquor to flash violently into steam and erupt from the vessel;
 - (ii) doors are opened and hot liquor allowed to spill out, e.g. from horizontal vessels not completely drained or vertical vessels filled above cover-flange level;
 - (iii) one of a bank of machines is inadvertently pressurised from an adjacent machine, via a common blow-down or drain line.

3.4.3 Fire and explosion hazards may arise from the use of flammable substances, or oxidizing agents which can intensify a fire by supplying more oxygen. Flammable substances (e.g. petroleum spirit) are often used for preparation of emulsion thickening in pigment printing. This incurs significant fire hazards to the workplace, particularly when the printed articles are subsequently baked at high temperature. Sodium hydrosulphite, a widely used reducing agent, may spontaneously ignite when wet. Some aqueous organic acids, such as acetic acid, are flammable at high concentrations. The solvent base of resin coatings or adhesives, which is intended to be easily vaporized during the drying process, is usually flammable, e.g. white spirit. In pigment printing, the thickening commonly used is oil-in-water emulsion, in which over 65% of the constituents is flammable solvent (e.g. white spirit). Subsequent evaporation in oven can give rise to significant fire and explosion risks.

3.4.4 Fine dust or loose fibres generated from textile processing operations like flocking may fly into the atmosphere or accumulate around machinery, ventilation ducts or light fittings. They will be easily ignited by electrical ignition sources such as overloaded circuit, damaged insulation and static discharge of electrical equipment. Fine dusts produced from processed and treated nylon fibres may become explosive.

4 Chemical Safety Programme

4.1 Overview

- 4.1.1 To ensure safety and health at work of employees engaged in textile finishing, a carefully planned chemical safety programme is essential. In the programme, the hazards of the materials and related processes should be identified and communicated to all affected employees. The risks arising from the hazards have to be assessed and control measures set up with their effectiveness monitored. The programme should also include emergency planning and training of employees.
- 4.1.2 The chemical safety programme should be organized and integrated into the general safety management system of the workplace. In addition, sufficient resources should be assigned to the development, implementation and maintenance of the programme.

4.2 Major elements

- 4.2.1 A chemical safety programme for textile finishing should include the following major elements:
- (a) risk assessment -- to identify the hazards and evaluate their risks in the processes;
 - (b) control of risks -- to adopt and maintain suitable preventive and protective measures to control the risks associated with the identified hazards;
 - (c) emergency preparedness -- to establish the plan and procedures for emergency response;

- (d) hazard communication -- to establish appropriate means of communication of safety and health matters to employees. This includes the provision of information, instruction and training to enable employees to do their jobs safely; and
- (e) monitoring and review -- to monitor the effectiveness of the safety measures and review and revise periodically to cope with new requirements or significant changes in the concerned processes and /or materials.

4.2.2 Depending on the individual situations of the workplace, employers may find it beneficial to include other elements such as inspection, accident investigation and health surveillance into the chemical safety programme, or to incorporate the chemical safety programme into the overall safety management programme of the organization.

5 Risk Assessment

5.1 Overview

5.1.1 Risk assessment is a process to evaluate what chemicals or processes would cause harm at work in terms of frequency of exposure, likelihood and consequence. Based on the assessment results, suitable safety measures could be developed to reduce the risks.

5.1.2 Risk assessment should be performed by competent persons with suitable experience and training on the concerned work activities. They should have knowledge on the nature and hazardous properties of the reactants and products/by-products as well as the characteristics of the physical and chemical changes at each stage of the process and the required safe practices. Specialists may be consulted for expert advice if needed.

5.1.3 The risk assessment should include:

(a) Identification of hazards

It is the process of identifying all hazardous chemicals used or may be present, and the hazardous chemical processes conducted in the workplace. The operating procedure of each chemical process is examined for the critical steps where potential hazards exist.

(b) Determination of risks

This is the process of making an objective evaluation of the risks associated with each hazard assuming that planned or existing controls are in place, and considering the effectiveness of the controls and the consequences of their failure. Also, it is necessary to decide if the risks are tolerable. The risks associated with a chemical process should be re-assessed whenever there is any change to the operating procedure, such as change in the scale of the process, change in the reactants, change in operating temperature, etc; or when safer procedures or improved control measures become reasonably practicable.

5.1.4 After risk assessment, the following actions should be taken to eliminate or control the identified risks:

- (a) development of safety procedures and risk control measures;
- (b) implementation and maintenance of safety procedures and risk control measures; and
- (c) review of safety procedures and risk control measures.

5.2 Risk assessment on textile finishing

5.2.1 Risk assessment on textile finishing requires knowledge of the properties of chemicals and the reactions involved in the concerned chemical processes. Due consideration should be given to the factors listed in the following paragraphs.

5.2.2 Physical form of the chemicals

The physical forms of the chemicals used in textile finishing have pronounced effects on the hazards of the chemicals. For those in the state of gases, vapours, fumes, aerosols, airborne particulates, the risk of entry into the human body as well as the risk of fire and explosion is increased. It should be noted that aerosol, particulate and powder forms of combustible materials can form explosive/flammable mixtures with oxidizing agents, including air.

5.2.3 Chemical changes

If chemical change is involved, the chemical reaction and the products should be studied. The hazards associated with the chemical reaction as well as hazardous properties of the reactants and products in textile finishing processes should be identified. Special attention should be paid to any possible side reactions and by-products.

5.2.4 Temperature and pressure changes

Many physical and chemical changes may evolve heat, causing a rise in temperature during the finishing processes. They may result in:

- (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 even more heat.

These effects can be intensified if there is no effective means to dissipate the heat evolved which may result in localised heating and superheating of the reaction mixture. It should also be noted that some exothermic reaction initiated by a rise in temperature may auto-accelerate and the reaction rate may become out of control.

5.2.5 Scale of the process

The scale of the process determines the amount of hazardous chemicals involved. Change in the scale affects the heating effect of the operation as well as heat dissipation and pressure change in the system.

5.2.6 Extent of exposure

The extent of exposure to hazardous chemicals is affected by:

- (a) frequency, duration and mode 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.

5.2.7 Working environment

The working environment ranging from the containers holding the chemicals to the general conditions of the workplace is an important aspect in the risk assessment of textile finishing. The following factors should be considered:

- (a) size and shape of the container where chemical or physical changes take place, especially the headspace in the container and passage for release of pressure; if the container cannot withstand or release the increase in pressure, explosion may occur;
- (b) presence of nearby ignition source, if explosive/flammable mixtures are encountered;
- (c) whether processes undertaken or chemicals stored or used are sensitive to air, moisture, temperature or light; and
- (d) ventilation of the environment.

6 Safety Measures

6.1 Overall strategy on establishing safety measures

- 6.1.1 The primary consideration is to adopt appropriate preventive measures to directly control the hazards at source, such as by elimination or substitution. For instance, certain azo dyes likely to form carcinogenic substances during dyeing process should be replaced by non-hazardous or less hazardous ones. These carcinogenic substances may also be regulated by the *Factories and Industrial Undertakings (Carcinogenic Substances) Regulations*. In case elimination or substitution is not possible, segregation of the chemicals or the process is an effective safety measure. Protective measures such as the use of personal protective equipment should only be considered as a supplementary means in addition to engineering controls to minimize workers' exposure to the hazards.
- 6.1.2 On many occasions, process and equipment modification can eliminate or minimize the risks arising from the hazardous chemicals and/or processes. Modifications may include improved process control systems or changes in chemical application methods as illustrated in 6.3.
- 6.1.3 Safety measures can be realised by engineering and/or administrative means. Engineering measures such as ventilation, equipment and process modification, etc. can eliminate or lower the risk at source while administrative measures reduce exposure of workers by implementation of safe work practices or procedures, and scheduling of breaks or rotation shifts.

- 6.1.4 It is preferable to incorporate safety considerations during design stage of a process or equipment, as this would save additional expenses and often reduce practical difficulty in subsequent safety adjustments.
- 6.1.5 All safety measures should be documented in the standard operating procedures of the finishing process, and should be made known to all workers concerned. The effectiveness of the safety measures should be constantly monitored. If changes are made to the standard operating procedure, a fresh risk assessment should be conducted and the safety measures should be reviewed and appropriately amended. In keeping with the concept of continuous improvement, the safety measures should be constantly reviewed to accommodate new development in safety technology.

6.2 Ventilation

- 6.2.1 Ventilation is an effective engineering means to prevent accumulation of vapours of explosive/flammable mixtures or inhalation of toxic gases or vapours in the workplace. However, attention must be paid to the relevant environmental protection requirements in the discharge of exhaust air to prevent contamination of the outside environment.

General dilution ventilation

- 6.2.2 Dilution ventilation is the dilution and displacement of contaminated air by fresh air. Fresh air is supplied to the work area by mechanical means or natural air currents through doors, windows or other openings in the workplace. The contaminated air is forced out through relief openings or drawn out by an exhaust fan.

- 6.2.3 This method is only suitable for replenishing stale air and should be used in conjunction with other local means of ventilation in order to remove airborne contaminants emitted from the chemical processes.

Local exhaust ventilation

- 6.2.4 Vapours and particulates are captured and removed by forced air current through a duct at the nearest point of emission before the contaminants are dispersed into the work area. This method is generally applied to equipment that cannot be readily enclosed. Dust clouds are raised when dye container lids are removed and replaced, when the dye is scooped, and during carriage of the scoop to and from the weighing scale. Installation of local exhaust ventilation will greatly reduce the concentration of fine inhalable particles, but it is important to ensure that the exhaust current does not pass through the breathing zone of the worker.

6.3 Process or equipment modification

- 6.3.1 Low bath-ratio dyeing can save energy and reduce chemicals used, because energy and chemicals used depend on bath volume. Jet dyeing and package dyeing are commonly used for low bath-ratio dyeing.
- 6.3.2 Where practicable, the weighed dyestuff should be mixed manually with water to a slurry or paste before transfer since tipping dry dyestuff into a mixing vessel will create a dust cloud. Exposure can be also greatly reduced by adding the dye in a water-soluble bag.
- 6.3.3 The use of automated chemical dosing systems can optimise the delivery of an exact amount of the right chemical at the preset time. Such system reduces the overuse of hazardous chemicals in textile finishing processes and prevents employees from being exposed to the hazardous chemicals.

6.3.4 Another typical example of equipment modification is on the size of the dye drums. Most powder dyes are shipped in drums that range in height from 75cm to 90cm. While the employees are transferring dye from these drums manually, they need to lean forward or even place their heads inside the drum to scoop out dye near the bottom. In this position, employees are greatly exposed to airborne dye dust, even in a ventilated work area. Such hazardous situation could be improved by using shorter drums while maintaining a space between the worker's face and the top of the drum to enable the ventilation to capture the dust before it reaches the employee's breathing zone. Limiting the drum height to about 63cm will greatly reduce the dust exposure of the employees.

6.4 Personal protective equipment (PPE)

- 6.4.1 The primary objective of using PPE is to protect workers against the risks of hazardous chemicals entering the body through inhalation or skin contact. Again, it must be stressed that PPE should only supplement and not replace the preventive measures. Appropriate PPE should be selected with regard to the hazards, physical nature and the routes of entry of the chemicals into the human body.
- 6.4.2 PPE should be properly used and maintained. They should be inspected for signs of damage before and after use. PPE should be regularly cleaned, stored and kept in good condition. Contaminated PPE should be properly treated or disposed of as appropriate and replacement sets kept readily available.
- 6.4.3 Wrongly selected, improperly used or maintained PPE may do more harm than providing none. The user may have a false sense of security and thus is subjected to a higher risk of injury or ill-health. For more information of the subject, readers should refer to *Chemical Safety in Workplace: Guidance Notes on Personal Protective Equipment for Use and Handling of Chemicals*.

Protective clothing

6.4.4 Protective clothing provides skin protection against chemical splashes, vapour and particulate exposures and other physical hazards. In textile finishing, suitable protective clothing should always be worn when dispensing and handling hazardous chemicals or dusty materials such as dyestuffs. Storage workers, maintenance employees as well as emergency staff should also be provided with appropriate protective clothing.

Hand and foot protection

6.4.5 Impervious gloves protect the hands of the worker from contacting hazardous chemicals. They should be made of appropriate material that would not be corroded or damaged by the hazardous chemicals involved in the operation. If workers have to work on wet floors, they should also wear protective footwear, preferably of slip-resistant type.

Face and eye protection

6.4.6 Where there is a risk of eye injury through splashing, suitable eye protectors or face shields should be worn. Safety spectacles can be fitted with prescription lenses if required, while safety goggles that completely enclose the eyes provides superior eye protection. If protection to the face, mouth and nose is required in addition to the eyes, face shield should be used.

Respiratory protective equipment (RPE)

6.4.7 Respiratory protective equipment (RPE) protects against exposure to dusts, gases, fumes and vapours, but exposure duration should be kept short.

- 6.4.8 Where engineering control may not be reasonably practicable such as during routine maintenance, cleaning, or in fire or in other emergencies where hazardous fumes are generated from significant chemical spillage or inadvertent mixing of incompatible chemicals, RPE should be used to protect the workers.
- 6.4.9 The choice of RPE depends on the physical and chemical nature of the exposed hazard, the concentration of hazardous substances and the duration of exposure. It must fit the wearer's face and its breathing resistance should be tolerable to the wearer. For fire and other major emergencies where asphyxiation or inhalation of toxic gases is possible, RPE should comprise full breathing apparatus.

6.5 Monitoring and health surveillance

- 6.5.1 Monitoring is a means to ensure the effectiveness of the control measures. In textile finishing, environmental monitoring generally involves measuring the levels of the contaminants in the air at strategic locations in the workplace or at the breathing zone of the workers concerned. The monitoring can be continuous or in a form that requires regular sampling and analysis using equipment that includes sensor with alarm device, direct-reading instrument, static sampler and personal sampler.
- 6.5.2 Based on the work activity and the result of the risk assessment, the management should establish and implement an appropriate monitoring programme to ensure that the levels of the airborne contaminants do not exceed the acceptable limits, such as the lower explosion limit (LEL) or the occupational exposure limit (OEL) of the chemicals. The monitoring programme should include:
- (a) monitoring parameters;
 - (b) frequency of monitoring;
 - (c) location and method of monitoring;
 - (d) alarm levels based on the acceptable limits; and
 - (e) follow-up actions.

6.5.3 If monitoring reveals that the acceptable limits are exceeded, the process concerned should be suspended and the causes investigated. Remedial actions should also be taken immediately, which include reviewing the corresponding standard operating procedures and control measures, and instigating appropriate amendments. Under no circumstances should the exposure of workers to airborne contaminants exceed the acceptable limits. For details of occupational exposure limits, readers should refer to the *Code of Practice on Control of Air Impurities (Chemical Substances) in the Workplace*.

6.5.4 In the workplace, all accidents or dangerous occurrences involving chemicals and related processes should be investigated and taken as a 'learn from mistake' exercise. The investigation should be led by a line manager or a professional having adequate knowledge about the operation and should identify:

- (a) the causes of the accidents or dangerous occurrences;
- (b) the reasons for any substandard performance; and
- (c) the underlying failures in the chemical safety programme.

The investigator should recommend appropriate measures to prevent recurrence, and the management should ensure that the recommendations are implemented. The investigation provides useful information for reviewing and improving the chemical safety programme.

6.5.5 For textile finishing employees who are liable to regular exposure to hazardous chemicals at work, health surveillance can be a means to monitor exposure biologically and to detect adverse health effects at an early stage thereby preventing further harm. Health surveillance includes, where appropriate, pre-assignment and periodic medical examinations, medical examinations for resumption of work after prolonged sickness absence, as well as medical examinations upon and after termination of work involving exposure to hazardous chemicals.

6.5.6 If cases of suspected over-exposure to hazardous chemicals are reported, investigation should be immediately conducted by persons with sufficient knowledge and experiences and the concerned operation should be suspended as appropriate. If investigation confirms over-exposure, remedial actions should be taken to improve the concerned operation procedures and control measures.

6.6 Some practical safety precautions

6.6.1 The systematic management approach of establishing measures to ensure the chemical safety in textile finishing has been discussed. Some practical precautionary measures on those commonly encountered processes will now be suggested. Such processes include handling and storage of chemicals (dyestuffs and non-dyestuffs), textile printing, use of pressure equipment and high temperature machinery. It should be noted that these precautions discussed below are only exemplary, as the hazards dealt with may vary from workplace to workplace. The systematic management approach should always be adopted to establish suitable safety measures.

Handling of dyestuffs

6.6.2 Dyes may present hazards to health. The following precautionary measures should be considered:

- (a) As dyestuff powders may form airborne dust, they should be dispensed under local exhaust ventilation.
- (b) The choice of low-dusting dyes such as those in granular, dust-suppressed or liquid form can reduce exposure.
- (c) High-speed mixers should not be started until any dry dye is wetted out and the stirrer blades are covered. The vessels should be fitted with lids to prevent emission of aerosols or droplets during high-speed mixing.

- (d) Walls should have smooth and impervious surfaces capable of being washed down, and floors should be smooth but non-slippery and preferably designed with a fall to a channel or drain for easy removal of cleansing water. The floors should be properly constructed to fit the type of material stored and to withstand rigorous impact from containers of all kinds. Dye stores should be well lit and ventilated.
- (e) Separate storage areas should be provided for dyestuffs and other chemicals, as spillages of chemicals require frequent floor washing operations, which create a moist atmosphere not conducive to the good storage of dyes.
- (f) All dye containers should be kept in good condition. They should be stored on pallets or platforms to facilitate cleaning of the floor. Lids should be kept close all times. The scoop used to transfer powdered dyes should enclose the powder to the greatest practicable extent, i.e., it should have a curved base and a partial canopy.
- (g) Eating, drinking and smoking in the dye store should be strictly prohibited. Workers should wash their hands carefully before eating, drinking, or smoking.
- (h) Protective clothing including impervious overalls, gloves, head coverings and footwear should be provided to and worn by dye handling workers.
- (i) Respiratory protective equipment should be provided for use:
 - (i) on the recommendation of the dyestuff manufacturer;
 - (ii) where persons are exposed to significant quantities of dust, for example during the cleaning of dye stores or following spillages of dyestuffs; and
 - (iii) when dyestuffs in finely divided powder form (instead of ordinary granular form) are being handled.

Handling and storage of chemicals

6.6.3 In most situations, safe handling and storage of chemicals can minimise exposure and thereby reduce the safety and health risks. The safe handling and storing procedures of chemicals include:

- (a) Incompatible chemicals such as acids and alkalis, oxidising agents and reducing agents, flammable and combustible materials, etc. should be stored separately from one another and clearly labelled. Reducing agents should be stored away from direct sunlight and other heating sources and preferably, in a cool, well-ventilated store constructed of fire-resisting materials.
- (b) Small quantities of flammable liquids should be stored in a fire-resisting cupboard or bin with clear marking outside the container. Larger quantities of flammable liquids should be stored in a separate fire-resisting room constructed in accordance with the requirements of the *Dangerous Goods Ordinance (Chapter 295)*.
- (c) Spillages should be avoided wherever possible by the provision and use of non-spill containers.
- (d) When spillages or leakages do occur they should be dealt with quickly using methods recommended by the supplier of the chemicals.
- (e) Wheeled trolleys should be used for transport and large dye drums should be mounted on castors.
- (f) In storing chemicals, particular care should be taken to avoid confusion where chemical names look very much alike, for example, sodium chlorate and sodium chlorite.
- (g) Separate dispensing scoops or handling containers should be used to prevent cross-contamination of incompatible chemicals.
- (h) Safe handling procedures should be developed. Warning notices on safe methods of handling hazardous chemicals should be posted and made clearly visible at the places where these chemicals are stored.

- (i) Where workers are required to deal with accidental release of toxic fume or gas, appropriate personal protective equipment including the recommended canister respirators or breathing apparatus should be provided and readily available.
- (j) Safety showers should be provided in places where there is a risk of substantial contact with corrosives.
- (k) When peroxide bleaching solution is used, it must always be diluted before it is transferred to the vessel. In addition, a temperature interlock should be provided so that the bleaching solution cannot be transferred to the pressure vessel if its temperature exceeds 45°C.
- (l) A safe method of controlling the concentration of hydrogen peroxide is to install a volumetric tank before the additions tank of the dyeing machine. The volumetric tank should be sized at the maximum safe volume of hydrogen peroxide that the vessel can accept and be fitted with an overflow pipe. Before the line connecting the additions tank to the vessel can be opened, the feed to the additions tank has to be isolated to prevent further peroxide flow.

Textile printing

- 6.6.4 To decrease the risk of explosion due to the flammable solvent giving out from printed fabrics in ovens, adequate explosion relief should always be provided where technically feasible, irrespective of the sophistication of the oven controls. The relief, in the form of explosion doors or lightweight explosion panels, should be sited to vent to a safe place where personnel are unlikely to be present. Relief distributed along the top of the oven is usually preferred.

- 6.6.5 Ultra-violet light is used to cure the light sensitive lacquer on flat screens to produce the desired print pattern. The light source should be suitably shielded or enclosed, using dark coloured curtains for example, to avoid unnecessary exposure to ultra-violet light. The controls for the light source should be positioned outside the enclosure.
- 6.6.6 Laser engraving of rotary screens has become a common technique in textile finishing, although it has problems of electrical safety and risk of injury to the eyes. Shields and covers should be effectively interlocked to prevent access until the laser is de-energised. At the engraving head, local exhaust ventilation should be applied to remove the fumes given off.
- 6.6.7 Precautions should also be exercised for engraving of copper printing rollers (for roller printing) since strongly corrosive substances such as nitric acid and ferric chloride solution are used.

Pressure equipment and high temperature machinery

- 6.6.8 Accidents could occur while operators are taking samples from pressurised dyeing machines. To prevent this, the sampling device should be interlocked to ensure that the sampling pot or device is depressurised before it can be opened to remove the sample. The sampling mechanism should be so designed as to prevent foreseeable mistaken actions by operators taking samples.
- 6.6.9 Some new machines fitted with programmable controllers are often supplied without a sampling device. The machine must be stopped in mid-cycle before the main lid is opened. In such situations the installation of door interlocks could ensure that the liquor is cooled and any pressure within the vessel is relieved prior to sampling.

- 6.6.10 Before every dye cycle, it is always a good practice to check the door-locking mechanism in both the open and closed positions to ensure that engagement of the locking device is even and complete over the entire circumference of the cover, and that the door locks correctly each time it is closed.
- 6.6.11 After loading the vessel and before the door is closed, all dirt and spillage should be cleaned from the locking parts of the door and the joint examined to confirm the door is properly seated in the groove.
- 6.6.12 Additional safety measures include provisions of the following:
- (a) a high standard of training, instruction and supervision of operatives;
 - (b) safe systems of work covering loading, unloading and clearance of blockages, as well as wearing of face shields and suitable protective clothing;
 - (c) on machines with multi-bolted doors, a door restraint or a seal breaking device to allow only partial opening of the door until any residual pressure has been released;
 - (d) on machines with quick opening doors, effective pressure and temperature interlocks, plus interlocks with the power and heating supplies; and
 - (e) on lidded vessels, the rim of the vessel to be at least 900 mm above the floor or working platform to reduce the risk of falling into the liquor when the lid is opened.

7 Emergency Preparedness

7.1 Overview

- 7.1.1 Emergency preparedness is vital to reduce injuries, ill-health and other damages, as quick and correct response is necessary in case of emergencies. In textile finishing, common emergency situations involving chemicals include fire, explosion, spills or release of hazardous chemicals, splashing of hot fluid, and any situation which result in personal injuries and acute illnesses.
- 7.1.2 As regards the emergency procedures in textile finishing, the management, assisted by its staff team, should:
- (a) identify and list out all possible emergency situations in the workplace;
 - (b) identify the effects and impact of the emergency situations;
 - (c) establish emergency response plans;
 - (d) provide and maintain emergency equipment and other necessary resources; and
 - (e) ensure that all staff are familiar with the arrangements in case of emergencies, through the provisions of instructions and training including regular drills.
- 7.1.3 Appropriate first aid facilities should be provided and adequate numbers of employees should be trained in first aid in accordance with the requirements under the *Factories and Industrial Undertakings (First Aid in Notifiable Workplaces) Regulations* or *Occupational Safety and Health Regulation* as appropriate.

7.2 Emergency planning

7.2.1 Emergency response plan should be established for handling all foreseeable emergency situations in the workplace. The plan should include:

- (a) assignment of responsibilities;
- (b) alarm systems;
- (c) emergency procedures; and
- (d) schedule for emergency drills to test readiness.

7.2.2 Assignment of responsibilities -- It is extremely important that all employees understand their own role in any emergency situation. A high-ranking staff member such as a line manager or a safety officer should be assigned to lead an emergency response team with the following responsibilities:

- (a) assessing the emergency situation in case of accident and taking necessary actions;
- (b) overseeing the implementation of the emergency response plan;
- (c) organising regular drills; and
- (d) ensuring that all emergency equipment are maintained in operating conditions.

Other supporting staff should be assigned to assist various emergency operations like fire-fighting or first-aid.

7.2.3 Emergency procedures -- Emergency procedures are instructions for the employees to follow in case of emergency situations. Appropriate procedures should be established for each type of emergency situations. Irrespective of the type of situations, the procedures should include the following:

- (a) reporting, declaring emergency and clearing off emergencies;
- (b) handling the special emergency situations;
- (c) evacuation; and
- (d) deployment of employees who must remain at work to perform critical operations before they evacuate.

7.2.4 Documentation -- The emergency response plans and other relevant information should be documented and communicated to all employees. Relevant information includes evacuation routes, the names and locations of the first aid team members, locations of safety equipment, telephone numbers of key personnel and emergency services. The documents in the form of manuals or notices should be kept or posted, as appropriate, in prominent places in the workplace that are easily accessible by all staff.

7.3 Emergency equipment

7.3.1 Appropriate emergency equipment should be provided for handling various emergency situations. These equipment include:

- (a) fire alarm pull station;
- (b) fire-fighting equipment, such as fire hose, fire extinguisher and fire blanket;
- (c) emergency lights and fume extraction in case of power failure;
- (d) shower and eyewash station;
- (e) first aid facilities; and
- (f) absorptive materials for cleanup of minor chemical spills.

7.3.2 All emergency equipment should be properly maintained. The equipment should be regularly checked for proper performance. Expired items should be disposed of appropriately and replaced whenever necessary. Locations of emergency equipment in the workplace should be made known to all staff.

8 Hazard Communication

8.1 Employers' responsibility

8.1.1 Under the provisions of the *Occupational Safety and Health Ordinance*, employers are obliged to provide such information as is necessary to ensure the safety and health of their employees at work.

8.2 Sources of hazard information

8.2.1 Limited yet essential hazard information about the chemical in use can be found on the label of its original container, whereas more detailed safety information can be obtained from the suppliers (chemical manufacturers, importers or distributors) or the respective material safety data sheet (MSDS). Other safety information sources include chemicals catalogues, chemistry journals, chemical handbooks and online databases.

8.3 Means of hazard communication

Labels

8.3.1 Labelling the container holding the hazardous substance is the most direct means of providing hazard information. The label should include the following hazard information:

- (a) identity of the substance -- chemical name or common name;
- (b) hazard classification and hazard symbol;
- (c) particular risks inherent in the substance; and
- (d) required safety precautions.

8.3.2 If it is not reasonably practicable for a container holding a hazardous substance to be labelled, a notice in respect of that substance with the following information should be displayed:

- (a) in English and Chinese;
- (b) identifying the container or containers holding that substance;
- (c) setting out clearly and indelibly the particulars as required by the *Factories and Industrial Undertakings (Dangerous Substances) Regulations*;
- (d) in a conspicuous place near the hazardous substance; and
- (e) with the symbol or symbols required to be shown not less than one-tenth of the area of the notice.

Detailed requirements on labelling dangerous substances are prescribed in the *Factories and Industrial Undertakings (Dangerous Substances) Regulations*.

Material safety data sheet (MSDS)

8.3.3 MSDS gives more detailed hazard information. A copy of the MSDS of each hazardous substance should be kept in the workplace and readily accessible by the employees. These safety data sheets are vital in the risk assessment of the hazards associated with the use and handling of the substances.

8.3.4 A standard format of MSDS (e.g. complying with ISO 11014-1) contains the following information, most of which are essential for risk assessment purpose:

- (i) product and company identification;
- (ii) composition/information on ingredients
- (iii) hazards identification;
- (iv) first-aid measures;
- (v) fire-fighting measures;
- (vi) accidental release measures;
- (vii) handling and storage;
- (viii) exposure controls/personal protection;

- (ix) physical and chemical properties;
- (x) stability and reactivity;
- (xi) toxicological information;
- (xii) ecological information;
- (xiii) disposal considerations;
- (xiv) transport information;
- (xv) regulatory information; and
- (xvi) other information.

Standard operating procedures

8.3.5 For processes involving hazardous substances, hot liquids, pressurized equipment, and any other processes that may incur risks to safety and health, hazard information and risk control measures should be stated clearly in the respective standard operating procedures and made known to the employees concerned.

Information, instruction and training

8.3.6 Employees should be adequately informed of and instructed on the following:

- (a) the safety information (e.g. MSDS) about the hazardous substance that they could be exposed to, including the nature of the hazards, exposure standards, possible routes of entry into the body and risks to health;
- (b) information on the proper use of and hazards associated with plant and equipment;
- (c) proper work practices and procedures to be followed in relation to the use, handling, storage, transportation, cleaning up and disposal of any hazardous substances when carrying out the finishing processes;
- (d) correct labelling of substances and the significance of label details;

- (e) the location, content and significance of safety signs, warning placards and material safety data sheets (MSDS) or equivalent information of the substances;
- (f) measures to control risks of exposure to hazardous substances and the reasons for such control measures;
- (g) emergency response procedures, including location and use of emergency equipment and facilities such as first-aid, washing, fire-fighting;
- (h) procedures for reporting faults and incidents, including spills; and
- (i) proper selection, use and maintenance of PPE.

8.3.7 Information and instruction can be provided to the employees by:

- (a) documentation in the form of safety manual, work procedures and emergency procedures is the primary means and the documents should be located in prominent locations in the workplace accessible by the employees; and
- (b) other means such as notice, poster, and video show should be used as appropriate in arousing the safety awareness on handling of hazardous substances and processes in textile finishing.

8.3.8 Training helps employees to acquire the necessary skills and knowledge to follow safe working procedures, take appropriate control measures, use appropriate personal protective equipment and follow emergency procedures. Training should also enable employees to participate in decision making relevant to safety and health in their workplace.

8.3.9 Employers should ensure that all levels of staff carrying out any textile finishing processes, e.g. workers, supervisors, store-keepers, emergency personnel and safety and health representatives, are adequately trained.

- 8.3.10 Training should be an ongoing process so that employees learn about new developments, and their knowledge and skills continue to improve. Refresher training is useful and should be provided, especially to employees returning from an extended period of leave or sickness absence, or when changes in the workplace render previous training obsolete.
- 8.3.11 Training should be reviewed to make sure that employees are gaining the skills and knowledge they need. Employers should ensure that their employees, after undergoing the appropriate training, understand what they have been taught.
- 8.3.12 The employers should keep the training record which should include:
- (a) the names of employees receiving training and the dates of attendance;
 - (b) an outline of the course contents; and
 - (c) the names and credentials of persons providing the training.

Appendix I

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Enquiries

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