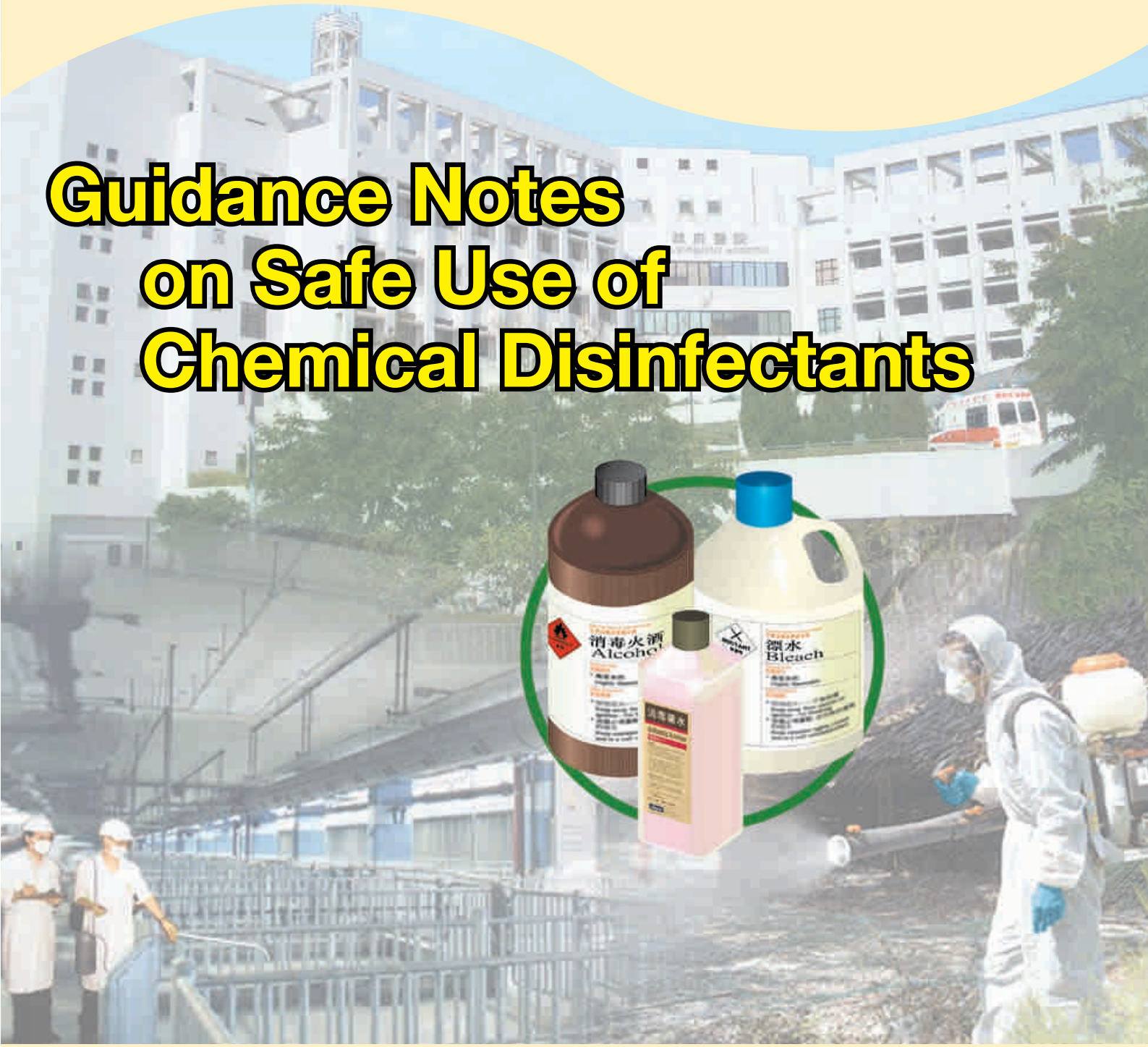
Chemical Safety in the Workplace

Guidance Notes on Safe Use of Chemical Disinfectants



Occupational Safety and Health Branch
Labour Department

Safety at work

Occupational Safety & Health Council

Chemical Safety in the Workplace

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1 Preface

Chemical disinfectants are chemical substances used to control, prevent, or destroy harmful microbes. Workers in hospitals, health care facilities, poultry facilities, abattoirs, food products manufacturing plants, sanitary and similar services, etc. frequently use chemical disinfectants to eradicate the diseases causing microbes.

Chemical disinfectants could be hazardous to workers if they are not properly handled. Some of the chemical disinfectants are flammable and explosive. They may react with incompatible chemicals violently and generate toxic gases. All chemical disinfectants are, by their very nature, potentially harmful or toxic to living organisms. Like other toxic substances, the chemical disinfectants could be harmful to humans upon entering the body.

However, the chemical disinfectants would be effective and safe tools when handled properly with the safety measures in place. If misused, they can be hazardous and harmful to workers.

This set of Guidance Notes would serve as a reference to facilitate users in identifying the hazards arising from the use of chemical disinfectants and taking effective safety measures. Users are encouraged to refer to the information provided in these Notes for establishing a chemical safety programme suitable for their working environment.

2 Introduction

Disinfection is a process in which chemical or physical means is used to control or destroy the microorganisms that are capable of causing diseases. There are three levels of disinfection[1] (i.e. high, intermediate and low level) with respect to the effectiveness of the disinfection.

Disinfecting agents are substances used to control or destroy harmful microorganisms such as bacteria, viruses, or fungi. Many disinfectants are non-specific in their action and will act against a spectrum of microorganisms. Chemical disinfectants can be grouped in accordance with their chemical properties. They work on various modes of action to destroy the microorganisms such as by rupturing the cell wall, denaturing proteins or lipids, oxidation, alkylation, etc. The efficacy of a disinfectant hinges on various factors including concentration, contact duration, temperature, pH, the presence of organic matters and metal ions.

Choice of the disinfectant to be used depends on the particular situations. Some of the disinfectants are adopted because of the wide spectrum of destroying microorganisms in order to achieve effective disinfections. Others destroy a smaller range of disease-causing organisms but are preferred because the chemical disinfectants are less or non-toxic to human and the level of disinfections required is low. There are disinfectants which possess surfactant effect and are used to clean and disinfect in "one-step" process.

Workers in hospitals, health care facilities, poultry facilities, abattoirs, food products manufacturing plants, sanitary and similar services, etc. frequently use chemical disinfectants to destroy diseases causing microorganisms. Some of the chemical disinfectants are flammable and explosive. There are disinfectants that would react with incompatible chemicals violently and generate toxic gases posing hazards to workers. All chemical disinfectants are, by their very nature, potentially harmful or toxic to living organisms. Like other toxic substances, the chemical disinfectants can enter the body through several routes, including absorption through skin or mucous membrane, inhalation and ingestion. Sometimes a chemical substance can enter through more than one of the routes. However, chemical disinfectants would be effective and safe tools when handled properly with the safety measures in place. If misused, they can be hazardous and harmful to workers and the environment.

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[1] *High-level disinfection* destroys all microorganisms, with the exception of high numbers of bacterial spores.
Intermediate-level disinfection controls *Mycobacterium tuberculosis*, vegetative bacteria, most viruses, and most fungi, but does not necessarily destroy bacterial spores.
Low-level disinfection destroys most bacteria, some viruses, and some fungi, but it cannot be relied on to destroy resistant microorganisms such as *Mycobacterium tuberculosis* or bacterial spores.

3 Chemical Disinfectants Classes

Disinfectants can be divided into classes on the basis of their chemical compositions and each class has its characteristics, hazards, toxicities and efficacy against various microorganisms. The classes are as follows:

3.1 Alcohols

Alcohols, usually in the form of 70% isopropyl alcohol or 60 to 80% ethyl alcohol, are commonly used topical disinfectants. They are effective against bacteria and enveloped viruses. Alcohols are not effective against bacterial spores and non-enveloped viruses. Alcohols are somewhat slow in their germicidal action.

3.2 Aldehydes

Aldehydes are broad-spectrum disinfectants. The most commonly used agents are formaldehyde and gluteraldehyde. Aldehydes are very effective against bacteria, fungi, viruses, mycobacteria and bacterial spores.

3.3 Chlorine Compounds

Chlorine compounds are considered broad spectrum, being effective against bacteria, enveloped and non-enveloped viruses, mycobacteria and fungi. At high concentrations, chlorine compounds can be sporicidal. The most commonly used agents are chlorine dioxide, sodium hypochlorite (Chlorine Bleach) and calcium hypochlorite.

3.4 Iodine Compounds

Iodine compounds are broad spectrum and considered effective for a variety of bacteria, mycobacteria, fungi and viruses. Tincture of iodine could be used as an antiseptic for skin cuts and scrapes. Iodine agents are inactivated by quaternary ammonium compounds and organic debris. An iodophor is a combination of iodine and a solubilizing agent or carrier; the resulting complex provides a sustained-release reservoir of iodine and releases small amounts of free iodine in aqueous solution to kill microbes.

3.5 Phenolics

The disinfectants are phenol (carbolic acid) derivatives. They have a characteristic pine-tar odor and turn milky in water. Phenols at 5% concentration are considered bactericidal, tuberculocidal, fungicidal and virucidal for enveloped viruses. They retain more activity in the presence of organic material than iodine or chlorine-containing disinfectants. Cresols, hexachlorophene, alkyl- and chloro- derivatives and diphenyls are more active than phenol itself.

3.6 Quaternary Ammonium Compounds

Quaternary ammonium compounds, such as benzalkonium chloride, are generally odourless, colourless, non-irritating, and deodorizing. The compounds have disinfectant effect and some have detergent action. However, some quaternary ammonium compounds are inactivated in the presence of some soaps or soap residues. Their antibacterial activity is reduced in the presence of organic material. Quaternary ammonium compounds are effective against bacteria but only and somewhat effective against fungi and viruses.

3.7 Oxidizing Agents

Common oxidizing agents are hydrogen peroxide, ozone, peracetic acid and potassium permanganate.

The hydrogen peroxide used as an antiseptic, is also effective in disinfection of inanimate objects. It could be sporicidal if operated at high temperatures. Peracetic acid is one of the effective liquid sporicides and is used widely in disinfection of food processing equipment and medical instruments because it does not leave toxic residues.

Potassium permanganate has broad antimicrobial properties. It is an effective algicide (0.01%) and virucide (1%) for disinfection, but tends to irritate tissues at concentrations > 1:10,000.

3.8 Others

Ethylene oxide has wide use as an disinfecting agent with very broad biocide activity against microorganisms including bacterial spores and viruses. It is a highly flammable chemical. It is toxic, mutagenic and carcinogenic. Chlorhexidine is a biguanide compound, one of the widely used disinfectants. It is effective against most bacteria and is non-irritating to tissues. Biguanide has a broad antibacterial spectrum, however it is limited in its effectiveness against viruses and is not sporicidal, mycobactericidal, or fungicidal.

4 Hazards

4.1 Overview

4.1.1 Chemical disinfectants are effective and safe tools for eliminating viruses and microbes when used properly. If not, they can be hazardous. The disinfectants could have dangerous properties that are potentially hazardous to workers, for example, ethylene oxide is highly flammable and explosive. Chemical disinfectants such as the strong oxidizers would generate toxic gaseous products upon reacting with other chemicals.

4.1.2 Many of the chemical disinfectants are harmful to workers if the disinfectants are unsafely handled. Some of the chemical disinfectants are irritating to the skin, eyes, and respiratory system. The highly corrosive disinfectants could inflict serious damage if they come into contact with the skin or eyes. The airborne disinfectants would also cause respiratory problems if used in poorly ventilated areas.

4.1.3 When selecting a disinfectant for a particular use, user should take into consideration the hazardous properties of the chemical disinfectant. Material Safety Data Sheet (MSDS) for all disinfectants used should be read and understood by all personnel, who will work with the chemicals.

4.2 Chemical hazards

4.2.1 Flammability is one of the potential dangers when chemical disinfectants are used. Alcohols are flammable liquids that could be ignited if used near a flame, spark or any ignition source particularly when the alcohols are applied by spraying as mist. Ethylene oxide is a highly flammable and explosive gas that has an explosive concentration range of 3% to 100% by volume. Formaldehyde gas, which is given off by either liquid formalin or paraformaldehyde powder, has a characteristic pungent odour and is highly flammable. It forms explosive mixtures with air and the explosive concentrations range from 7% to 73% by volume. Hydrogen peroxide possesses strong oxidizing properties and spilling high concentration peroxide solutions on flammable substance can cause an immediate fire. Sodium hypochlorite in aqueous solutions is not explosive but the anhydrous sodium hypochlorite becomes an explosive substance. Calcium hypochlorite is not flammable. However, it acts as an oxidizer with combustible materials.

4.2.2 Mixing chemical disinfectants with other chemical substances could be hazardous. Chlorine, which is a toxic gas, is rapidly released from sodium hypochlorite solutions (bleaching solutions) if mixed with acids for example, the acidic cleaning agents. In such circumstances, workers would be exposed to high concentrations of chlorine that could be fatal. Calcium hypochlorite decomposes readily in water or when heated, releasing oxygen and toxic chlorine. It may react explosively with ammonia, amines, or reducing agents. When formaldehyde is mixed with strong oxidizers, violent reactions could occur. Mixing formaldehyde solution (formalin) with potassium permanganate could cause an explosion.

4.3 Health hazards

4.3.1 Formaldehyde is an effective disinfectant. It is a toxic and carcinogenic chemical and can cause eye irritation, cough, shortness of breath, skin irritation, chronic bronchitis and exacerbation of asthma. It can also react with chlorine to form another carcinogen. Ethylene oxide is toxic by inhalation. It is also an irritant to the skin, eyes, and the respiratory tract. Ethylene oxide may damage the nervous system, and the chemical is also a carcinogen.

4.3.2 Glutaraldehyde is a strong irritant to the skin, eyes, and respiratory system. Contact with the chemical can cause skin sensitisation, leading to allergic contact dermatitis. Exposure to the chemical may exacerbate asthma. High concentrations of hypochlorite are irritating to the mucous membranes, eyes and skin. Concentrated hydrogen peroxide solution is corrosive and the domestic-strength peroxide solutions could cause local burns, irritation of the mucous membranes, eyes and the skin. Quaternary ammonium compounds might cause mild to severe irritation of the skin and mucous membranes depending on the chemical properties and the concentration. Allergic reactions can occur to workers handling iodine solutions and iodophors. Concentrated iodine compounds can be irritating to skin. Phenols disinfectants may cause irritation of the skin, local burns, headache, vomiting, diarrhoea, and damage to the kidneys in severe cases. Alcohol disinfectants can be irritating to the injured skin. Inhalation of concentrated alcohol vapour may cause irritation of the respiratory tract and have effects on the central nervous system.

5 Chemical Safety Programme

5.1 Overview

5.1.1 To ensure the safety and health of employees engaged in handling disinfectants, a carefully planned chemical safety programme is essential. The aim of a chemical safety programme is to systematically identify and investigate potential hazards in order to minimize the risk of adverse health and safety effects due to exposure to chemicals in the workplace. In the programme, the chemical hazards of disinfectants should be firstly identified. The risks arising from these hazards are assessed taking account of the work situations and personnel involved. Appropriate preventive and/or control measures are then set up to eliminate or mitigate the risks, with their effectiveness being regularly monitored and reviewed. The associated hazard information and protective measures should be communicated to all affected employees. The chemical safety programme should also include other elements like planning of emergency responses and training of employees.

5.1.2 The chemical safety programme should be organized and integrated into the overall safety management system of the workplace to facilitate its effective implementation. Employers should deploy adequate manpower and resources for the development, implementation and maintenance of the programme.

5.2 Major elements

5.2.1 A chemical safety programme should include the following major elements:

(a) risk assessment – to identify the potential hazards arising from the materials and processes involving the use of disinfectants and to assess their associated risks taking into account the adequacy and effectiveness of existing control measures;

(b) safety measures – to adopt and maintain preventive and/or control measures to eliminate the risks or minimize them to acceptable levels;

(c) emergency preparedness – to establish plans and procedures for emergency response;

(d) hazard communication – to establish appropriate and effective means to disseminate the safety and health information on the materials and processes to employees via adequate instruction and training; and

(e) monitoring and review – to monitor the effectiveness of the adopted safety measures with regular review and revision which may also be required for any new requirements or significant changes in the materials or processes.

5.2.2 Depending on individual situation of the workplace, employers may find it beneficial to include other elements such as inspection, accident investigation and health surveillance in the chemical safety programme.

6 Risk Assessment

6.1 Overview

6.1.1 Risk assessment is a process to estimate the level of risk and decide whether the risk is tolerable or acceptable. Before risks can be assessed, the hazards related to the process and associated disinfectants have to be identified. The risks are then estimated in terms of the people who might be involved and their exposure, the likelihood and potential consequences of the identified hazards. Suitable safety measures will then be developed and implemented with periodic monitoring and reviews.

6.2 Factors for consideration in the risk assessment

6.2.1 Many factors can influence the risk of hazards associated with chemical disinfectants in the workplace. These include physical, chemical and toxic properties of the disinfectants, work practices, the nature and duration of the exposure, the effects of combined exposures, the routes of entry into the human body, and the susceptibility of the worker.

6.2.2 It should be noted that many of the chemical disinfectants are proprietary prepared formulations and their chemical components may not be shown in detail on the containers. Employers who use the chemical disinfectants should obtain detailed hazard information and user safety precautions from the suppliers.

6.2.3 Reference should be made to relevant legislation, codes of practice, guidelines and best trade practices in order to decide on the need and adequacy of safety measures. Employers should keep an inventory of all chemical substances in the workplace, identify whether they are hazardous and ensure that they are handled and stored safely. It is also essential to obtain the Material Safety Data Sheet (MSDS) of the chemical disinfectants from the suppliers, as it contains a wealth of information indispensable for risk assessment, stipulation of safety measures and emergency planning.

6.2.4 The risk assessment should be reviewed regularly and whenever there is any indication to suspect that it is no longer valid or when there has been a significant change in the circumstances to which the assessment relates. In particular, the risks associated with the processes and chemical disinfectants should be reviewed when:

(a) there are changes to any of the processes or their scales;

(b) there are changes in the materials used; or

(c) safer procedures or improved preventive measures become available or reasonably practicable in light of recent technological advancement.

6.2.5 When assessing airborne exposure, the *Code of Practice on Control of Air Impurities (Chemical Substances) in the Workplace* issued by the Labour Department should be followed.

6.2.6 Risk assessment should be performed by competent persons who are well knowledgeable about the hazards associated with the chemical disinfectants and related processes including the physical and chemical changes at each stage of the processing work. Specialist or expert advice should be consulted whenever needed.

6.2.7 The *Chemical Safety in the Workplace: Guidance Notes on Risk Assessment and Fundamentals of Establishing Safety Measures* published by the Labour Department provides detailed information about the systematic approaches for conducting risk assessment related to chemical hazards.

7 Safety Measures

7.1 Strategy in establishing safety measures

7.1.1 The primary consideration is to adopt appropriate preventive measures such as by elimination or substitution in order to directly remove the hazards at source. On many occasions, a chemical disinfectant or process can be replaced by a safer one that eliminates or minimizes the risks to acceptable level. If such measures are not possible, segregation of the disinfectants or the processes or other control measures should be taken. The use of personal protective equipment should only be considered a supplementary means or as the last resort to minimize workers' exposure to the hazards.

7.1.2 Safety measures can be realised by engineering and administrative controls. Engineering control measures such as installation of suitable types of ventilation can eliminate or lower the level of disinfectant in the air at source. Administrative control measures such as by implementation of safe work practices and scheduling of breaks or rotating shifts can limit worker's time spent near the hazard thus reducing their exposure. The adoption of good housekeeping practices could not be more emphasized when disinfectants are concerned.

7.1.3 It is desirable to consider safety and health aspects of the materials, processes and equipment at the design or purchase stage. This will save additional expenses and often reduce practical difficulty in subsequent adjustments to accommodate the safety features. Management should also keep abreast of the up-coming safety alternatives or devices that are available on the market.

7.1.4 All safety measures should be documented, for example, in the standard operating procedures (SOP), and should be made known to the workers concerned. The effectiveness of such measures should be constantly monitored and reviewed to ensure adequacy of the adopted safety measures. If any changes are made to the SOP in respect of the use of disinfectants, a fresh risk assessment should be conducted and any amended protective measures should be documented in the SOP accordingly.

7.2 Substitution/ Elimination

7.2.1 There are occasions where a hazardous chemical disinfectant could be substituted by using other less harmful disinfectants to minimize or eliminate risks, for example, ortho-phthalaldehyde (OPA) has been used as glutaraldehyde alternative.

7.2.2 In addition to chemical disinfectants, heat, radiation or other physical means may also be appropriately used to reduce or eliminate microbes. As such, hazardous chemical disinfections process could be replaced by physical methods where applicable. Objects could be disinfected effectively using steam under pressure (autoclave), dry heat (flame, baking) or gamma radiation.

7.3 Engineering control measures

7.3.1 The primary objective of adopting engineering control is to eliminate or lower the risks at source. Engineering controls include ventilation, enclosure and isolation.

7.3.2 Ventilation is one of the effective engineering means to prevent accumulation of vapours of explosive/flammable mixtures or inhalation of toxic gases or vapours in the workplace. There are two types of ventilation: general dilution ventilation and local exhaust ventilation. Whatever the type, ventilation should be used together with other methods of control to strengthen the safety protection. Attention must be paid to the relevant environment protection requirements in the discharge of exhaust air to prevent contamination of the outside environment. Enclosure is an alternative means to contain hazardous substance or work process if the substance and process cannot be eliminated or substituted. Highly toxic chemical could be handled in a closed glove box. Isolation is a safety measure to control exposure to hazards. Worker could be isolated from hazardous working environment by engineering control measures, for example using isolation booth etc.

7.4 Administrative control measures

7.4.1 Administrative control measures include arrangement of work schedules and stipulation of safe work practices so that the risk of exposure of individual employee to chemical disinfectants can be reduced. Employers should ensure that these are incorporated into the management system as far as practicable. Typical safe work procedures that reduce the worker's exposure to chemical disinfectants should include the following:

(a) ensuring the time spent near the hazard is kept to minimum. Workers should not stay between the work piece and the extraction system during operation;

(b) keeping pots or bottles of chemical disinfectants closed when not in use;

(c) avoiding skin contact with chemical disinfectants;

(d) keeping minimum amount of chemical disinfectants for use in the workplace, usually no more than a half-day's or one shift's supply; and

(e) adopting general practices of good housekeeping.

7.5 Personal protective equipment (PPE)

7.5.1 The primary objective of using PPE is to supplement other control measures by minimizing worker's risks of exposure to chemical disinfectants through inhalation or skin contact. Being only passive protective measures PPE should not replace preventive measures and in general, it should be considered as the last resort in respect of the safety measures outlined in this section.

7.5.2 Appropriate PPE should be chosen with regard to the hazards and physical nature of the chemical disinfectants and their routes of entry into the human body. The MSDS information and risk assessment will help determine the PPE requirements. Before and after use, PPE should be inspected for any signs of damage. It should be regularly cleaned and stored in good condition. Contaminated PPE should be properly treated or disposed of as appropriate, and replacement sets kept readily available. Moreover, as no PPE will give long-term protection, a programme should be in place for its regular replacement.

7.5.3 Wrongly selected, improperly used or maintained PPE may do more harm than good as the user may have a false sense of security. Readers should refer to *Chemical Safety in the Workplace: Guidance Notes on Personal Protective Equipment for Use and Handling of Chemicals* for details.

Protective clothing

7.5.4 Protective clothing protects the skin or personal clothing from contact with chemical disinfectants and prevents spread of contamination. When handling chemical disinfectants, such as dispensing and storage, or conducting work processes involving chemical disinfectants, employees should always wear suitable protective clothing. Protective clothing includes gloves, aprons, gowns and overalls. It is important to choose protective clothing made of materials that resist penetration or damage by the chemical disinfectants involved.

7.5.5 It is prudent to always check with the suppliers and consult the MSDS of the chemical disinfectants involved.

Face and eye protection

7.5.6 Where there is a reasonably foreseeable risk of eye injury, suitable goggles, eyecup or cover types eye protectors should be worn. Special-purpose goggles may be required for irritating mist. If protection to the whole face including mouth, nose and eyes is required, face shield should be used.

Respiratory protective equipment

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

7.5.8 RPE should be used to protect the workers where engineering control is not reasonably practicable such as during maintenance work, cleaning, or emergencies where hazardous vapour is generated from chemical spillages or inadvertent mixing of incompatible chemicals.

7.5.9 The choice of RPE depends on the air contaminants concentration, duration of exposure and physical and chemical nature of the chemical disinfectants.

7.5.10 The following RPE can protect against airborne chemical contaminants:

(a) air purifying respirators – when fitted correctly, most half-face and full-face respirators equipped with appropriate filters could reduce the exposure to air contaminants by 90% and 98% respectively; many powered air-purifying respirators that use battery-operated motor blower to draw air through filters have similar efficiency.

(b) airline respirators – airline respirators supply clean air to the mask, helmet or hood using an airline, and the device could reduce the exposure to air contaminants by 96% to 99.9%, depending on the type of covering.

7.6 Precautions during handling and storage

7.6.1 When selecting a disinfectant, its health effects on human, the extent of exposure, and the appropriate health and safety precautions should be considered. Different disinfectants should not be mixed or used in combination without proper assessment of the risks and potential hazardous reactions, and taking proper safety measures. It should be noted that chemical disinfectants must not mix with incompatible chemicals. For example, it should never mix bleach with ammonia or with acidic products including drain, toilet bowl, and metal cleaners. Toxic fumes (strong enough to be fatal) will result. If necessary, use detergents first and rinse thoroughly with water before using bleach for disinfection. It is also known that mixing peroxide disinfectants with cleaner agents containing acids or alkalis could form hazardous explosive mixtures.

7.6.2 Full-strength concentrates are seldom used for disinfection purposes. Working concentrations should not exceed manufacturers' specifications as overdosing increases the risk to operators, in addition to being wasteful, and may damage plant and equipment.

7.6.3 Diluting disinfectant concentrates by manually tipping drums is a poor practice; it will inevitably cause a spill risk and should not be carried out. Proper dispensing device or equipment should be used to prevent spillage during the transfer of disinfectant concentrates for dilution. Mixing of solution should also be performed carefully to avoid splashing. Where appropriate, purchasing disinfectants in their dilute form or in pre-pack quantities for direct dilution are the safer options.

7.6.4 Responsible person should select a workplace with mechanical extraction ventilation for diluting disinfectants, if it is not practicable, work in open air and keeping away from other persons could also be considered. Proper personal protective gear should be used when disinfectants are handled, as most are harmful and some are even toxic. For example, when aldehydes are used, personal protective equipment such as gloves, protective clothing and eyes protection should be worn; respiratory protective equipment may also be necessary.

7.6.5 Chemical disinfectants should be stored separately from incompatible chemicals in a cool and ventilated area protected from direct exposure to sunlight. Some of the chemical disinfectants, such as concentrated peroxides, are shock sensitive and they should be handled carefully.

7.6.6 Alcohols, which are flammable, require appropriate precautions in storage and use. Small quantities of alcohols should be stored in a fire-resisting cupboard or bin with clear markings outside the container when not in use. Large quantities of alcohols should be stored in a separate fire-resisting room constructed in accordance with the requirements of the *Dangerous Goods Ordinance (Chapter 295).*

7.6.7 It is often illegal, as well as unsafe, to dispose of hazardous materials improperly. Waste of different nature of disinfectants should be disposed in separate containers labelled with the name and type of the chemical waste in prominent area according to their chemical nature. Chemical waste should be held in containers of suitable design and construction to prevent leakage or spillage of the contents under normal conditions of handling, storage and transport. The *Code of Practice on the packing, labelling and storage of chemical wastes* issued by the Environmental Protection Department should be followed when disposing chemical wastes.

7.7 Health surveillance

7.7.1 Employers are recommended to carry out health surveillance if exposure of any employee to any chemical disinfectant is such that:

(a) an identifiable disease or adverse health effect may be related to the exposure;

(b) there is a reasonable likelihood that the disease or effect may occur under the particular conditions of work; and

(c) there are valid tests for detecting the disease or the effect. To this end, physicians knowledgeable in occupational medicine practice should be consulted for advice.

8 Emergency Preparedness

8.1 Overview

8.1.1 Emergency preparedness is vital to provide quick and effective response to industrial incidents that may result in injuries, loss of life and damage to property. During the use of disinfectants, emergency situations mainly arise from chemical spillages, emission of noxious fumes, and on some occasions from fire and explosion.

8.1.2 In regard to chemical safety and health in the use of disinfectant, the employer or management should:

(a) identify and list out all possible emergency situations in the workplace;

(b) assess the effects and impacts of the emergency situations;

(c) develop and implement an emergency response plan, which may include procedures to handle minor leaks and spills, and an evacuation plan ;

(d) provide and maintain emergency equipment and other necessary resources; and

(e) ensure that staff are familiarized with the arrangements in case of emergencies by providing procedural instructions and employee training and organizing drills.

8.1.3 Appropriate first aid facilities and adequate numbers of trained first-aiders as required by the *Occupational Safety and Health Regulation* should be provided.

8.1.4 The MSDS in respect of handling accidental release of disinfectants and disposal of waste should be consulted.

8.2 Emergency response plan

8.2.1 An emergency response plan should be established for handling various foreseeable emergency situations in the workplace. It should provide the following:

(a) assignment of responsibilities;

(b) alarm systems;

(c) emergency response procedures; and

(d) schedule for emergency drills.

8.2.2 Assignment of responsibilities – It is extremely important that all employees understand their own roles during any emergency situations as assigned in the overall safety plan. In particular, the head of the emergency response team should be charged with the following duties:

(a) assessing the emergency situation and taking necessary actions;
(b) overseeing the implementation of the emergency response plan;
(c) organising regular drills; and
(d) ensuring all emergency equipment is well maintained.

8.2.3 Emergency response procedures – Emergency response procedures are operating instructions for employees to follow in case of emergency situations. Appropriate procedures should be established for each type of emergency situations and cover the following:

(a) reporting, declaring and clearing off emergencies;
(b) handling of emergency situations;
(c) evacuation; and
(d) deployment of employees to perform critical operations before they evacuate.

8.2.4 The emergency response plan and related information should be documented and communicated to all employees: evacuation routes, names and locations of first aid team members, locations of safety equipment, telephone numbers of key personnel and emergency services. The documents should be kept or posted in prominent places in the workplace. Handling of spillages of hazardous chemicals and other emergencies should be included in the chemical safety programme.

8.3 Emergency equipment

8.3.1 Appropriate emergency equipment should include but not limited to:

(a) fire alarm;
(b) fire-fighting equipment, such as fire hoses, fire extinguishers and fire blankets;
(c) emergency lights and backup for fume extraction in case of power failure;
(d) emergency showers and eyewashes;
(e) first aid facilities, such as first aid kit; and
(f) absorbent material for cleanup of minor chemical spills.

8.3.2 All emergency equipment should be properly maintained and regularly inspected for proper performance. Expired items should be replaced. Locations of emergency equipment in the workplace should be made known to all staff.

9 Hazard Communication

9.1 Overview

9.1.1 Under 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.

9.1.2 The information is indispensable in the identification of potential hazards related to the use and handling of workplace chemicals during risk assessment and preparation of emergency response plans.

9.2 Sources of hazard information

9.2.1 Limited but essential hazard information can be found on the label of the container of the substances, whereas detailed information can be obtained from the suppliers (chemical manufacturers, importers or distributors) of the chemicals. Other information sources include chemicals catalogues, chemistry journals, chemical handbooks and online databases.

9.3 Means of hazard communication

9.3.1 Typical means of hazard communication include labels, MSDS, standard operating procedures and employee training. Employers may also find placards, notices and signboards useful for their workplaces.

Labels

9.3.2 Labelling each container containing hazardous substance is the most direct means of hazard communication. The label should include the following information:

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

9.3.3 If it is not reasonably practicable to put full information on a container, the container should at least be labelled with the identity of the chemical and the hazard group(s) and symbol(s). Other required information can be given in an information sheet placed in the close vicinity. Statutory requirements for labelling of dangerous substances are prescribed in the *Factories and Industrial Undertakings (Dangerous Substances) Regulations.*

Material Safety Data Sheet (MSDS)

9.3.4 An MSDS provides important source of information about a specific chemical used in the processing work, especially when the chemical is used for the first time. The information includes safe handling and storage of the chemical, first-aid procedures, potential effects of contact and measures to take in the event of a spill or leak. ISO 11014-1 recommends a standard format for the MSDS, which contains the following sixteen sections or headings of information:

(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 (SOP)

9.3.5 Hazard information can also be communicated via SOP, which refer to a set of systematic step-by-step written procedures to be followed for completing a process or operation. The SOP should describe the tasks to be performed, data to be recorded, operating conditions to be applied with associated safety and health precautions.

9.3.6 The inclusion of appropriate hazard information in SOP relies very much on how thorough and thoughtful the risk assessment is undertaken, so as to effectively eliminate or control the risks in the entire process.

10 Information, Instruction and Training

10.1 Overview

10.1.1 After assessing the risks in the workplace and adopting appropriate preventive measures, employers should make sure that their employees fully understand the risks at work, and that the work practices can help them perform their jobs safely. To achieve this, employees should be provided with adequate safety information, instruction and training.

10.2 Information and instruction

10.2.1 Employees should be informed of the following:

(a) safety information about the disinfectants regarding the risks that they could probably be exposed to, including the nature of hazards, exposure standards, possible routes of entry into the body and risks to health;

(b) correct labelling of disinfectants and the significance of label details;

(c) content and significance of MSDS;

(d) measures to reduce the risks of exposure to disinfectants, including practice of personal hygiene;

(e) safe work procedures on the use, handling, storage, transportation, cleaning up and disposal of disinfectants;

(f) information on the safe handling of plant and equipment;

(g) emergency response procedures, including locating and using emergency equipment and facilities for first aid, decontamination and fire-fighting;

(h) procedures for reporting faults and incidents, including spills; and

(i) proper selection, use and maintenance of PPE.

10.2.2 Information and instruction should be provided to employees by:

(a) SOP, safety manual, and emergency procedures being located in prominent locations in the workplace easily accessible by employees;

(b) others such as notice, poster and video show arousing the safety awareness of everyone on handling disinfectants and relating processes.

10.3 Employee training

10.3.1 Employees should be informed of the hazards arising from the use of disinfectants. Training in proper handling and storage of disinfectants should be provided and employees should be familiarised with the SOP if there were any. The training should also include emergency procedures for dealing with incidents. Periodic refresh training should be arranged. Content of the training programme should include those information and instruction aspects.

10.3.2 Training helps employees to acquire the necessary skills and knowledge that enable them 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 workplace safety and health.

10.3.3 Employers should ensure that all persons involved in the use of disinfectants, including workers, supervisors, store personnel, emergency personnel and safety and health representatives, are adequately trained.

10.3.4 Training should be an ongoing process so that employees can learn about the new developments of workplace safety and continue to improve their relevant knowledge and skills. Refresher training is useful and should be provided, especially to employees returning from an extended leave or when there are changes of work procedures or chemicals that may render previous training obsolete.

10.3.5 The training programme should be reviewed periodically to make sure that employees are gaining the skills and knowledge they need. Employers should also ensure that their employees, after undergoing appropriate training, understand what they have been taught.

10.3.6 Employers should keep track of the training and records of training normally, which should include at least the following:

(a) names of employees receiving training, and dates of attendance;
(b) outline of the course content; and
(c) names and credentials of trainers.

Appendix I

Some Common Chemical Disinfectants

Some of the common chemical disinfectants and their characteristics are described in the following paragraphs. Each of the chemical disinfectants has its characteristics, hazards and efficacy against various microorganisms.

1. **Ammonium hydroxide** is a colourless liquid that is commonly found as household ammonia. It has a strong irritating odour and is corrosive at high concentrations. Ammonium hydroxide is an alkali. Alkalis have been used as disinfectant against a wide range of pathogens including most bacteria and viruses. The disinfection activity of alkalis is slow but increases with higher temperature. Alkalis are ineffective against the non-enveloped viruses and bacterial spores.

2. **Benzalkonium chloride** and **cetylpyridinium chloride** are quaternary ammonium compounds that are widely used as disinfectants. They are cationic detergents. Benzalkonium chloride and cetylpyridinium chloride are reported non-toxic at use-dilution concentrations. However, prolonged contact with the disinfectants at high concentrations can irritate the skin. They are effective against bacteria, fungi and enveloped viruses. The disinfectants have residual effect, keeping surfaces bacteriostatic for a brief time. Benzalkonium chloride and cetylpyridinium chloride are the active ingredients in disinfectants for homes, farms, hospitals, offices, etc. The compounds are considered stable in storage but are easily inactivated by organic matters, anionic detergents, soaps and hard water.

3. **Calcium hypochlorite** is a widely used chlorine compound that is highly effective against bacteria, algae, fungi and other microorganisms. Calcium hypochlorite is adopted primarily to chlorinate swimming pool and to treat water supplies and sewage. It is also frequently used as a bleaching agent and sanitizer in industrial applications. Calcium hypochlorite disinfectant usually contains 65% available chlorine. As calcium hypochlorite is a strong oxidant, there are fire and explosion risks on contact with acids, combustible substances and reducing agents. It reacts violently with many other substances including ammonia, amines, nitrogen compounds, etc. causing explosion hazard.

4. **Calcium oxide (CaO)**, commonly known as **lime** or **quicklime**, is a white caustic solid. It is soluble in water, forming calcium hydroxide and generating heat. Contact with water or moisture may generate enough heat to ignite nearby combustible materials. Calcium oxide reacts violently with acids and halogens. Dissolved in water, calcium oxide forms a medium strong alkali that has biocidal effect on some bacteria and viruses. The chemical is often used to disinfect animal carcasses. Solutions of slaked lime (i.e. calcuim hydroxide) are used to disinfect premises. Calcium oxide is corrosive and can severely irritate and burn the skin and eyes on contact. Inhalation of calcium oxide dust will cause respiratory discomfort.

5. **Chlorhexidine** is one of the biguanide disinfectants that destroy microorganisms by damaging the cell membrane permeability. It is reported non-irritating and, while considered a bactericidal, virucidal and fungicidal, is less effective against these agents than many other disinfectants. Chlorhexidine could maintain effectiveness in the presence of organic matters.

6. **Cresol** and **hexachlorophene** are phenol disinfectants. The phenols are broad-spectrum disinfectants. They are ideal for destroying many bacteria but less effective against viruses. They are not active against bacterial spores. The disinfectants are applicable in situations where a heavy load of organic materials is present. Phenol compounds are the active ingredients in most bottles of "household disinfectant". The compounds are commonly found in scrub soaps and surface disinfectants. Phenol compounds can be irritating to the skin and eyes and have a distinct odour. When phenol compounds are breathed, ingested, or applied to the skin at high concentrations, they can be very harmful. Ingestion of phenol compounds may cause vomiting, circulatory collapse, paralysis, convulsions, and coma.

7. **Ethyl alcohol**, also known as ethanol, a colourless, volatile, highly flammable liquid with characteristic odour. Ethanol is an effective disinfectant that is commonly available. Its rapid killing action and lack of chemical residue make chemical ideal for disinfection for many medical items. The activity of ethanol drops sharply when diluted to below 50% in concentration, with the optimal concentration range being 60-90% solutions with water (volume/volume). Ethanol and solutions containing more than 50% ethanol are flammable and easily ignited. Excessive exposure to ethanol could pose health hazards.

8. **Ethylene oxide** is used primarily as a means of sterilizing heat-sensitive materials such as medical preparations and instruments. It is active against a wide variety of bacteria, fungi, and viruses. Ethylene oxide is a colourless and odourless gas. It is highly toxic, flammable and explosive. Ethylene oxide has an explosion concentration range of 3-100% in air by volume. It is an irritant to the skin, eyes and respiratory system. Ethylene oxide may damage the nervous system. It is a carcinogen.

9. **Formaldehyde** is a toxic and colourless gas with pungent and suffocating odour at room temperature. Formaldehyde is a carcinogen. The chemical is readily soluble in water. Commercial formaldehyde chemical is produced and sold as an aqueous solution (formalin) containing 37-50% formaldehyde by weight. Aqueous formaldehyde could be used as a disinfectant or preservative. Besides being a liquid disinfectant, formaldehyde may be used as a fumigant to disinfect objects surface and air.

10. **Glutaraldehyde** (1,5-pentanedial) is an effective disinfectant against bacteria, fungi and viruses. Glutaraldehyde is widely used as an antimicrobial agent in a variety of applications such as in cooling water systems, paper-pulp industry, poultry industry, cosmetic field, microbiological field, food industry and medical area. The extensive use of this biocide is due to being non-corrosive to metals, stainless steel, rubber, etc. Glutaraldehyde is soluble in water and organic solvents and the solutions are stable for long periods of time. Its efficacy is highly dependant on pH and temperature. Glutaraldehyde works best at a pH greater that 7 and high temperatures. It is considered more efficacious than formaldehyde in the presence of organic matters, soap and hard water. Exposure to glutaraldehyde liquid or vapour may cause health problems including skin sensitisation, exacerbation of asthma and leading to allergic contact dermatitis, etc.

11. **Hydrogen peroxide** is a colourless liquid at ambient conditions. It is a common oxidizing and bleaching agent. The chemical is widely used in deodorants, water and sewage treatment or as rocket fuels and disinfectants. A preparation containing hydrogen peroxide at 15-20% concentration is considered bactericidal, virucidal and fungicidal. At high concentrations, it is a sporicidal. Diluted forms of hydrogen peroxide are often used as cleansers for human cuts and scrapes. Concentrated hydrogen peroxide solution is reactive and explosive. It is also corrosive and on contact, the concentrated hydrogen peroxide solutions may cause chemical burn of the skin and eyes.

12. **Iodine compounds** are broad spectrum and considered effective for a variety of bacteria, fungi and viruses. Iodines are often formulated with soaps and considered to be relatively safe. Concentrated iodine compounds can be irritating to the skin, stain clothes or damage rubber and metals. Tincture of iodine has been used as an antiseptic for skin cuts and scrapes. Iodine agents are inactivated by quaternary ammonium compounds and organic debris.

13. **Iodophors** are preparations containing elemental iodine complex with a polymer carrier (i.e. the complexing agent) of high molecular weight. The resulting complex provides a sustained-release of iodine in aqueous solution. Iodophors' bactericidal activity is relatively slow. Iodophors are general use disinfectants, which are less readily inactivated by organic matter than elemental iodine. Povidone-iodine (PVI) is a commonly available iodophor, usually prepared as a 7.5-10% solution. Formulations with lower concentrations have good antimicrobial activity because dilution can increase iodine concentrations. As the amount of free iodine increases, the degree of skin irritation also may increase.

14. **Isopropyl alcohol**, also known as isopropanol, is a highly flammable colourless liquid with an odour reminiscent of ethanol or acetone. Isopropyl alcohol is found in alcohol sponges, cleaning agents, and rubbing alcohol. The rubbing alcohol generally contains 70% isopropyl alcohol. Isopropyl alcohol is an irritant of the eyes and mucous membranes. Prolonged skin contact with isopropyl alcohol may cause eczema.

15. **Ortho-phthalaldehyde (OPA)** is a light yellow solid and is chemically related to glutaraldehyde. Like glutaraldehyde, high pH may make the chemical more active against microorganisms. OPA is widely used as glutaraldehyde alternative. It is a potential skin and respiratory sensitiser and thus can aggravate pre-existing asthma or dermatitis. OPA is non-flammable and is stable at a wide pH range.

16. **Paraformaldehyde** is a white powder with the odour of formaldehyde. Paraformaldehyde has been used as a fumigant for over 30 years to decontaminate laboratory facilities and to disinfect sickrooms, clothing, linen, and sickroom utensils. When heated, paraformaldehyde releases formaldehyde gas, an effective disinfectant. Paraformaldehyde is an irritant to the skin, eyes and the respiratory system. High concentrations exposures to paraformaldehyde could lead to pulmonary edema.

17. **Peracetic acid** (or peroxyacetic acid) is a colourless liquid with a strong vinegary odour. Peracetic acid is an irritant and it decomposes to acetic acid, oxygen and water and therefore does not pose an environmental hazard. Peracetic acid is a strong oxidizing agent that rapidly kills a wide range of microorganisms. A concentration of 0.2% peracetic acid is active against all microorganisms including bacterial spores, and is effective in the presence of organic matter at low temperature. It is usually applied as a spray, or as a mop-on solution. Peracetic acid can corrode metals and it can also cause materials discolouration.

18. **Sodium hypochlorite** is the active ingredient in common bleach and is effective against bacteria, viruses and fungi. It is one of the most widely used of the chlorine containing disinfectants used. Sodium hypochlorite solution is used on a large scale for surface purification, bleaching, odour removal and water disinfection. Liquid chlorine bleach usually contains 5.25% solution of sodium hypochlorite as disinfectant. Diluted hypochlorite solutions lose potency quickly and therefore it should be made freshly prepared before use. Sodium hypochlorite is corrosive to metal surfaces at high concentrations. When the hypochlorite solution come in contact with formaldehyde, bis-chloromethyl ether, a known carcinogen, is produced. Mixing hypochlorite solution with an acid would rapidly release chlorine, a toxic gas. Bleached articles should not be autoclaved without removing the hypochlorite residue by reduction with sodium thiosulphate or sodium bisulphate.

Appendix II

Potential Hazards of Some Chemical Disinfectants

Category	Chemical Disinfectants	Potential Hazards
Alcohols	• Ethyl alcohol • Isopropyl alcohol	• The chemicals are flammable and could form explosive vapour/air mixtures. • They may react violently with strong oxidants. • Alcohols could de-fat the skin and cause dermatitis. • Inhalation of concentrated alcohol vapour may cause irritation of the respiratory tract and effects on the central nervous system.
Aldehydes	• Formaldehyde • Paraformaldehyde • Glutaraldehyde • Ortho-phthalaldehyde (OPA)	• Formaldehyde in gas form is extremely flammable. It forms explosive mixtures with air. It should only be used in well-ventilated areas. • The chemicals are irritating, toxic to humans upon contact or inhalation of high concentrations. • Formaldehyde is a known carcinogen.
Chlorine Compounds (Hypochlorites)	• Sodium hypochlorite • Calcium hypochlorite • Sodium dichloroisocyanurate	• Mixing hypochlorites with strong acids may result in violent chemical reaction that could release toxic gases. • The chemicals react explosively with ammonia, amines, or reducing agents. • The chemicals may cause skin irritation. Concentrated hypochlorites solutions can cause chemical burns of the skin.
Iodine Compounds	• Iodine (aqueous solution or tincture) • Povidone-iodine	• Concentrated iodine compounds can irritate the skin.

Potential Hazards of Some Chemical Disinfectants (Continue)

Category	Chemical Disinfectants	Potential Hazards
Oxidizing Agents	• Hydrogen peroxide • Peroxyacetic acid	• Concentrated peroxide solutions are reactive and explosive. • The chemicals are irritants and may cause chemical burns of the skin and eyes when concentrated.
Phenols	• Cresol • Hexachlorophene	• Phenols can cause skin and eye irritation • When phenol compounds are inhaled, ingested, or applied to the skin at high concentrations, the chemicals are harmful to human.
Others	• Ethylene Oxide	• Ethylene oxide is highly flammable and explosive. • The chemical is an irritant to the skin, eyes, and the respiratory tract. • Ethylene oxide is toxic by inhalation and is a known carcinogen.

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Enquiries

If you wish to obtain further information about this guide or require advice on occupational safety and health, please contact the Occupational Safety and Health Branch of the Labour Department through:

Telephone	:	2559 2297 (auto-recording after office hours)
Fax	:	2915 1410
E-mail	:	enquiry@labour.gov.hk

Information on the services offered by the Labour Department and on major labour legislation can also be found by visiting our Home Page at http://www.labour.gov.hk.

You can also obtain information on the various services provided by the Occupational Safety and Health Council through its telephone hotline at 2739 9000.

Complaints

If you have any complaints about unsafe workplaces and practices, please call the Labour Department's occupational safety and health complaint hotline at 2542 2172.

Occupational Safety and Health Branch
Labour Department

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