Chapter 1

INTRODUCTION

Protection of worker′s safety and health should be of prime concern to employers as workers are at risk of exposing themselves to various kind of hazard that exist because of the nature of work involved. Personal protective equipment has been used since ancient times to give protection to the wearer against harmful elements. Despite their drawback and limitations, the use of personal protective equipment may, in certain circumstances, be the only practicable protection. When this is the case these equipment must be properly selected, used and maintain so that adequate protection will be provided.

Personal protective equipment is any equipment which is intended to be worn or held by a person at work and which protects him against one or more risks to health or safety and any additional accessory designed to meet that objective.

Preference should always be given to safe-place rather than safe-person policies. ′Safe-place′ means that the working environment is ensured free from contaminants or hazardous conditions or factors which pose a risk to workers or any other person who may be present at the place of work. It refers to control of risk at the source, which can be achieved through the application of engineering principles and adoption of a safe system of work. Risks are eliminated, isolated or minimised.

The use of personal protective equipment, which represents the safe–person approach offers protection only to the wearer. However, measures controlling the risk at source can protect everyone at the workplace. Theoretical maximum levels of protection are seldom achieved with personal protective equipment in practice, and the actual level of protection is difficult to assess. The use of personal protective equipment may give a false sense of security to the wearer as the risk is not eliminated but merely prevent the hazards from being in contact with the worker.

Effective protection is only achieved through suitable, correctly fitted, properly used and properly maintained personal protective equipment. Another problem with personal protective equipment is that it may restrict the wearer to some extent by limiting mobility, or visibility, or by requiring additional weight to be carried. Due to these reasons the wearing of personal protective equipment to control risk is to be used as a ′last resort′ or as the ′last line of defence′. Engineering controls and safe system of work should be considered first. However, in some circumstances personal protective equipment will still be needed to control the risk of being exposed to hazards adequately.

1.1 Scope & Application

These guidelines is intended as a guide for employers in order to comply with the requirements pertaining to the use of approved and suitable personal protective equipment as stipulated under the Occupational Safety & Health (Use and Standard of Exposure of Chemical Hazardous to Health) Regulations 2000. This guideline will not cover personal protective equipment that is not related to protection against chemical exposures such as hearing protectors or safety harness.

1.2 Definitions

1.2.1 Terms Used Under Respiratory Protection

Aerosol

Particles (solid or liquid) suspended in the air.

Breakthrough (for cartridges/canister)

A stated concentration of the chemical can be detected on the downstream side of the cartridge or canister.

Canister/Cartridge

A container with either a filter, sorbent or catalyst, or combination of these items, which removes specific contaminant(s) from the air passed through the container.

Change schedule

A predetermined interval of time after which an existing cartridge is replaced with a new one.

Degree of protection afforded by a respirator

Ratio of the airborne concentration of the contaminant outside the respirator (Co) to the concentration of contaminant inside the face piece of the respirator (Ci).

Disposable respirator/Maintenance free respirator

A device for which maintenance is not intended and which is designed to be discarded after excessive breathing resistance; sorbent exhaustion, physical damage or end-of-service-life renders it unsuitable for use.

Dust

An aerosol consisting of solid particles derived from the breaking up of larger particles.

End-of-service-life indicator

A system that warns the user of the approach of the end of adequate respiratory protection.

Filter

A component used in respirators to remove solid or liquid aerosols from the inhaled air.

Full face-piece

A face-piece that covers the face from roughly the hairline to below the chin.

Fumes

Solid aerosols of extremely small particle size, generated by condensation of a substance from vapour state to the solid state. It is normally associated with molten metal where the metal is vaporised, followed by the oxidation of the vapour and condensation of the oxide into fine solid particles.

Gas

A fluid that has neither independent shape nor volume

Half face-piece

A face-piece that fits over the nose and under the chin.

Immediately Dangerous to Life and Health or IDLH

An atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Examples are an atmosphere containing less than 16% oxygen or an atmosphere containing hydrogen cyanide in excess of 50ppm.

Mist

An aerosol composed of liquid particles.

Negative pressure respirator

A respirator in which the air pressure inside the respirator inlet covering is less than the ambient air pressure during inhalation.

Oxygen-deficient atmosphere

An atmosphere, which does not contain enough oxygen to fully support the body's metabolic processes. It is generally acknowledged that an atmosphere with oxygen concentration below 19.5% by volume is deficient in oxygen.

Positive pressure respirator

A respirator in which the pressure inside the respirator inlet covering is higher than the ambient air pressure.

Respirator

A personal device designed to protect the user from the inhalation of hazardous atmosphere.

Respirator inlet covering

The portion of a respirator that connects the user's respiratory tract to an air-purifying device or a respirable gas source, or both. It may be a face-piece, helmet or hood. The inlet covering serves as a barrier against the contaminated atmosphere and as a framework to which air-purifying elements may be attached.

Service life

The amount of time required to reach breakthrough for a cartridge or a canister.

Sorbent

A material that is contained in a canister or cartridge that can remove specific gases or vapours from the inhaled air.

Vapour

The gaseous phase of matter that normally exists in a liquid or solid state at room temperature

1.2.2 Terms Used Under Hand Protection

Breakthrough time

Time it takes a chemical to permeate completely through and is determined by applying the chemical on the glove exterior and measuring the time when the chemical is first detected on the inside surface.

Degradation

Measurement of the physical deterioration of the material due to contact with a chemical. The material may get harder, stiffer, more brittle, softer, weaker, or the material may actually dissolve in the chemical.

Permeation rate

The rate at which the chemical will move through the material in a laboratory and is expressed in units of [weight of chemical] per [unit area of material] per unit [unit of time], e.g. $mg/m^3/s$ or $\mu g/cm^2/min$.

Chapter 2

LEGAL REQUIREMENTS

The legislation that stipulates the provision of personal protective equipment for protection against hazardous substances can be found in the Factories & Machinery Act 1967 and a number of regulations made there under; and the Occupational Safety & Health Act 1994 and the Occupational Safety & Health (Use & Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000.

2.1 Factories & Machinery Act 1967

The requirements pertaining to personal protective equipment are under Section 24 of the Factories & Machinery Act and also stipulated under these Regulations:

a) Factories & Machinery (Safety, Health & Welfare) Regulations 1970;
-Regulations 32(a), (c), (e) to (i)

b) Factories & Machinery (Lead) Regulations 1984;
-Regulations 20 to 24 and 46(2)

c) Factories & Machinery (Building Operations & Works of Engineering Construction) (Safety) Regulations 1986;
-Regulations 11 to 15

d) Factories & Machinery (Asbestos Process) Regulations 1986; and
-Regulations 9 and 10

e) Factories & Machinery (Mineral Dust) Regulations 1989.
-Regulations 4(2), 17 to 20

2.2 Occupational Safety & Health Act 1994

Provisions pertaining to the use of personal protective equipment can be found in the Occupational Safety and Health Act 1994 and also in the Occupational Safety & Health (Use & Standards of Exposure of Chemical Hazardous to Health) Regulations 2000.

General Duties of Employees at Work

The Occupational Safety & Health Act 1994: Section 24(1) states (in part) that

'It shall be the duty of every employee while at work-
c) to wear or use at all times any protective equipment or clothing provided by the employer for the purpose of preventing risks to his safety and health; and
d) *to comply with any instruction or measure on occupational safety and health instituted by his employer or any other person by or under this Act or any regulation made there under.'*

This mean that employees who are provided with personal protective equipment or clothing must wear or use them at all times and in accordance to safety instructions.

Duty Not to Charge Employees for Things Done or Provided

Occupational Safety & Health Act 1994: Section 26 states that:

No employer shall levy or permit to be levied on any employee of his any charge in respect of anything done or provided in pursuance of this Act or any regulation made there under.

This means that personal protective equipment provided by an employer to his employees must be made at no cost to the employees.

2.2.1 Occupational Safety & Health (Use & Standards of Exposure of Chemical Hazardous to Health) Regulations 2000

Personal Protective Equipment as a Control Measure

USECHH Regulations 2000: Regulation 15(1) states that

The employer shall control chemicals hazardous to health through the following control measures:
a) elimination of chemicals hazardous to health from the place of work;
b) substitution of less hazardous chemicals for chemicals hazardous to health;
c) total enclosure of the process and handling systems;
d) isolation of the work to control the emission of chemicals hazardous to health;
e) modification of the process parameters;
f) application of engineering control equipment;
g) adoption of safe work systems and practices that eliminate or minimize the risk to health; or
*h) provision of **approved personal protective equipment**.*

The provision of approved personal protective equipment is listed last in the control hierarchy. Other means are preferred over the use of personal protective equipment.

Use of Approved Personal Protective Equipment

USECHH Regulations 2000: Regulation 16 states that

(1) Approved personal protective equipment shall be used-

a) where the application of control measures specified in paragraphs 15(1)(a) to (g) would be impracticable;

b) as an interim measure while other preferred control measures are being designed and installed; or

c) where the measures taken to comply with paragraphs 15(1)(a) to (g) do not adequately control an employee's exposure to chemicals hazardous to health

(2) Where the approved personal protective equipment is used to control exposure to chemicals hazardous to health, the employer shall establish and implement procedures on the issuance, maintenance, inspection and training in the use of the approved personal protective equipment.

(3) The approved personal protective equipment provided to employees pursuant to sub regulation (1) shall-

a) be suitable to the type of work in which they are employed;

b) fit the employees;

c) not adversely affect the health or medical condition of the employees; and

d) *be in sufficient supply and readily available to employees who require it.*

The mandatory requirements here are on the use of personal protective equipment that is approved by the Director General and that its use is seen as the last resort, as an interim measure, or as to complementary measure to other preferred control measures. Other requirements include the equipment's suitability to the work, not prejudicing the health of the employees and the equipment is readily available for employees to use.

Compliance with Permissible Exposure Limits Using Respirator

USECHH Regulations 2000: Regulation 8 states that

(1) For the purpose of determining whether the employer has complied with the permissible exposure limit, the degree of protection afforded by the respirator for the periods during which the respirator is worn shall be taken into account.

(2) The period referred to in sub regulation (1) shall be averaged with the exposure level of the airborne concentration during the period when respirators are not worn to determine the employee's daily time-weighted; and

(3) For the purpose of this regulation, "degree of protection" means the ratio of the airborne concentration of the contaminant outside the respirator to the concentration of the contaminant inside the face piece of the respirator.

The degree of protection afforded by the personal protective equipment must be taken into account when determining compliance with the permissible exposure limits. The effectiveness (degree of protection) of a respirator is determined by its protection factor (PR). In the selection of respirators, the **assigned protection factors** are used. For adequate respiratory protection, select a respirator with an assigned protection factor greater than or equal to the hazard ratio. The hazard ratio (HR) is the ratio of an airborne contaminant to its permissible exposure limit.

For example, an employee wearing a respirator having an assigned protection factor of 10 and whose average personal exposure to xylene is 350 parts per million is considered to be exposed to 35 parts per million xylene during the period he is wearing the respirator. If he only wears the respirator for certain number of hours out of the eight-hour work shift, then his daily time-weighted exposure is calculated thus:

$$(C_w\ t_w + C_{nw}\ t_{nw}) / 8$$

where C_w, t_w = exposure concentration, duration while wearing respirator
C_{nw}, t_{nw} = exposure concentration, duration while not wearing respirator

A wearing of the respirator for four hours in the above situation will result in a daily time-weighted exposure of ((35 x 4) + (350 x 4)) / 8 = 192.5 parts per million xylene, which is non-compliance since the permissible exposure limits of xylene is 100 parts per million.

NB: Please refer to Section 3.2.3 for further discussion on 'assigned protection factor'.

Chapter 3

RISK REDUCTION THROUGH PERSONAL PROTECTIVE EQUIPMENT

The principle utilised by personal protective equipment in prevention of injuries is to prevent contact between the hazards and the external or internal parts of the body that is to be protected. This includes the protection for the head, which include the eye, face, and the ear; the auditory and respiratory system; and the body and the limbs. There are also appliances which do not act as a barrier between the hazard and the part of the body to be protected, but are regarded as personal protective equipment. These are life jackets, buoyancy aids, safety harness and high visibility clothing (HSE, 1992)

Since other methods of controlling risk are generally preferred, personal protective equipment is only to be used:

1. When such equipment is necessary to protect the safety and health of the worker where risk have not been adequately controlled by any other means such as engineering controls and safe system of work;

2. Where its use could not be substituted by any other means, such as:
   - In an emergency situation or rescue work
   - During fire-fighting activities
   - Where close or direct contact is necessary to carry out work e.g. in welding operations and manual handling of chemicals
   - In situation where there is a possibility of heavy or sharp object falling or knocking against hard objects
   - In situation where there is a possibility of stepping onto sharp objects
   - During cleaning or maintenance operations
   - For certain intermittent or short term operations where installing engineering controls would be economically impractical

3. As a temporary measure while other control measure, such as engineering control, is being introduced;

4. As a backup or to complement other measures.

Personal protective equipment should not be used if the risk caused by wearing it is greater than the protection it is supposed to provide. A good example is the use respirator that is supposed to protect the wearer against airborne contaminant but if the wearer is asthmatic or has heart problem, the respirator could cause breathing difficulty for him.

3.1. Risk Associated With Hazardous Chemicals

Basically the risks associated with hazardous chemicals are either by inhalation of the particulates or gases and vapours or the direct contact of the chemicals with the skin, or eyes. The protection required against these risks can be addressed based on the part of the body where contact takes place, viz. the head, face/eyes, respiratory system (nose/mouth), body, hand and leg/feet.

The risks associated with hazardous chemicals can be summarized as follows:

Area of Exposure	Risks	Examples of Protection
Head	Splashes, chemical burns, skin absorption	Helmet, bump cap, face shields
Face/Eyes	Chemical burns, splashes, irritation, skin or eye absorption	Face shields, goggles, and safety spectacles. Changing work methods to isolate harmful chemicals from workers may effectively control irritation to the eyes from harmful vapours.
Respiratory system	Breathing in atmospheric contaminant. Respiratory irritation. Asphyxiation.	Air purifying respirator. Supplied Air respirator.
Body	Chemical burns, splash, skin absorption	Hazardous chemical suit, apron, long-sleeve shirt
Hands	Chemical burns, dermatitis, skin absorption	Chemical resistance gloves
Leg & Feet	Chemical burns, skin absorption	Safety footwear, leggings

Table 1: Risks Associated With Hazardous Chemicals

3.2. Selection, Use and Maintenance of Approved Personal Protective Equipment

Personal protective equipment for protection against chemical hazards can be categorised according to the risk and parts of the body to be protected:

3.2.1. Head protection;
3.2.2. Eyes and face protection;
3.2.3. Respiratory protection;
3.2.4. Hands and arm protection;
3.2.5. Body protection;
3.2.6. Feet and leg protection.

Industrial Safety helmet

Bump caps

3.2.1. Head Protection

Types

The four widely used types of head protection are crash helmets; industrial safety helmets; bump caps; and caps (HSE, 1992). However, for chemical protection, industrial safety helmets and bump caps can be used to protect against chemical splashes, drips or sprays to the head;

Selection

Select head protectors that match the risk(s) anticipated and ensure that they fit the wearer. To fit, head protection selected should be of an appropriate shell size for the wearer and have an easily adjustable headband, nape and chinstrap.
Head protection should be as comfortable as possible. Comfort is improved by the following (HSE, 1992):

a) A flexible headband of adequate width and contoured both vertically and horizontally to fit the forehead;
b) An absorbent, easily cleanable or replaceable sweat-band;
c) Textile cradle straps;
d) Chin straps (when fitted) that:
   i) do not cross the ears,
   ii) are compatible with any other personal protective equipment needed
   iii) are fitted with smooth, quick-release buckles which do not dig into the skin,
   iv) are made from non-irritant materials,
   v) can be stowed on the helmet when not in use.

Use

Whenever possible, the head protection should not hinder the work being done. If other personal protective equipment such as ear protectors or eye protectors is required, the design must allow them to be worn safely and in comfort. Check manufacturer's instructions regarding the compatibility of head protection with other types of personal protective equipment.

Use helmets according to manufacturer's guideline, e.g. not all helmets are designed to provide impact protection when worn backwards.

Never drilled ventilation holes in the shell of the helmet! This will reduce or eliminate both impact and electrical insulation protection.

Maintenance

Head protection must be maintained in good condition. Poor maintenance may make the head protection ineffective, uncomfortable or unhygienic.

Head protection should:

- Be stored, when not in use, in a safe place and should not be stored in direct sunlight or in excessively hot, humid condition;
- Be inspected regularly for signs of damage or deterioration;
- Have defective harness components replaced (if the design or make allow this). Harnesses from one design or make of helmet cannot normally be interchanged with those from another;
- Have the sweatband regularly cleaned or replaced.
- Do not paint or cover helmet with stickers (hairline cracks could be hidden).

Replacement of head protection should be in accordance with the intervals recommended by the manufacturer. It will also need to be replaced if the harness is damage and cannot be replaced, or when the shell is damaged or it is suspected that its shock absorption or penetration resistance has deteriorated.

Damage to the shell of a helmet can occur when:

a) objects fall onto it;
b) it strikes against a fixed object;
c) it is dropped or thrown;

Deterioration in shock absorption or penetration of the shell can occur from:

a) exposure to certain chemical agents, such as paints or adhesives;
b) exposure to heat and sunlight, such as near a window of a room or a vehicle;
c) ageing due to heat, humidity, sunlight and rain.

Hazards posed by Helmets

Persons working overhead should wear helmets with chinstrap to secure the hat from becoming a falling object itself.

3.2.2. Eyes and Face Protection

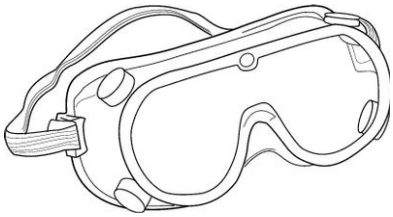
The eyes and face have to be protected against the hazard of impact, splashes from chemicals or molten metal, liquid droplets (chemical mist and sprays), gases, dust, welding arcs (sparks, fumes and ultraviolet radiation), non-ionising radiation and the light from lasers.

Types

Eye and face protectors include:

1. Safety spectacles are meant to protect against impact and are less effective for chemical splashes;

2. Goggles, which are made with a flexible plastic frame and one-piece lens and have an elastic headband, are more effective for protection against chemical splash as they afford the eye total protection from all angles as the whole periphery of the goggle is in contact with the face;



3. Eye shields, which are like safety spectacles but are heavier and design with frameless one-piece mould lens. Some eye shields may be worn over prescription spectacles;

4. Face-shields, which protect the face from the forehead to the neck from the chemical splashes, but do not protect from dust, mist or gases as it do not fully enclose the eyes. They may be worn over standard prescription spectacles and are generally not prone to misting. Often the transparent is made of polycarbonate. Use goggles with face-shield whenever handling chemical.

Selection

The selection of the eye and face protection depends primarily on the hazards. However, comfort, style and durability should also be considered. The table below provides a selection of the eye and face protection based on the hazard or risks involved:

Table 2: Eye and Face Protection

SOURCE	RISKS	PROTECTION
Chemicals (e.g. acid/alkali handling, chemical handling, degreasing, plating)	Splash Irritating mists	Goggles, eyecup and cover types. For severe exposure, use face shield over primary eye protection Special-purpose goggles
Dust (e.g. Bagging, woodworking, buffing, general dusty conditions	Nuisance dust	Spectacle, goggles, eyecup and cover types

For the spectacles' wearer, eye protection is achieved either by the use of prescription safety spectacles that are individually matched to the wearer or by the use of specially designed eye shields that may be worn over the prescription spectacles.

Use

Eye protectors must be provided both for person directly involved or employed, and others who may come into contact with the process and be at risk from the hazards. Eye protectors issued on a personal basis and used only by the person they are issued to. If they are reissued they should be thoroughly cleaned and disinfected.

Spectacles with side-shields and goggles are considered 'primary' eye protectors (those that can be worn alone or with 'secondary' protectors), while face-shields are termed as 'secondary' protectors as they must be worn with a 'primary' protector (3M, 2002).

Maintenance

The lenses of eye protectors are to be kept clean as dirty lenses restrict vision, which can cause eye fatigue and lead to accidents. Lenses that are scratched or pitted must be replaced as they may impair vision and their resistance to impact may be impaired.

Transparent face-shields must be replaced when warped, scratched or have become brittle with age. Please refer to the manufacturer's guideline on how to clean the lenses as different lens material require different kind of treatment.

3.2.3. Respiratory Protection

Since inhalation is the main route of entry into the body for chemical substances, respiratory protection is of great importance when handling these substances. Protection of the respiratory system against the entry of harmful dust, fumes, mists, vapours and gases is crucial, as respiration is a vital process of the body.

Inhalation of contaminated air may cause breathing problems or difficulty that in turn can adversely affect the health of a person. For normal and healthy breathing we need about 21% oxygen in the breathing air. An oxygen deficient environment is an environment containing oxygen less than 19.5% (Occupational Safety and Health Administration, United States of America). Lack of oxygen can lead to asphyxiation, where the body is deprived of oxygen for the normal functioning of the body.

A respirator consists of an enclosure or face-piece that covers the mouth and nose, or the entire face, or a helmet or hood which covers the head. The hood is connected by means of a hose to either a clean air supply or to an air-purifying respirator, which provides clean air for breathing in environments containing airborne contaminants or hazardous materials with oxygen level of 19.5% to 21%.

Caution: An air-purifying respirator should never be used where the oxygen content of the air is less than 19.5%!

Types

Respiratory protection can be categorised in terms of the pressure created in the respirator or the oxygen content in the environment where work is carried out.

Positive and Negative Pressure Respirators

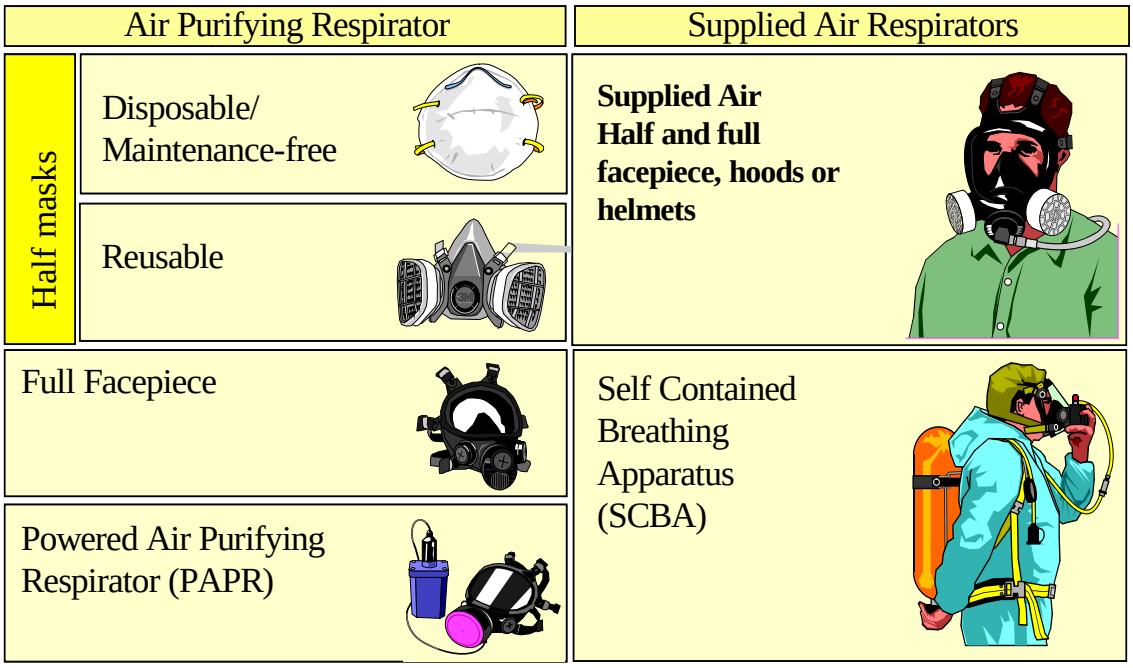
Both air-purifying and air-supplying respirators can be either positive pressure or negative pressure devices.

A positive pressure respirator maintains a positive pressure with respect to ambient pressure inside the face-piece during both inhalation and exhalation. The positive pressure is maintained by forcing air into the face-piece from a hose connected to a pressurised tank, compressor, or blower motor. Regulator valves are also used when the air supply comes from a high-pressure source. A positive pressure respirator is safer because the slightly over-pressured face-piece will prevent hazardous/toxic materials from entering the face-piece should there be minor leakages.

A negative pressure respirator has a negative pressure inside the face-piece relative to the ambient pressure during inhalation and positive pressure during exhalation. Air for breathing is drawn into the face-piece by the inhalation pressure. The air may be ambient air drawn through filters or it may come from an external source (tank or nearby clean air) through hoses.

The face-pieces of respirators are either tight fitting or loose fitting. Tight fitting face-pieces usually consist of half-masks that cover the face from below the chin to over the nose and full face-pieces that cover the face from the hairline to below the chin. Loose fitting face-pieces consist of helmets or hoods, and these require a forced air supply, at some constant flow rate.

Air Purifying and Supplied Air Respirators



Air-Purifying Respirators

These are respirators, which remove or trap particulates, vapours or gases to make it suitable for breathing. However, this type of respirators should **not be used** in an oxygen deficient atmosphere. Air-purifying respirators are to be used only in atmospheres containing sufficient amount of oxygen.

Air-purifying respirators can be generally be classified as:

a) Particulate respirators, which protect the wearer from airborne particulates such as dust, fumes, aerosols;

b) Gas and vapour or chemical-cartridge respirators, which remove gaseous contaminants by passing the contaminated air through material that traps the harmful gases or vapours;

c) Powered air-purifying respirators which utilise a blower to draw in contaminated air through a filter element that removes the contaminants and supplies purified air to the wearer; and

d) Disposable/maintenance-free respirator, which are generally used for protecting against particulates. Some makes incorporate charcoal into the filter material to give additional protection against gases and vapour. These are to be worn over a limited time or for a specific work activity such as during a cleaning operation. They are not meant for a long-term usage.

Most air-purifying respirators are negative pressure devices except for powered-air-purifying-respirators (PAPR), which are under positive pressure.

Supplied Air Respirators

Supplied air respirators can be classified into:

1. Self-contained respirators or self-contained breathing apparatus (SCBA), which get air supply from compress air cylinders, or a reservoir breathing bag with absorbent for exhaled carbon dioxide; and

2. Airline respirators, which get uncontaminated or purified air supplied by an air compressor through an airline or hose.

Most supplied air respirators are positive pressure devices. These positive pressure air-supplying devices come in two modes:

I. Pressure demand

A valve senses the pressure in the face-piece and provides the volume of air necessary to maintain a positive pressure in the face-piece under all conditions.

II. Continuous flow

A constant volume of air is continuously supplied into the face-piece. Depending on the volume of air supplied, the user could breathe hard enough to create a negative pressure in the face-piece. Another disadvantage is that it uses more air than a pressure demand system.

The pressure demand systems are usually preferred because of the numerous disadvantages of the continuous flow systems and what is more important is the safety consideration, where in an atmosphere immediately dangerous to life and health (IDLH) the creation of a negative pressure inside the face-piece will cause contaminant to leak into the face-piece thereby causing fatality or serious health effects. Refer to the **Appendix 1** for IDLH data for various chemicals.

SCBA and Airline system with compressed breathing air escape bottle, which in addition to protecting the wearer against airborne contaminants will provide adequate oxygen supply from either a reservoir of compressed air carried by the wearer (SCBA) or from external uncontaminated air source (airline) in combination with a compressed breathing air escape bottle. Only these respirators can be used in an oxygen deficiency or IDLH atmosphere.

Selection

Selection of suitable respirators is based on the hazards or risks and the characteristics of the respirator. Employers must identify and evaluate the respiratory hazard(s) in the workplace. This evaluation must include a reasonable estimate of employee exposures to respiratory hazard(s) and an identification of the contaminant's chemical state and physical form. Where the employer cannot identify or reasonably estimate the employee exposure, the employer must consider the atmosphere to be IDLH.

An employer must select DOSH-approved respirators from a sufficient number of respirator models and sizes so that the respirator is acceptable to, and correctly fits, the user.

The selection of an appropriate respirator should be based on these underlying principles:

a. The level of protection required (protection factor) is based on the toxicity and concentration of the contaminant;

b. The effectiveness of air-purifying respirators is dependent on the "fit" of respirator to the user, and how well and for how long the filtering medium will work;

c. Full face-piece, tight fitting respirators leak less than half face-piece respirators;

d. Leakage of ambient air into the face-piece from pressure-demand atmosphere-supplying respirators will be less than for most continuous flow devices;

e. Air-purifying respirators for gases and vapours are often not effective for high concentrations or for certain types of contaminants;

f. SCBA respirators can offer the highest levels of protection but are cumbersome and expensive; and

g. Supplied air respirators can offer high levels of protection, but restrict mobility.

Use respirators that can reduce the exposure to well below the permissible exposure limits as stipulated in the USECHH Regulations. This could be achieved by

a) Choosing the assigned protection factor; and
b) Going through the respirator selection flowchart.

Assigned Protection Factor (APF)

Recommended assigned protection factors for respirator inlet coverings are given in the table below:

Table 3: Recommended Assigned Protection Factor

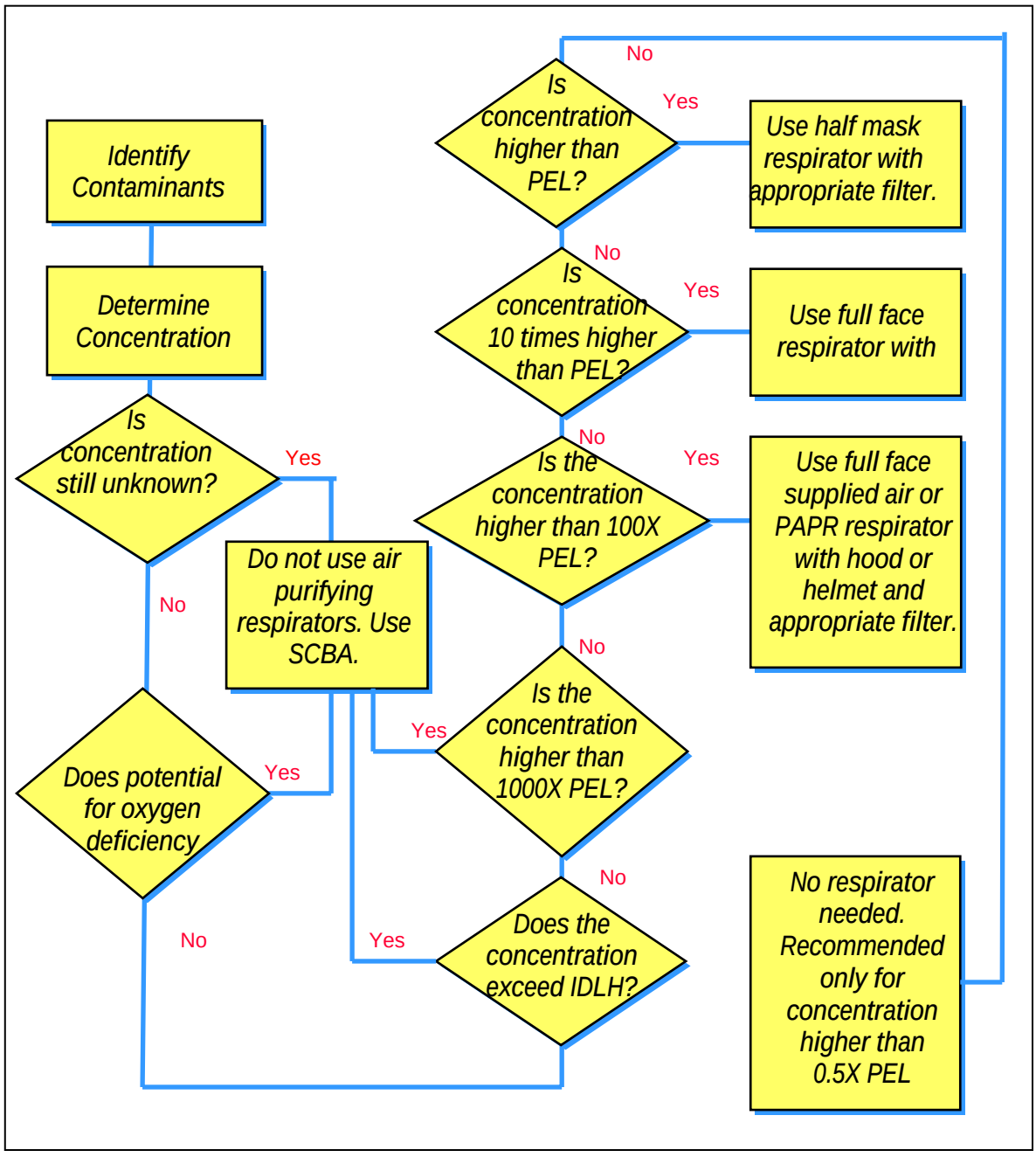
Negative-pressure type	Tight-fitting respiratory inlet covering	
	Half face-piece	Full face-piece
1) Air purifying	10	100
2) Supplied-air		
a) SCBA, demand type	10	100
b) Airline, demand type	10	100

Positive-pressure type	Respiratory inlet covering			
	Loose-fitting face-piece	Tight fitting		Helmet & hood
		Half face-piece	Full face-piece	
1) Powered air-purifying	25	50	1000	1000
2) Supplied-air				
a) SCBA				
(i) Pressure demand	-	-	>1000	-
(ii) Open or closed circuit	-	-	10000	-
b) Airline				
(i) Pressure demand	-	50	1000	-
(ii) Continuous flow	25	50	1000	1000

Respirator Selection Flow Chart

The following flow chart simplifies the steps in respirator selection.

Figure 1: Respirator Selection Flow Chart



Example of Using the Assigned Protection Factor Table and the Selection Flowchart.

Let assume the following scenario:

Chemical used	: Acetone
Permissible Exposure Limit (PEL)	: 500 ppm
Immediately Dangerous to Life and Health (IDLH)	: 20000 ppm
Exposure level (at work area)	: 1788 ppm
Oxygen deficiency potential	: No

Calculate the Hazard Ratio:

Hazard Ratio = Exposure Level ÷ PEL
= 1788 / 500
= 3.6

Because this is a not an oxygen deficiency environment with a hazard ratio of more than 1X PEL but less than 10X PEL, therefore, the recommended respirator is an air-purifying half face-piece respirator.

Note: *APF and the Selection Chart help to determine the right type of respirator for air-purifying respirator. It does not tell us which type of filtration media to be used.*

Since the Assigned Protection Factor and Selection Chart will not tell us which type of filtration media to be used a guide is necessary. Table 4 is the guide to help you selecting the filter media for certain chemicals, based on NIOSH (USA) standard.

It is important to note that not all gases and vapours can be absorbed effectively with the use of chemical cartridges. Good examples are those chemical that has no smell (e.g. carbon monoxide) or have a very short service life on the cartridge (e.g. methanol).

Selecting the suitable respirator is very critical in preventing worker's exposures to chemical hazardous to health. It is very important to ensure that only the correct type of respirator and filter media is being used, and where there is any doubt, expert and/or manufacturer's advice should be sought.

Table 4: Filter Media Selection

Contaminants	Filter media
Dust, Mist, Fumes	Particulates filter: **N95, R95, P95, N99, R99, P99, N100, R100, P100** •*N-Series: **N**ot for oil* *–Approved for non-oil particulate contaminants* *–Examples: dusts, fumes, mists not containing oil* •*R-Series: **R**esistant to oil* *–Approved for all particulate contaminants* *–Examples: dusts, fumes, mists (including those containing oils)* *–Time restriction of 8 hours when oils are present* •*P-Series: Oil **P**roof* *–Approved for all particulate contaminants* *–Examples: dusts, fumes, mists (including those containing oils)* •*Efficiency Level: 95%, 99%, 99.97%* *eg. N95 means the filter media has at least 95% efficiency tested at 0.3 micrometer and it can only be used in non-oil environment.*
Gases and Vapour	Chemical Cartridges (type and colour code): **Organic Vapour (OV) - Black** **Acid Gas (AG) – White** **OV/AG combination – Yellow** **Ammonia / Methylamine – Green** **Formaldehyde – Olive** **Multi-Gas and Vapour (combination of all the above) – Light Brown** **Mercury / Chlorine – Orange**

Respirator Fit Test

Employees required to wear a tight-fitting respirator must be fitted properly and tested for face seal leakage before using the respirator in a contaminated area. Fit testing helps determine that a particular model and size of respirator fits a worker so there is minimal face seal leakage. It shall be conducted for all tight-fitting air purifying and supplied-air respirator, including SCBA.

The employees with tight-fitting respirator shall be tested prior to initial use of the respirator, whenever a different respirator face-piece (size, style, model or make) is used, and at least annually thereafter.

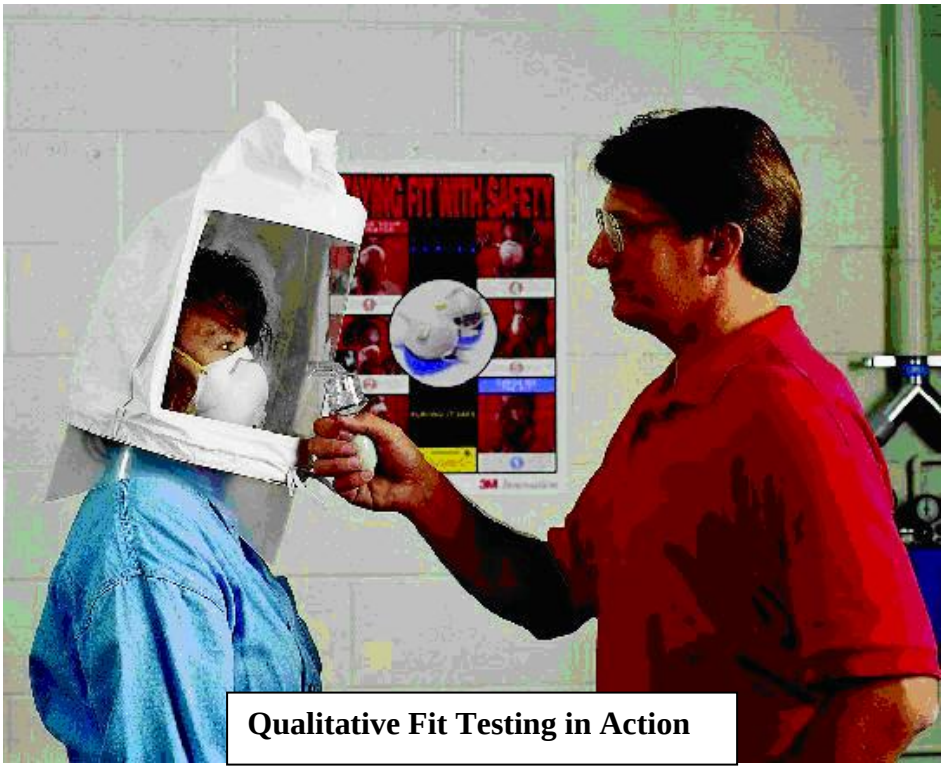
A fit test must not be conducted if there is any hair growth between the face and the sealing surface of the respirator such as stubble, moustache, beard, long side burns or the user is putting on prescriptive glasses with temple bars for tight-fitting full face-piece. Any safety equipment, such as goggles and safety glasses, which is worn with the respirator in the normal course of work, should also be worn during the fit testing.

Prior to the commencement of the fit test, the user should be instructed in the proper donning of the respirator and conduct a user seal check (fit check) and also receive an explanation of fit test procedures.

If a situation is encountered where a fit with a respirator cannot be obtained, then the fit testing could be repeated using a different size or model. If this still fails, then transferring the worker to a job where respiratory protection is not required or providing the worker with a loose-fitting respirator of sufficient protection must be considered.

There are two methods of fit testing:
a) Qualitative, and
b) Quantitative Fit Test

Qualitative Fit Test



Qualitative Fit Testing in Action

For qualitative fit testing, banana oil (isoamyl acetate) testing agent can be used only for those respirator equipped with organic vapour cartridges. Saccharin and Bitrex test agents are used for testing particulate dust respirators and irritant smoke test agent should be used only with high efficiency filters such as P100 filter.

Quantitative Fit Test

For quantitative fit test, a special quantitative fit testing equipment and a trained technician (by manufacturer) is required.

Note: *If a quantitative fit test is used for negative-pressure respirator, a fit factor that is at least 10 times greater than the assigned protection factor shall be obtained before that respirator can be assigned to the user. For positive-pressure respirators, a fit factor of at least 100 must be obtained.*

Refer to the US Occupational Safety and Health Administration -Accepted Fit Test Protocols for details of the qualitative fit-test protocols and the quantitative fit-test protocols.

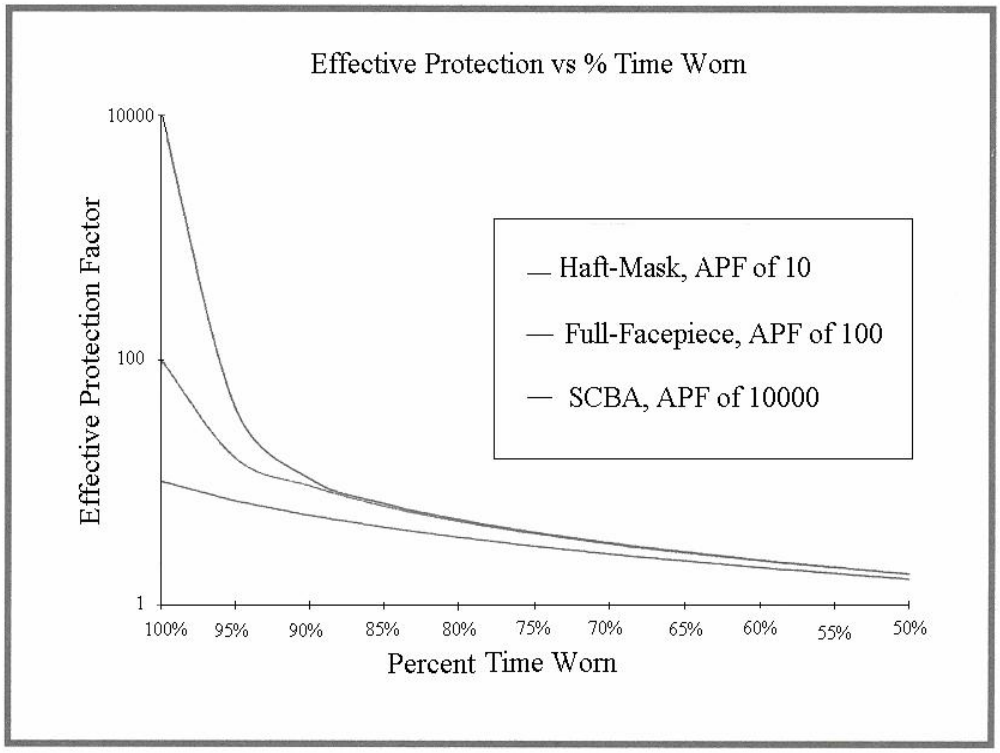
Use

Follow the manufacturers' instructions and limitations on the use of respirators. For respiratory protection to be effective to keep all contaminants out of worker's air intake, they must be worn for 99% of the time in the hazardous environment. Not wearing a respirator for short periods while it is needed could have a profound effect on overall protection. While a respirator is not worn, the protection factor it provides is 1 (i.e. the individual is exposed to the ambient contaminant concentration). The effective protection factor (EPF) can be calculated from the following equation (The Occupational Environment-Its Evaluation & Control):

$$EPF = \frac{\text{Work time requiring respirator use in minutes}}{(1/APF)(\text{Wear time in minutes}) + \text{Non wear time in minutes}}$$

For example, if a person removes his or her respirator for 1 minute to talk during a task that takes 1 hour, the wear time is 59 minutes or 98% of the task duration. If the person uses a respirator with a level of protection of 1000, the effective level of protection actually achieved is 56! As non-wear time increases for any respirator, the protection levels for all respirators approach 1. **Hence, respirators must be worn continuously throughout the time when the risk or risks are present.** Refer to Figure 2 below for comparison of effective protection versus percentage of time worn for half-mask and full face-piece respirators and SCBA.

Figure 2: Effective Respiratory Protection versus % Time Worn



(Source: The Occupational Environment-Its Evaluation and Control, AIHA)

Tight-fitting respirator shall not be worn by employees who have

1. Facial hair that comes between the sealing surface of the face-piece and the face or that interferes with valve function; or
2. Any condition that interferes with the face-to-face-piece seal or valve function -If the employee wears corrective glasses or goggles or other PPE, the equipment shall not interfere with the seal of the face-piece to the face of the user.

Respirator User Seal (Fit) Check

Each time after putting on a tight-fitting respirator, it is important that the user is to perform seal check or fit check. This is necessary to ensure no leakage when it is used in contaminated environment. A positive and negative pressure seal checks are easy to conduct and can be performed by the wearer, following the manufacturer's recommended procedure.

User seal check is also required prior to conducting fit testing. Below are examples of seal check for various respirator types.

Example of Negative Pressure Seal Check for reusable respirator.
Place the palms over the cartridge and inhale gently.
The respirator should collapse slightly.
(Refer to manufacturer's guides)

Example of Positive Pressure Seal Check for reusable respirator.
Place the palm over the exhalation valve cover and exhale gently.
The face piece should bulge.
(Refer to Manufacturer's Guide)

Example of Negative Pressure Seal Check for maintenance-free valved respirator.
Place both hands over the respirator and inhale sharply.
The respirator should collapse slightly
(Refer to Manufacturer's Guides).

Example of Positive Pressure Seal Check for non-valved maintenance-free respirator
Place both hands completely over the respirator and exhale sharply
(Refer to Manufacturer's Guides)

Maintenance

The employee should leave the respirator use area in the following situations:

1. To wash their faces and respirator face-pieces as necessary to prevent eye or skin irritation associated with respirator use; or
2. If they detect vapour or gas breakthrough, changes in breathing resistance, or leakage of the face-piece; or
3. To replace the respirator or the filter, cartridge or canister elements.

Replacement of Filters and Cartridges

The service life of a filter depends on filter/sorbent characteristics, contaminant concentration, airflow rate and relative humidity. For cartridges, the sorbent type, mesh size and quantity affect the ability for contaminant removal. Many sorbent beds are designed to remove very specific chemical(s) and may not be effective for other chemicals.

a. Particulate filter

The breathing resistance for particular filter will progressively increase as it traps particles and eventually become so high that the filter must be replaced. The time for this to occur varies according to the filter characteristics, the type and concentration of the particles in the air. As a guide, the breathing resistance can be considered too high when there is a perceived increase in breathing resistance. The resistance can also be increased if the filter is used in a damp condition.

For powered air purifying respirators, clogging of the filters is normally signalled by a fall in the airflow rate.

A filter should be replaced when it is very dirty or damage.

It is important to note that washing or cleaning clogged filters with compressed air is not advisable as it may damage the filter.

b. Cartridges or canister

Cartridges or canister should be replaced on a regular basis, when an odour or taste is perceived in the inhaled air or when the user experiences discomfort. The breathing resistance normally does not increase during use. Some cartridges or canister may have built-in end-of-service-life indicator.

Another recommended method is for the employer to determine the Change Schedule so that the cartridges or canisters are replaced before the end of their useful life (service life). In order to determine an appropriate change schedule, the breakthrough time for the gas or vapour in question must be known or estimated. An appropriate cartridge/canister change schedule is one that is both convenient and assures that the concentration of the chemical in the inhaled air does not exceed the exposure limit. For example, a cartridge may have a breakthrough time of 10 hours for a given vapour. Changing cartridges at the end of the work shift is usually convenient, and this period of use is less than the breakthrough time (assuming a 8-hour work shift). Employers are advised to consult respirator manufacturers for assistance in determining the service life of a cartridge for a specific chemical and deciding on the change schedule.

Cleaning

Respirators issued to an individual shall be cleaned regularly. If respirators are shared, they shall also be cleaned before being worn by different individuals. Respirators intended for emergency used shall be cleaned after each use.

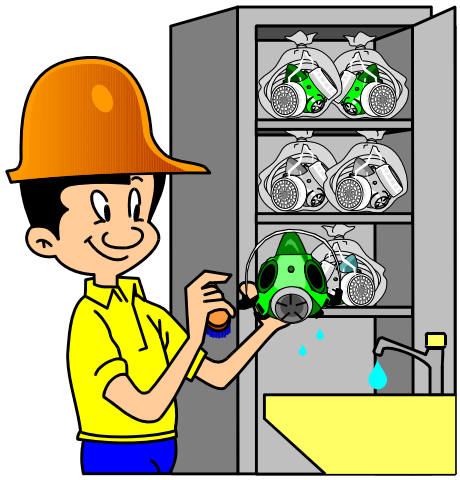
Users who maintain their own respirators should be trained in cleaning procedures. Alternatively, a centralized maintenance cleaning and storage station may be used if there are many routine respirator users.

After removal of any filters or cartridges, the face piece, straps and filter holders should be washed with mild detergent in warm water using a soft brush, thoroughly rinsed in clean water and air dried (away from direct sunlight) in a clean place. Rough handling should be avoided as it may damage the respirator.

Manufacturer's cleaning and disinfecting method can also be used. Note that some soaps or detergent may damage the respirator or cause irritation to the user. All respirators must be thoroughly rinsed after cleaning with detergents.

Storage

Respirators should be stored in a convenient location, away from contaminated areas. Respirators for emergency use should be maintained and stored, ready for immediate use. They should be kept at locations where they are readily available but adequately secured so that unauthorized use or tempering is prevented. Storage cabinets used to store the emergency equipment should be clearly marked.



Respirators shall be stored in a manner that will protect them against physical and chemical agents such as dirt, damaging chemicals, moisture, sunlight, temperature extremes and mechanical damage or distortion. Respirators should be placed in a clean, sealable plastic bag or container when not in use.

Limitations of Respirators

Respirators, as with other equipment, have certain limitations. Major limitations are:

1. Testing the effectiveness of the protection afforded by respirators is very difficult;

2. Difficult to get employees to wear because many respirators are uncomfortable to wear, especially in hot environment or when they have to be worn for long periods of time;

3. Employees often do not believe a hazard exist, especially when the chemicals do not have odour or colour or the health effects take years to occur;

4. Obtaining good seal with the respirator can be difficult for some workers due to facial contour or size, facial hairs, scars or significant deformities of the face;

5. Weight of certain respirators can reduce the ability of the worker to function his work;

6. The poor ability of air-purifying elements to filter certain hazardous chemicals reduces the effectiveness of a respirator;

7. Protection factor offered by certain respirators as determined by laboratory studies may not be realised in the workplace;

8. Certification programme cannot be relied upon to ensure that a respirator will offer a certain degree of protection to every worker.

3.2.4. Hand and Arm Protection

Types

There are various types of hand protection such as gloves, gauntlets, mitts, wrist cuffs, and armlets. Gloves provide protection against:

Table 5: Glove Selection

Risk Factor	Glove Type
Extreme temperature Hot or cold	For contact with chemical at extreme temperature (hot or cold), glove with suitable material coating to protect from the chemical and heat insulation construction should be used. Double donning with glove liner made of para-aramid, cotton and leather can be considered as an alternative. Gloves made of neoprene are good for handling oil in low temperatures and gloves made of Kevlar, glass fibre and leather can be used at higher temperatures;
Corrosive, irritating or toxic chemical	Glove made of suitable material to protect from the chemical used. The toxicity of the chemical shall be considered during glove selection stage. Gloves made from chemical resistant material and which are impervious to liquid penetration;
Skin infection caused by Micro-organism	Impervious glove with liquid proof AQL of 1.5 or better.

Even though gloves can be used to protect workers from a variety of risks, these guidelines will focus mainly on the protection from chemicals that are hazardous to health. There are many tasks where the hands come into contact with toxic or corrosive substances. Examples include maintenance of machinery, cleaning up chemical spillage and mixing and dispensing pesticide formulations. If correctly selected and used, gloves provide a barrier between the wearer's skin and the harmful substance, preventing local damage or in some cases absorption through the skin.

Selection

Gloves or other hand protection should be capable of giving protection from hazards, be comfortable and fit the wearer. The choice should be made on the basis of suitability for protection, compatibility with the work and the requirements of the user. Always follow the manufacturer's instructions and marking for appropriate use and level of protection.

When selecting gloves for chemical protection, it is crucial to determine the type of chemical the users are exposed to. Always make reference to the Chemical/Material Safety Data Sheet provided by the chemical manufacturer. Other factors need to consider include:

a) Contact sequence: this will decide the level of protection, i.e., protection against accidental splash or continuous contact.

b) Extend of arm exposure: this will determine the length of the glove for suitable protection coverage.

c) Environmental condition: chemical permeation rate would increase proportionately under elevated temperature of the chemical.

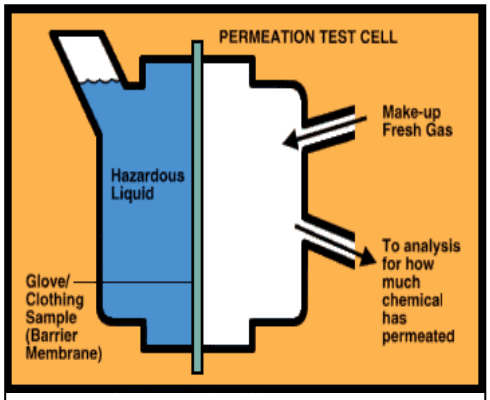
d) Mechanical hazard presence: this will determine chemical resistant glove with mechanical protection feature.

Once the above factors are identified, reference to the chemical to determine the suitability of the selected gloves. Factors that determine the resistance of glove material against the specific chemicals are:

I. Permeation breakthrough time -permeation and resistant data provided by the glove manufacturer

II. Permeation rate

III. Degradation rating



CHEMICAL PERMEATION TEST COMPLY TO ASTM F739 OR EN374

It is a good practice to seek consultation from glove supplier during the selection process. Relevant information such as test data, performance declaration and recommendation should be obtained from the glove supplier for documentation purpose. To ensure the workers are properly trained, it is encouraged that the employer should seek training and certification for the relevant personnel from the glove supplier.

Caution: *Most glove recommendation articles provided by the supplier are based on extrapolations from the results of laboratory tests which were run using standard test methods that may not adequately replicate any specific conditions of end use. Pure chemicals were tested, so any synergistic effects of mixing chemicals have not been accounted for. For these reasons, and because the glove supplier has no detailed knowledge of or control over the conditions of end use, any recommendation must be considered as advisory. The employer has the final responsibility for selecting gloves and other personal protective equipment. Specific request for glove supplier to conduct permeation test for chemical that is in doubt is encouraged.*

Use and Maintenance

Care should be taken in the donning, use, removal and storage of protective gloves. They should be maintained in good condition, checked regularly and discarded if worn out or deteriorated. They should fit the wearer properly leaving no gap between the glove and the wearer's sleeve.

Barrier integrity of chemical protective glove can be easily affected by the storage condition. Always store the glove in a cool and dry area away from direct exposure to sunlight or ultraviolet source. Always refer to the recommended storage condition provided by the glove supplier.

Gloves are to be used with proper care. Always inspect the gloves before using them, always inspect for signs of defects such as holes or tearing. Gloves should also be free of foreign materials and their shape should not be distorted. Discard any defective glove. During usage, if observed sign of discoloration or change in the material stiffness, the glove has been degraded and shall be replaced immediately. Always report and record down any observation of premature failure.

Do not let chemicals come into contact with skin. One of the ways to achieve this is to consider the mode of attire positioning with respect to the glove. Mode of attire positioning with respect to the glove and the protective clothing depends on the working posture. If the activities involved level below shoulder, always ensure the cuff of the glove inserted inside the protective sleeve. For posture above shoulder, the protective sleeve should be inserted inside the cuff of the glove to prevent chemical from entering into the glove. Upon completion of task, it is advisable to remove any chemical residue with the use of suitable decontaminating agent. There is no guideline to dictate which detergent / solvent to be used as it is solely depends on the chemical exposed to. Removal of chemical residue should be done before removing the glove from the hand. It is important to ensure adequate study to be conducted by the users to ensure thorough decontamination. Insufficient decontamination would deteriorate the glove further even if it were not in use. Handle and remove gloves carefully to avoid contamination of hands and the insides of the gloves. The glove should be dried in a decontaminated area.

After the use of gloves, it is good practice to wash the hand with soap and running water. Dry the hands carefully and use hand cream to keep the skin from becoming dry through lost of natural oils. Before any glove is to be reused, factors such as the chemical toxicity, the effectiveness of the decontamination process, and the absorption characteristic of the gloves need to be considered. If in doubt about the effectiveness of the decontamination, it is advisable not to reuse the gloves.

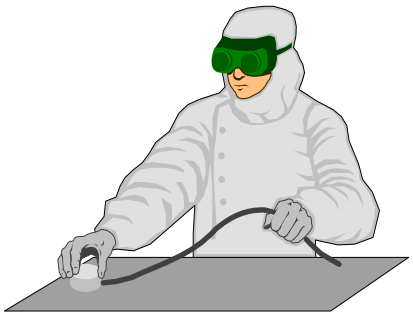
Caution! *Gloves should not be worn when working near moving equipment and machinery parts as the glove may get caught in the equipment and draw the hand and arm of the worker into the moving machinery.*

3.2.5. Body Protection

Types

The risk that workers may encounter include heat, cold, bad weather, chemical or metal splash, spray from pressure leaks or spray guns, impact or penetration, contaminated dust, and excessive wear or entanglement of own clothing.

The types of body protection include conventional or disposal overalls, boiler suits, warehouse coats, laboratory coats, donkey jackets, apron and specialist protective clothing such as chemical suits and aluminium asbestos suits for hot work. Choice of material includes non-flammable, anti-static, chain mail, chemically impermeable or high visibility materials.



Selection

In selecting protective clothing the factors to be considered includes:

a) Penetration of chemicals through seams, pores, zippers and materials imperfections;
b) Degradation of clothing due to exposure to chemicals, heat and sunlight; and
c) Permeation of chemicals through clothing, i.e. without going through pinholes, seams or other openings.

Table 6: Selection Guide for Protective Clothing

Risks	Protection
Low risk chemicals	Chemical resistant clothing, coveralls and laboratory coats made from cotton or synthetic material such as nylon or Terylene with a water repellent finish
Strong solvents, oils and greases	Coats, overalls and aprons made from neoprene or polyurethane coated nylon, or Terylene or rubber aprons.
Potent chemicals	Totally encapsulating suits that are either vapour-proof (made of PVC, Viton, butyl or Teflon) or liquid-splash proof (made of PVC, butyl, Viton, or Teflon) and are fed with breathable air.
Fibres and dusts	Suits made from bonded olefin that forms a dense shield that keeps out fibres and particles.

Use, Maintenance & Disposal

Protective clothing should only be used for the purpose intended. It should be maintained in good condition and checked regularly. It should be repaired or discarded if damaged. Contaminated clothing should be washed before reuse. Contaminated laundry water should not be disposed off directly but treated prior to discharging into streams, rivers or sea. Clothing that are totally contaminated should be treated as scheduled waste and should be disposed off as scheduled waste disposal procedures.

3.2.6. Feet and Leg Protection

Types

The use of safety footwear; gaiters; leggings and spats can protect the feet and leg. Safety footwear includes:

a. Safety boot or shoe – normally have stainless steel toe-caps to protect the feet against crushing and may have some other safety features such as anti-slip soles, steel mid-soles, etc.;

b. Foundry boots – have steel toe-caps, are heat resistant and designed to keep molten metal out (without external features such as laces and usually have Velcro fasteners or elasticised sides for quick release);

c. Wellington boots – usually made of rubber but are available in polyurethane and PVC which offer protection against water and wet conditions;

d. Antistatic footwear – prevents build up of static electricity, reduce the danger of igniting a flammable atmosphere, and gives some protection against electric shock;

e. Conductive footwear – prevents the build up of static electricity but gives no protection against electric shock.

Selection

The selection of foot protection depends primarily on the hazard. However, comfort, style and durability should also be considered. Generally, safety footwear should be flexible, wet resistant and absorb perspiration. Where ankles need protection, boots instead of shoes should be selected.

Select safety shoes and boots with impact protection for tasks involving the carrying or handling of materials such as packages, objects, parts or heavy tools, which could be dropped; and for other activities where objects might fall onto the feet. Safety shoes or boots with compression protection would be required for work activities involving skid trucks around bulk rolls and around heavy pipes, which could potentially roll over an employee's feet. Safety shoes with puncture protection would be required where sharp objects such as nails, wire, tacks, screws, large stapes, scrap metal etc., could be stepped on by employees causing a foot injury.

For working with hazardous chemicals, footwear provided should be both impermeable and resistant to attack by chemicals. The footwear should be in one-piece, i.e. no stitches allowed.

Use and Maintenance

Always follow the manufacturer's instructions and markings for appropriate use and level of protection.

Safety footwear should be maintained in good condition, checked regularly and discarded if worn or deteriorated. Laces should be checked regularly and replaced if necessary. Materials lodged into the tread should be removed. The stitching should be checked for loose, worn or cut seams. Spraying the upper layers of new footwear with a silicone spray or applying a protective wax will give extra protection against wet conditions.

3.2.7 Summary PPE Selection & Replacement

Summary of the types of PPE and their functions; and the summary of minimum indicators for PPE replacement are given as Table 7 and Table 8 respectively.

Table 7: Summary of PPE Types and Their Functions

Type	Function	Example
Head	to protect the users from chemical splash	Safety helmet, bump cap
Face/eye	to protect the users from molten metal, liquid chemicals, acids or caustic liquids	Safety goggles face shield
Respiratory system	to protect users against occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays or vapours with the primary objective to prevent breathing atmospheric contaminant.	Air purifying respirator. Supplied air respirator.
Body	to protect users against liquid chemicals, acids or caustic spills, serves as fall protection.	Long-sleeve shirt, apron, chemical suit, safety harness
Hand	to protect the users from exposures to hazards such as those from skin absorption of harmful substances, chemical burns, thermal burns	Chemical resistance gloves, finger coats
Foot	to protect the users from contact with hot liquid.	Safety shoes, safety boot

Table 8: Summary of Minimum Indicators for PPE Replacement

PPE type	Minimum Indicators for Replacement
Safety helmet	Broken/severed crown strap; cracked/broken safety helmet; severed chin strap
Safety glasses/ goggles	Scratches on the lens, blurred or fogged lens that inhibits user vision; loose frame that led to safety glasses falling off
Face shield	Scratches on the lens, blurred or fogged lens that inhibits user vision; attachment not in good condition
Disposable/ Maintenance free respirator	Disability and difficulty to breathe or restrained air movement in and out for the user
Reusable respirator, half-mask and full-face	Disability and difficulty to breathe or restrained air movement in and out for the user due to stuffy filters; gas/vapour smell going through due to incorrect use of cartridges; leakages to exhalation valve; leakages to the respirator face-piece found through positive or negative pressure test
Supplied air system	Disability and difficulty to breathe or restrained air movement in and out for the user; leakages to exhaust valve; leakages to the respirator face-piece found through positive or negative pressure test; inadequate compressed air
Apron/chemical suit	Leakages, deterioration or torn chemical suit allowing liquid chemicals, acids or caustic to seep through
Chemical resistance gloves	Leakages, deterioration or torn chemical suit allowing liquid/gas/vapour of chemicals, acids or caustic to seep through
Safety shoes	Wear and tear or slippery sole; damage and deterioration to safety shoes

Chapter 4

PPE PROGRAMME

For personal protective equipment to be effective as a control measure it must be consolidated as a programme and managed properly. A programme on personal protective equipment should consist of the following elements:

Selection of personal protective equipment
Issuance of personal protective equipment & fit testing
Information, instruction & training
Proper use & Supervision
Inspection, Storage, Availability & Maintenance
Disposal
Record keeping
Review of programme
Workers responsibilities

4.1. Selection of Personal Protective Equipment

4.1.1 Medical Evaluation of Employees Required to Use Respirators

Before employees are required to wear respirators a medical evaluation need to be conducted by a medical practitioner to determine whether the employee is fit to wear a respirator taking into consideration his health conditions. A sample medical evaluation questionnaire is given in **Appendix 2.**

4.1.2 Assessment of Risks

Before personal equipment is selected for use, an assessment should be carried out to determine whether the equipment to be provided is suitable. This assessment should ensure that hazards and risks of the work processes are clearly identified. The assessment should include the assessment of risk or risks involved; the types of protection required to adequately protect against the risk or risks identified, and assessment of the risk posed by the equipment itself.

Assessing the risk will involve the identification of type of hazard present and the assessment of the degree of risk. The type of personal protective equipment to be selected depends on the types of hazard present, the parts of the body endangered and the degree of protection required.

Comparison of characteristic of available personal protection equipment and the required protection should also be part of the assessment of selecting the most suitable equipment. When selecting personal equipment to be used for doing a job, the nature of the job and the demands it places on the worker should be taken into account. An assessment of the effectiveness of the equipment chosen should be made to ensure it is providing the desired protection and is not creating any additional safety or health problems. Personal protective equipment should be selected which will best protect workers in the circumstances. In some cases use of personal protective equipment may create a secondary risk not identified in the original assessment. These risks should be evaluated.

4.1.2 Consultation with the supplier

The availability of personal protective equipment is extensive and the employer must ensure the provision of equipment is suitable for the conditions and operations that may exist whilst undertaking specific work activities. There is no singular form of personal protective equipment that can be used universally for all types of hazards and work conditions.

There are many different types of gloves, respiratory and body protection available on the market. For example, there is no one type of glove that will provide hand protection from all hazards. Selection of gloves and protective clothing that will provide the appropriate level of protection is a complex task. Likewise, the selection of respiratory protection is equally complex.

Therefore, should there be any doubts, it is important for the employers to consult the experts/ manufacturers of personal protective equipment for advice pertaining to the correct selection of personal protective equipment for specific application at their workplaces.

4.1.3 Suitability of PPE

Selection of personal protective equipment should be based on the suitability of the equipment to protect the wearer. The term suitable indicates:

e) Appropriate for the risks involved and conditions at the place where exposure to the risk may occur;
f) Adequate protection is afforded without increasing the overall risk;
g) It takes into account ergonomics requirements and the state of health of the user or wearer;
h) It is capable of fitting the wearer correctly;
i) It is design and manufactured according to a certain standard of quality.

The personal protective equipment should be selected for use if the risk or risks have not been adequately controlled by engineering or other means, or where the use of other means is not possible or practicable.

The protective equipment should match up with the risk or risks e.g. for protecting against a chemical splash it may be necessary to provide the worker with eye, face, body and limbs protection by the user of safety spectacles or goggles, face screens, apron, gloves, and protective footwear.

Selection of personal protective equipment should consider whether protection is required for a specific risk or to control multiple risks presented by the same hazard or a combination of hazards. For example, using a pesticide sprayer to spray pesticides in a plantation presents risks to the eyes (mists); lungs (mists & vapour); whole of body (mists); and hands (liquid).

The selected equipment should provide adequate control of the risk or risks the wearer is exposed to. The equipment must be able to protect the wearer either from the risk of acute bodily injury, suffocation or the risk of chronic effect to health. Protection against the risk to acute effects or injury will mean that the equipment must be able to provide an effective barrier between the hazard and the wearer.

For protection against health risks, personal protection with an adequate protection factor (or degree of protection) must be selected such that the exposure of the wearer to the hazard is well below the recommended occupational exposure limit. However, where no personal protective equipment will provide adequate control of risk e.g. Fire fighter's clothing, the personal protective equipment with the best protection practicable for the circumstances should be chosen.

Personal protective equipment must be chosen such that it will give minimum discomfort to the wearer. Uncomfortable equipment is unlikely to be worn properly. In selecting personal protective equipment to be used for a particular job, the nature of the job and the demands it places on the worker should be taken into account. Those who do the job must be consulted as equipment selected involves the consideration of the physical effort to do the job, the methods of work, the duration the equipment need to be used or worn, and the requirements for visibility and communication.

4.2. Issuance & Fit Testing

It is the duty of the employer (Regulations 15(1) of USECHH Regulations 2000) to provide items of personal protective equipment. Factors to be considered in deciding upon the most appropriate provision of equipment for a particular workplace include:

- Absolute requirement for personal protective equipment at that workplace;
- Availability of the personal protective equipment;
- Location of the workplace;
- Need for a personal fit; and
- Industry practice, including whether personal protective equipment is a normal requirement for that industry sector.

Provision of personal protective equipment at the workplace should be made known to employees before they commence work or before they are required to wear or use the personal protective equipment, as appropriate to the circumstances.

In considering the provision of personal protective equipment, selection directly by employees may be appropriate where individual fit is integral to the safe operation of the equipment (e.g. footwear).

Personal protective equipment should be checked to ensure that it fits properly and is worn correctly. Comfort of personal protective equipment is an important factor in ensuring its use.

To ensure personal protective equipment is selected appropriately, the following process should occur:

- Employers and employees should familiarise themselves with the potential hazards and the availability of personal protective equipment;
- Employers and employees should have an understanding of the criteria for selecting appropriate personal protective equipment which provides adequate level of protection against the risks present; and
- Employers and employees should evaluate the selected equipment to ensure it fits properly and is used appropriately, and does not create secondary health or safety risks.

4.3. Information, Instruction & Training

All employees at a workplace exposed to hazards should be trained in safe work practices including the correct use of personal protective equipment. The employer has a duty to provide this training and relevant information. Where items of personal protective equipment are to be worn by non-employees at a workplace, sufficient instruction should be provided to ensure the correct wearing of these items of personal protective equipment.

A follow-up assessment of employees' safety training should be carried out periodically to ensure the work is being carried out in a safe manner and that personal protective equipment is being properly used and is effective.

Training can be separated into induction and more specific job training.

• Induction Training

General information about personal protective equipment should form an integral part of an induction-training program for new employees.

An induction program relevant to personal protective equipment should include:

a. Duty of care under the Occupational Safety and Health Act 1994*;*
b. Safety and health policies and procedures;
c. Provision, use, storage & maintenance of personal protective equipment, particularly the risks caused by incorrect use or maintenance of the equipment; and
d. Emergency procedures in case of special risks e.g. chemical spills or fires.

- **Job Training**

Training of new employees for their specific jobs should cover the hazards and risks associated with the job identified in a hazard identification and risk assessment process. It should also include instruction in the use of personal protective equipment required by the job including:

- Correct selection, use and wearing of personal protective equipment;
- Comfort and fit requirements;
- Limitations in use and effectiveness; and
- Maintenance and replacement procedures.

Ongoing training should be provided to employees, as work practices and equipment are up-dated.

4.4. Proper Use & Supervision

Personal protective equipment should be used in accordance with the manufacturer's instructions for use. Proper use of personal protective equipment can only be achieved through adequate instructions, training and supervision. The degree of protection afforded is by the personal protective equipment is greatly dependent on the duration of use in the hazardous environment. For respiratory protection to be effective to keep all contaminants out of worker's air intake, they must be worn for more than 99% of the time in the hazardous environment. Hence, this equipment must be worn continuously throughout the time when the risk or risks are present.

Personal protective equipment provided should be made full use of and its use should not create risk to the wearer or other people at the place of work. Most personal protective equipment must be returned after use to the storage place provided. An exception may be made for some equipment the employee may take away from the workplace (such as safety shoes), or which are used or worn intermittently and need only be returned at the end of the working period, shift or assignment (such as welding visors).

4.5. Inspection, Storage, Availability & Maintenance

4.5.1 Storage & Inspection

An employer should ensure that personal protective equipment is stored in a clean and fully operational condition. Storage arrangements should ensure that the equipment is safe from interference and damage, and that it is easily accessible when needed.

Personal protective equipment should also be inspected regularly at intervals specified by the manufacturer or supplier, to determine that it is in a serviceable condition, both during storage and in use. For example, torn gloves should be replaced even though they are newly supplied.

4.5.2. Supply, Availability & Maintenance

An employer should ensure that personal protective equipment that is supplied to employees, at no cost, is readily available and in good operating condition. Section 26 of the Occupational Safety & Health Act 1994 stipulates that the employer should not levy a charge on his employee anything provided in pursuance to the Act or any regulations made under this Act.

Replacements of equipment should be made at regular intervals based on manufacturer's recommendation or whenever they are found to be defective or no longer effective in providing the necessary protection.

The employer should also ensure that personal protective equipment is maintained in a condition that ensures its continued effective operation. Damaged or defective personal protective equipment should be discarded or repaired.

A system to ensure appropriate maintenance of personal protective equipment is carried out should be instituted. This system should include:

a) Responsibilities for maintenance;
b) Designation of personnel;
c) Storage procedures;
d) Cleaning procedures;
e) Checking procedures;
f) Information on the duration of protection for gloves, respiratory canisters, etc.; and
g) Training on correct maintenance of personal protective equipment used at the workplace; and criteria for replacement.

4.6. Disposal

Disposal of damaged, defective or worn out personal protective equipment should be done in a manner that do not posed a hazard not only to the employees handling the disposed equipment but also to the operators of the disposal site or even the public.

The disposed equipment should be packed in a suitable packaging and be labelled if necessary. Equipment contaminated with carcinogen or toxic substances, such as respirators worn in asbestos contaminated environment, and should be properly labelled to warn workers handling the disposed item of the dangers or risks involved. Workers should use suitable personal protective equipment when handling these contaminated personal protective equipment or clothing.

Please consult the Department of Environment for disposal of contaminated personal protective equipment or clothing.

4.7. Record keeping

Keeping records of the programme is important in that it is essential as an evidence of the employers discharging of his responsibilities in protecting his employees. Records of assessment, issuance and training of the employees should be kept either for legal purposes or for purpose of reviewing the programme. For health risk assessment the USECHH Regulations 2000 stipulates the assessment report be kept for a period of at least 30 years. For other records, they should be kept for period of at least as long as the employees are employed with the company. A sample of the record format is given in **Appendix 3**.

4.8. Review of Programme

The PPE programme should be reviewed from time to time especially whenever there are changes to the overall safety & health policy or whenever a reassessment of the chemical health risk had been undertaken or whenever there are evidence that the use of PPE has not been effective in protecting the health of the workers at the place of work that has caused injury or health issues.

4.9. Worker Cooperation

Since PPE, are in most instances, are personal issues the user or wearer need to cooperate with the programme administrator in order for PPE programme to be effective. Cooperation of workers is required in the following areas:

a) Selection of suitable PPE;
b) Instruction, training & education sessions;
c) Proper use of PPE; and
d) Care and maintenance of PPE.

Chapter 5

APPROVAL OF PERSONAL PROTECTIVE EQUIPMENT

Under regulation 15(1) of the USECHH Regulations 2000, one of the actions to control exposure is the provision of approved personal protective equipment. Under the USECHH Regulations 'approved' means approved in writing by the Director General of Occupational Safety and Health.

5.1. Criteria for Approval of PPE

For personal protective equipment the criteria for approval is as follows:

a) Designed to recognised standards;
b) Tested according to recognised standards;
c) Passed the test conducted by an accredited testing laboratory; or
d) A developed country approves the use of the equipment.

Standards recognised for the design of personal protective equipment are given in Table 9 below:

Table 9: Recognized Standards for Personal Protective Equipment

Protective Equipment	Malaysian Standard (MS)	Other Standards
Safety helmets	MS 183:1983	ANSI Z89.1-1986, ANZI Z89.1-1997
Eye protectors		ANSI Z87.1-1989, EN 166:2001
Protective clothing		ASTM (Methods F1383-92, F739-91, F1407-95)
Respiratory protective devices		NIOSH (USA) 42 CFR 84, ANSI Z88.2-1992, AS/NZS 1715, AS/NZS 1716-2003, EN136, EN140, EN141, EN143, EN149, EN12419, EN1835, EN12941, EN12942, KMOL 2000-15, JMHLW Dust Respirators 2000, JMHLW Gas Masks 2001, JIS T8153, JIS T8157
Industrial safety gloves and mittens		AS2161, ASTM F739, EN374-1, EN374-2, EN374-3, EN388, EN407, EN420, EN511, EN/ISO 10819 AS/NZS 2161.1, AS/NZS2161.2, AS/NZS2161.3, AS/NZS2161.4, AS/NZS2161.9, AS/NZS2161.10
Occupational protective footwear	MS 1599:1998	ANSI Z41-1991, AS2210, EN345

5.2. Application Procedure

An application to get an approval for personal protective equipment must be made to the Director General and shall be forwarded to him together with the following items:-

a) a sample of the equipment;

b) a catalogue and/or manual on the use of the equipment;

c) an approval letter or proof of recognition/endorsement of the equipment by an internationally recognised certification body or national approving authority;

d) report of equipment testing from an accredited testing laboratory;

e) letter of appointment as authorised supplier/distributor from equipment's manufacturer or agent; and

f) a certified true copy of the standard used for the design & testing of the equipment

The completed application shall be forwarded to: -

The Director General
Department of Occupational Safety and Health,
Levels 2, 3, & 4, Block D3, Parcel D,
Federal Government Administration Centre,
62502 WP Putrajaya

Note: Users can use those PPE that been designed & tested according to the approved methods listed in Table 9 or insist on the PPE approval letter issued by the Director General of DOSH from the PPE supplier.

References

1. *P.U.(A) 131: Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations 2000. Malaysian government gazette: 4th April 2000.*

2. *The Occupational Environment-Its Evaluation & Control,(1997) Ed. Salvatore R. Nihardi, AIHA, USA*

3. *Personal Protective Equipment, Anuar Mohd. Mokhtar in Occupational Safety & Health in Malaysia (1996), Malaysian NIOSH, Malaysia,*

4. *Respirators, Sheldon H. Rabinovitz in "Hazardous Chemicals Desk Reference",*

5. *Oregon OSHA Online Course on PPE, Module Six. http://www.cbs.state.or.us/external/osha/educate/training/pages/203m6.htm*

6. *Health and Safety Executive's Personal Protective Equipment at Work, Personal Protective Equipment at Work Regulations 1992-Guidance on Regulations (1992), HMSO, London.*

7. *Singapore Standard CP 74:1998, Code of Practice for Selection, use and maintenance of respiratory protective devices. Singapore Productivity & Standards Board, 1999.*

8. *Canadian Centre for Occupational Health & Safety website http://www.ccohs.com/oshanswers/prevention/ppe/gloves.html.*

APPENDIX 1: LIST OF CHEMICALS & THEIR IDLH'S CONCENTRATIONS

NIOSH CHEMICAL LISTING AND DOCUMENTATION OF REVISED IDLH VALUES (AS OF 3/1/95)

SUBSTANCE	REVISED IDLH VALUE
Acetaldehyde	2,000 ppm
Acetic acid	50 ppm
Acetic anhydride	200 ppm
Acetone	2,500 ppm [LEL]
Acetonitrile	500 ppm
Acetylene tetrabromide	8 ppm
Acrolein	2 ppm
Acrylamide	60 mg/m^3
Acrylonitrile	85 ppm
Aldrin	25 mg/m^3
Allyl alcohol	20 ppm
Allyl chloride	250 ppm
Allyl glycidyl ether	50 ppm
2 Aminopyridine	5 ppm
Ammonia	300 ppm
Ammonium sulfamate	1,500 mg/m^3
n-Amyl acetate	1,000 ppm
sec-Amyl acetate	1,000 ppm
Aniline	100 ppm
o-Anisidine	50 mg/m^3
p-Anisidine	50 mg/m^3
Antimony compounds (as Sb)	50 mg Sb/m^3
ANTU	100 mg/m^3
Arsenic (inorganic compounds, as As)	5 mg As/m^3
Arsine	3 ppm
Azinphosmethyl	10 mg/m^3
Barium (soluble compounds, as Ba)	50 mg Ba/m^3
Benzene	500 ppm
Benzoyl peroxide	1,500 mg/m^3

Benzyl chloride	10 ppm
Beryllium compounds (as Be)	4 mg Be/m^3
Boron oxide	2,000 mg/m^3
Boron trifluoride	25 ppm
Bromine	3 ppm
Bromoform	850 ppm
1,3-Butadiene	2,000 ppm [LEL]
2-Butanone	3,000 ppm
2-Butoxyethanol	700 ppm
n-Butyl acetate	1,700 ppm [LEL]
sec-Butyl acetate	1,700 ppm [LEL]
tert-Butyl acetate	1,500 ppm [LEL]
n-Butyl alcohol	1,400 ppm [LEL]
sec-Butyl alcohol	2,000 ppm
tert-Butyl alcohol	1,600 ppm
n-Butylamine	300 ppm
tert-Butyl chromate	15 mg Cr(VI)/m^3
n-Butyl glycidyl ether	250 ppm
n-Butyl mercaptan	500 ppm
p-tert-Butyltoluene	100 ppm
Cadmium dust (as Cd)	9 mg Cd/m^3
Cadmium fume (as Cd)	9 mg Cd/m^3
Calcium arsenate (as As)	5 mg As/m^3
Calcium oxide	25 mg/m^3
Camphor (synthetic)	200 mg/m^3
Carbaryl	100 mg/m^3
Carbon black	1,750 mg/m^3
Carbon dioxide	40,000 ppm
Carbon disulfide	500 ppm
Carbon monoxide	1,200 ppm
Carbon tetrachloride	200 ppm
Chlordane	100 mg/m^3
Chlorinated camphene	200 mg/m^3
Chlorinated diphenyl oxide	5 mg/m^3
Chlorine	10 ppm
Chlorine dioxide	5 ppm
Chlorine trifluoride	20 ppm

Chloroacetaldehyde	45 ppm
alpha-Chloroacetophenone	15 mg/m^3
Chlorobenzene	1,000 ppm
o-Chlorobenzylidene malononitrile	2 mg/m^3
Chlorobromomethane	2,000 ppm
Chlorodiphenyl (42% chlorine)	5 mg/m^3
Chlorodiphenyl (54% chlorine)	5 mg/m^3
Chloroform	500 ppm
1-Chloro-1-nitropropane	100 ppm
Chloropicrin	2 ppm
beta-Chloroprene	300 ppm
Chromic acid and chromates	15 mg Cr(VI)/m^3
Chromium (II) compounds [as Cr(II)]	250 mg Cr(II)/m^3
Chromium (III) compounds [as Cr(III)]	25 mg Cr(III)/m^3
Chromium metal (as Cr)	250 mg Cr/m^3
Coal tar pitch volatiles	80 mg/m^3
Cobalt metal, dust and fume (as Co)	20 mg Co/m^3
Copper (dusts and mists, as Cu)	100 mg Cu/m^3
Copper fume (as Cu)	100 mg Cu/m^3
Cotton dust (raw)	100 mg/m^3
Crag (r) herbicide	500 mg/m^3
Cresol (o, m, p isomers)	250 ppm
Crotonaldehyde	50 ppm
Cumene	900 ppm [LEL]
Cyanides (as CN)	25 mg/m^3 (as CN)
Cyclohexane	1,300 ppm [LEL]
Cyclohexanol	400 ppm
Cyclohexanone	700 ppm
Cyclohexene	2,000 ppm
Cyclopentadiene	750 ppm
2,4-D	100 mg/m^3
DDT	500 mg/m^3
Decaborane	15 mg/m^3
Demeton	10 mg/m^3
Diacetone alcohol	1,800 ppm [LEL]
Diazomethane	2 ppm
Diborane	15 ppm

Dibutyl phosphate	30 ppm
Dibutyl phthalate	4,000 mg/m^3
o-Dichlorobenzene	200 ppm
p-Dichlorobenzene	150 ppm
Dichlorodifluoromethane	15,000 ppm
1,3-Dichloro 5,5-dimethylhydantoin	5 mg/m^3
1,1-Dichloroethane	3,000 ppm
1,2-Dichloroethylene	1,000 ppm
Dichloroethyl ether	100 ppm
Dichloromonofluoromethane	5,000 ppm
1,1-Dichloro 1-nitroethane	25 ppm
Dichlorotetrafluoroethane	15,000 ppm
Dichlorvos	100 mg/m^3
Dieldrin	50 mg/m^3
Diethylamine	200 ppm
2-Diethylaminoethanol	100 ppm
Difluorodibromomethane	2,000 ppm
Diglycidyl ether	10 ppm
Diisobutyl ketone	500 ppm
Diisopropylamine	200 ppm
Dimethyl acetamide	300 ppm
Dimethylamine	500 ppm
N,N-Dimethylaniline	100 ppm
Dimethyl 1,2-dibromo 2,2-dichlorethyl phosphate	200 mg/m^3
Dimethylformamide	500 ppm
1,1-Dimethylhydrazine	15 ppm
Dimethylphthalate	2,000 mg/m^3
Dimethyl sulfate	7 ppm
Dinitrobenzene (o, m, p isomers)	50 mg/m^3
Dinitroocresol	5 mg/m^3
Dinitrotoluene	50 mg/m^3
Di sec-octyl phthalate	5,000 mg/m^3
Dioxane	500 ppm
Diphenyl	100 mg/m^3
Dipropylene glycol methyl ether	600 ppm
Endrin	2 mg/m^3
Epichlorohydrin	75 ppm

EPN	5 mg/m^3
Ethanolamine	30 ppm
2-Ethoxyethanol	500 ppm
2-Ethoxyethyl acetate	500 ppm
Ethyl acetate	2,000 ppm [LEL]
Ethyl acrylate	300 ppm
Ethyl alcohol	3,300 ppm [LEL]
Ethylamine	600 ppm
Ethyl benzene	800 ppm [LEL]
Ethyl bromide	2,000 ppm
Ethyl butyl ketone	1,000 ppm
Ethyl chloride	3,800 ppm [LEL]
Ethylene chlorohydrin	7 ppm
Ethylenediamine	1,000 ppm
Ethylene dibromide	100 ppm
Ethylene dichloride	50 ppm
Ethylene glycol dinitrate	75 mg/m^3
Ethyleneimine	100 ppm
Ethylene oxide	800 ppm
Ethyl ether	1,900 ppm [LEL]
Ethyl formate	1,500 ppm
Ethyl mercaptan	500 ppm
N-Ethylmorpholine	100 ppm
Ethyl silicate	700 ppm
Ferbam	800 mg/m^3
Ferrovanadium dust	500 mg/m^3
Fluorides (as F)	250 mg F/m^3
Fluorine	25 ppm
Fluorotrichloromethane	2,000 ppm
Formaldehyde	20 ppm
Formic acid	30 ppm
Furfural	100 ppm
Furfuryl alcohol	75 ppm
Glycidol	150 ppm
Graphite (natural)	1,250 mg/m^3
Hafnium compounds (as Hf)	50 mg Hf/m^3
Heptachlor	35 mg/m^3

n-Heptane	750 ppm
Hexachloroethane	300 ppm
Hexachloronaphthalene	2 mg/m^3
n-Hexane	1,100 ppm [LEL]
2-Hexanone	1,600 ppm
Hexone	500 ppm
sec Hexyl acetate	500 ppm
Hydrazine	50 ppm
Hydrogen bromide	30 ppm
Hydrogen chloride	50 ppm
Hydrogen cyanide	50 ppm
Hydrogen fluoride (as F)	30 ppm
Hydrogen peroxide	75 ppm
Hydrogen selenide (as Se)	1 ppm
Hydrogen sulfide	100 ppm
Hydroquinone	50 mg/m^3
Iodine	2 ppm
Iron oxide dust and fume (as Fe)	2,500 mg Fe/m^3
Isoamyl acetate	1,000 ppm
Isoamyl alcohol (primary and secondary)	500 ppm
Isobutyl acetate	1,300 ppm [LEL]
Isobutyl alcohol	1,600 ppm
Isophorone	200 ppm
Isopropyl acetate	1,800 ppm
Isopropyl alcohol	2,000 ppm [LEL]
Isopropylamine	750 ppm
Isopropyl ether	1,400 ppm [LEL]
Isopropyl glycidyl ether	400 ppm
Ketene	5 ppm
Lead compounds (as Pb)	100 mg Pb/m^3
Lindane	50 mg/m^3
Lithium hydride	0.5 mg/m^3
L.P.G.	2,000 ppm [LEL]
Magnesium oxide fume	750 mg/m^3
Malathion	250 mg/m^3
Maleic anhydride	10 mg/m^3
Manganese compounds (as Mn)	500 mg Mn/m^3

Mercury compounds [except (organo) alkyls, as Hg]	10 mg Hg/m^3
Mercury (organo) alkyl compounds(as Hg)	2 mg Hg/m^3
Mesityl oxide	1,400 ppm [LEL]
Methoxychlor	5,000 mg/m^3
Methyl acetate	3,100 ppm [LEL]
Methyl acetylene	1,700 ppm [LEL]
Methyl acetylenepropadiene mixture	3,400 ppm [LEL]
Methyl acrylate	250 ppm
Methylal	2,200 ppm [LEL]
Methyl alcohol	6,000 ppm
Methylamine	100 ppm
Methyl (namyl) ketone	800 ppm
Methyl bromide	250 ppm
Methyl Cellosolve (r)	200 ppm
Methyl Cellosolve (r) acetate	200 ppm
Methyl chloride	2,000 ppm
Methyl chloroform	700 ppm
Methylcyclohexane	1,200 ppm [LEL]
Methylcyclohexanol	500 ppm
o-Methylcyclohexanone	600 ppm
Methylene bisphenyl isocyanate	75 mg/m^3
Methylene chloride	2,300 ppm
Methyl formate	4,500 ppm
5-Methyl 3-heptanone	100 ppm
Methyl hydrazine	20 ppm
Methyl iodide	100 ppm
Methyl isobutyl carbinol	400 ppm
Methyl isocyanate	3 ppm
Methyl mercaptan	150 ppm
Methyl methacrylate	1,000 ppm
Methyl styrene	700 ppm
Mica	1,500 mg/m^3
Molybdenum (insoluble compounds, as Mo)	5,000 mg Mo/m^3
Molybdenum (soluble compounds, as Mo)	1,000 mg Mo/m^3
Monomethyl aniline	100 ppm
Morpholine	1,400 ppm [LEL]

Naphtha (coal tar)	1,000 ppm [LEL]
Naphthalene	250 ppm
Nickel carbonyl (as Ni)	2 ppm
Nickel metal and other compounds (as Ni)	10 mg Ni/m^3
Nicotine	5 mg/m^3
Nitric acid	25 ppm
Nitric oxide	100 ppm
p-Nitroaniline	300 mg/m^3
Nitrobenzene	200 ppm
p-Nitrochlorobenzene	100 mg/m^3
Nitroethane	1,000 ppm
Nitrogen dioxide	20 ppm
Nitrogen trifluoride	1,000 ppm
Nitroglycerine	75 mg/m^3
Nitromethane	750 ppm
1-Nitropropane	1,000 ppm
2-Nitropropane	100 ppm
Nitrotoluene (o, m, p isomers)	200 ppm
Octachloronaphthalene	Unknown
Octane	1,000 ppm [LEL]
Oil mist (mineral)	2,500 mg/m^3
Osmium tetroxide (as Os)	1 mg Os/m^3
Oxalic acid	500 mg/m^3
Oxygen difluoride	0.5 ppm
Ozone	5 ppm
Paraquat	1 mg/m^3
Parathion	10 mg/m^3
Pentaborane	1 ppm
Pentachloronaphthalene	Unknown
Pentachlorophenol	2.5 mg/m^3
n-Pentane	1,500 ppm [LEL]
2-Pentanone	1,500 ppm
Perchloromethyl mercaptan	10 ppm
Perchloryl fluoride	100 ppm
Petroleum distillates (naphtha)	1,100 ppm [LEL]
Phenol	250 ppm
p-Phenylene diamine	25 mg/m^3

Phenyl ether (vapor)	100 ppm
Phenyl etherbiphenyl mixture (vapor)	10 ppm
Phenyl glycidyl ether	100 ppm
Phenylhydrazine	15 ppm
Phosdrin	4 ppm
Phosgene	2 ppm
Phosphine	50 ppm
Phosphoric acid	1,000 mg/m^3
Phosphorus (yellow)	5 mg/m^3
Phosphorus pentachloride	70 mg/m^3
Phosphorus pentasulfide	250 mg/m^3
Phosphorus trichloride	25 ppm
Phthalic anhydride	60 mg/m^3
Picric acid	75 mg/m^3
Pindone	100 mg/m^3
Platinum (soluble salts, as Pt)	4 mg Pt/m^3
Portland cement	5,000 mg/m^3
Propane	2,100 ppm [LEL]
n-Propyl acetate	1,700 ppm
n-Propyl alcohol	800 ppm
Propylene dichloride	400 ppm
Propylene imine	100 ppm
Propylene oxide	400 ppm
n-Propyl nitrate	500 ppm
Pyrethrum	5,000 mg/m^3
Pyridine	1,000 ppm
Quinone	100 mg/m^3
Rhodium (metal fume and insoluble compounds, as Rh)	100 mg Rh/m^3
Rhodium (soluble compounds, as Rh)	2 mg Rh/m^3
Ronnel	300 mg/m^3
Rotenone	2,500 mg/m^3
Selenium compounds (as Se)	1 mg Se/m^3
Selenium hexafluoride	2 ppm
Silica, amorphous	3,000 mg/m^3
Silica, crystalline (respirable dust)	
cristobalite/tridymite:	25 mg/m^3

quartz/tripoli:	50 mg/m^3
Silver (metal dust and soluble compounds, as Ag)	10 mg Ag/m^3
Soapstone	3,000 mg/m^3
Sodium fluoroacetate	2.5 mg/m^3
Sodium hydroxide	10 mg/m^3
Stibine	5 ppm
Stoddard solvent	20,000 mg/m^3
Strychnine	3 mg/m^3
Styrene	700 ppm
Sulfur dioxide	100 ppm
Sulfuric acid	15 mg/m^3
Sulfur monochloride	5 ppm
Sulfur pentafluoride	1 ppm
Sulfuryl fluoride	200 ppm
2,4,5-T	250 mg/m^3
Talc	1,000 mg/m^3
Tantalum (metal and oxide dust, as Ta)	2,500 mg Ta/m^3
TEDP	10 mg/m^3
Tellurium compounds (as Te)	25 mg Te/m^3
Tellurium hexafluoride	1 ppm
TEPP	5 mg/m^3
Terphenyl (o, m, p isomers)	500 mg/m^3
1,1,1,2-Tetrachloro 2,2-difluoroethane	2,000 ppm
1,1,2,2-Tetrachloro 1,2-difluoroethane	2,000 ppm
1,1,2,2-Tetrachloroethane	100 ppm
Tetrachloroethylene	150 ppm
Tetrachloronaphthalene	Unknown
Tetraethyl lead (as Pb)	40 mg Pb/m^3
Tetrahydrofuran	2,000 ppm [LEL]
Tetramethyl lead (as Pb)	40 mg Pb/m^3
Tetramethyl succinonitrile	5 ppm
Tetranitromethane	4 ppm
Tetryl	750 mg/m^3
Thallium (soluble compounds, as Tl)	15 mg Tl/m^3
Thiram	100 mg/m^3
Tin (inorganic compounds, as Sn)	100 mg Sn/m^3
Tin (organic compounds, as Sn)	25 mg Sn/m^3

Titanium dioxide	5,000 mg/m^3
Toluene	500 ppm
Toluene 2,4-diisocyanate	2.5 ppm
o-Toluidine	50 ppm
Tributyl phosphate	30 ppm
1,1,2-Trichloroethane	100 ppm
Trichloroethylene	1,000 ppm
Trichloronaphthalene	Unknown
1,2,3-Trichloropropane	100 ppm
1,1,2-Trichloro 1,2,2-trifluoroethane	2,000 ppm
Triethylamine	200 ppm
Trifluorobromomethane	40,000 ppm
2,4,6-Trinitrotoluene	500 mg/m^3
Triorthocresyl phosphate	40 mg/m^3
Triphenyl phosphate	1,000 mg/m^3
Turpentine	800 ppm
Uranium (insoluble compounds, as U)	10 mg U/m^3
Uranium (soluble compounds, as U)	10 mg U/m^3
Vanadium dust	35 mg V/m^3
Vanadium fume	35 mg V/m^3
Vinyl toluene	400 ppm
Warfarin	100 mg/m^3
Xylene (o, m, p isomers)	900 ppm
Xylidine	50 ppm
Yttrium compounds (as Y)	500 mg Y/m^3
Zinc chloride fume	50 mg/m^3
Zinc oxide	500 mg/m^3
Zirconium compounds (as Zr)	50 mg Zr/m^3

APPENDIX 2: RESPIRATOR MEDICAL EVALUATION QUESTIONNAIRE

To the employer: Answers to questions in Section 1, and to question 9 in Section 2 of Part A, do not require a medical examination.

To the employee: Can you read (circle one): Yes / No

Your employer must allow you to answer this questionnaire during normal working hours, or at a time and place that is convenient to you. To maintain your confidentiality, your employer or supervisor must not look at or review your answers, and your employer must tell you how to deliver or send this questionnaire to the health care professional who will review it.

Part A. Section 1. (Mandatory) The following information must be provided by every employee who has been selected to use any type of respirator (please print).

1. Today's date: _____

2. Your name: _____

3. Your age (to nearest year): _____

4. Sex (circle one): Male/Female

5. Your height: ____m.

6. Your weight: ____ kg.

7. Your job title:_____

8. A phone number where you can be reached by the health care professional who reviews this questionnaire (include the Area Code): _____

9. The best time to phone you at this number: _____

10. Has your employer told you how to contact the health care professional who will review this questionnaire (circle one): Yes / No

11. Check the type of respirator you will use (you can check more than one category):
    a. ____ N, R, or P disposable respirator (filter-mask, non-cartridge type only).
    b. ____ Other type (for example, half- or full face-piece type, powered-air purifying, supplied-air, self-contained breathing apparatus).

12. Have you worn a respirator (circle one): Yes / No

If ''yes,'' what type(s): _____

Part A. Section 2. (Mandatory) Questions 1 through 9 below must be answered by every employee who has been selected to use any type of respirator (please circle ‘‘yes’’ or ‘‘no’’).

1. Do you currently smoke tobacco, or have you smoked tobacco in the last month: Yes / No

2. Have you ever had any of the following conditions?
    a. Seizures (fits): Yes / No
    b. Diabetes (sugar disease): Yes / No
    c. Allergic reactions that interfere with your breathing: Yes / No
    d. Claustrophobia (fear of closed-in places): Yes / No
    e. Trouble smelling odours: Yes / No

3. Have you ever had any of the following pulmonary or lung problems?
    a. Asbestosis: Yes / No
    b. Asthma: Yes / No
    c. Chronic bronchitis: Yes / No
    d. Emphysema: Yes / No
    e. Pneumonia: Yes / No
    f. Tuberculosis: Yes / No
    g. Silicosis: Yes / No
    h. Pneumothorax (collapsed lung): Yes / No
    i. Lung cancer: Yes / No
    j. Broken ribs: Yes / No
    k. Any chest injuries or surgeries: Yes / No
    l. Any other lung problem that you’ve been told about: Yes / No

4. Do you currently have any of the following symptoms of pulmonary or lung illness?
    a. Shortness of breath: Yes / No
    b. Shortness of breath when walking fast on level ground or walking up a slight hill or incline: Yes / No
    c. Shortness of breath when walking with other people at an ordinary pace on level ground: Yes / No
    d. Have to stop for breath when walking at your own pace on level ground: Yes / No
    e. Shortness of breath when washing or dressing yourself: Yes / No
    f. Shortness of breath that interferes with your job: Yes / No
    g. Coughing that produces phlegm (thick sputum): Yes / No
    h. Coughing that wakes you early in the morning: Yes / No
    i. Coughing that occurs mostly when you are lying down: Yes / No
    j. Coughing up blood in the last month: Yes / No
    k. Wheezing: Yes / No
    l. Wheezing that interferes with your job: Yes / No
    m. Chest pain when you breathe deeply: Yes / No
    n. Any other symptoms that you think may be related to lung problems: Yes / No

5. Have you ever had any of the following cardiovascular or heart problems?
   a. Heart attack: Yes / No
   b. Stroke: Yes / No
   c. Angina: Yes / No
   d. Heart failure: Yes / No
   e. Swelling in your legs or feet (not caused by walking): Yes / No
   f. Heart arrhythmia (heart beating irregularly): Yes / No
   g. High blood pressure: Yes / No
   h. Any other heart problem that you've been told about: Yes / No

6. Have you ever had any of the following cardiovascular or heart symptoms?
   a. Frequent pain or tightness in your chest: Yes / No
   b. Pain or tightness in your chest during physical activity: Yes / No
   c. Pain or tightness in your chest that interferes with your job: Yes / No
   d. In the past two years, have you noticed your heart skipping or missing a beat: Yes / No
   e. Heartburn or indigestion that is not related to eating: Yes / No
   f. Any other symptoms that you think may be related to heart or circulation problems: Yes / No

7. Do you currently take medication for any of the following problems?
   a. Breathing or lung problems: Yes / No
   b. Heart trouble: Yes / No
   c. Blood pressure: Yes / No
   d. Seizures (fits): Yes / No

8. If you've used a respirator, have you ever had any of the following problems? (If you've never used a respirator, check the following space and go to question 9)
   a. Eye irritation: Yes / No
   b. Skin allergies or rashes: Yes / No
   c. Anxiety: Yes / No
   d. General weakness or fatigue: Yes / No
   e. Any other problem that interferes with your use of a respirator: Yes / No

9. Would you like to talk to the health care professional who will review this questionnaire about your answers to this questionnaire: Yes / No

Questions 10 to 15 below must be answered by every employee who has been selected to use either a full face-piece respirator or a self-contained breathing apparatus (SCBA). For employees who have been selected to use other types of respirators, answering these questions is voluntary.

10. Have you ever lost vision in either eye (temporarily or permanently): Yes / No

11. Do you currently have any of the following vision problems?
    a. Wear contact lenses: Yes / No
    b. Wear glasses: Yes / No
    c. Colour blind: Yes / No
    e. Any other eye or vision problem: Yes / No

12. Have you ever had an injury to your ears, including a broken ear drum: Yes / No

13. Do you currently have any of the following hearing problems?
    a. Difficulty hearing: Yes / No
    b. Wear a hearing aid: Yes / No
    c. Any other hearing or ear problem: Yes / No

14. Have you ever had a back injury: Yes / No

15. Do you currently have any of the following musculoskeletal problems?
    a. Weakness in any of your arms, hands, legs, or feet: Yes / No
    b. Back pain: Yes / No
    c. Difficulty fully moving your arms and legs: Yes / No
    d. Pain or stiffness when you lean forward or backward at the waist: Yes / No
    e. Difficulty fully moving your head up or down: Yes / No
    f. Difficulty fully moving your head side to side: Yes / No
    g. Difficulty bending at your knees: Yes / No
    h. Difficulty squatting to the ground: Yes / No
    i. Climbing a flight of stairs or a ladder carrying more than 25 lbs or 11 kg: Yes / No
    j. Any other muscle or skeletal problem that interferes with using a respirator: Yes / No

Part B Any of the following questions, and other questions not listed, may be added to the questionnaire at the discretion of the health care professional who will review the questionnaire.

1. In your present job, are you working at high altitudes (over 5,000 feet or 1,500 metres) or in a place that has lower than normal amounts of oxygen: Yes / No

If ‘‘yes,’’ do you have feelings of dizziness, shortness of breath, pounding in your chest, or other symptoms when you’re working under these conditions: Yes / No

2. At work or at home, have you ever been exposed to hazardous solvents, hazardous airborne chemicals (e.g., gases, fumes, or dust), or have you come into skin contact with hazardous chemicals: Yes / No

If ‘‘yes,’’ name the chemicals if you know them:
_____

3. Have you ever worked with any of the materials, or under any of the conditions, listed below?

a. Asbestos: Yes / No
b. Silica (e.g., in sandblasting): Yes / No
c. Tungsten/cobalt (e.g., grinding or welding this material): Yes / No
d. Beryllium: Yes / No
e. Aluminium: Yes / No
f. Coal (for example, mining): Yes / No
g. Iron: Yes / No
h. Tin: Yes / No
i. Dusty environments: Yes / No
j. Any other hazardous exposures: Yes / No

If ‘‘yes,’’ describe these exposures:
_____

4. List any second jobs or side businesses you have: _____

5. List your previous occupations: _____

6. List your current and previous hobbies: _____

7. Have you been in the military services? Yes / No

If ‘‘yes,’’ were you exposed to biological or chemical agents (either in training or combat): Yes / No

8. Have you ever worked on a HAZMAT team? Yes / No

9. Other than medications for breathing and lung problems, heart trouble, blood pressure, and seizures mentioned earlier in this questionnaire, are you taking any other medications for any reason (including over-the-counter medications): Yes / No

If ‘‘yes,’’ name the medications if you know them:_____

10. Will you be using any of the following items with your respirator(s)?

a. HEPA Filters: Yes / No
b. Canisters (for example, gas masks): Yes / No
c. Cartridges: Yes / No

11. How often are you expected to use the respirator(s) (circle ‘‘yes’’ or ‘‘no’’ for all answers that apply to you)?

a. Escape only (no rescue): Yes / No
b. Emergency rescue only: Yes / No
c. Less than 5 hours per week: Yes / No
d. Less than 2 hours per day: Yes / No
e. About 2 to 4 hours per day: Yes / No
f. Over 4 hours per day: Yes / No

12. During the period you are using the respirator(s), is your work effort:

a. Light (less than 200 kcal per hour): Yes / No

If ‘‘yes,’’ how long does this period last during the average shift: ____ hrs. ___ mins. Examples of a light work effort are sitting while writing, typing, drafting, or performing light assembly work; or standing while operating a drill press (1–3 lbs. or 2-7 kg) or controlling machines.

b. Moderate (200 to 350 kcal per hour): Yes / No

If ‘‘yes,’’ how long does this period last during the average shift: ____ hrs. ___ mins. Examples of moderate work effort are sitting while nailing or filing; driving a truck or bus in urban traffic; standing while drilling, nailing, performing assembly work, or transferring a moderate load (about 35 lbs.or15 kg) at trunk level; walking on a level surface about 2 mph (3 km/h) or down a 5-degree grade about 3 mph (5 km/h); or pushing a wheelbarrow with a heavy load (about 100 lbs. or 45 kg) on a level surface.

c. Heavy (above 350 kcal per hour): Yes / No

If ‘‘yes,’’ how long does this period last during the average shift: ____ hrs. ___ mins. Examples of heavy work are lifting a heavy load (about 50 lbs. or 23 kg.) from the floor to your waist or shoulder; working on a loading dock; shovelling; standing while bricklaying or chipping castings; walking up an 8-degree grade about 2 mph (3 km/h); climbing stairs with a heavy load (about 50 lbs. or 23 kg.).

13. Will you be wearing protective clothing and/or equipment (other than the respirator) when you're using your respirator: Yes / No

If ''yes,'' describe this protective clothing and/or equipment:
_____

14. Will you be working under hot conditions (temperature exceeding 77° F or 25° C): Yes / No

15. Will you be working under humid conditions: Yes / No

16. Describe the work you'll be doing while you're using your respirator(s):
_____

17. Describe any special or hazardous conditions you might encounter when you're using your respirator(s) (for example, confined spaces, life-threatening gases):
_____

18. Provide the following information, if you know it, for each toxic substance that you'll be exposed to when you're using your respirator(s):

Name of the first toxic substance: _____
Estimated maximum exposure level per shift:
_____
Duration of exposure per shift _____
Name of the second toxic substance: _____
Estimated maximum exposure level per shift: _____
Duration of exposure per shift: ____
Name of the third toxic substance:
_____
Estimated maximum exposure level per shift: _____
Duration of exposure per shift: _____
The name of any other toxic substances that you'll be exposed to while using your respirator:
_____

19. Describe any special responsibilities you'll have while using your respirator(s) that may affect the safety and well-being of others (for example, rescue, security):
_____

APPENDIX 3: EMPLOYEES PPE ISSUANCE RECORD FORMAT

Name: _____ Department: _____
Staff No: _____ Date join department: _____
NRIC No: _____ Position: _____

PPE type	Date issued	*Date inspection/ reissue	*Date inspection/ reissue	*Date inspection/ reissue	*Date inspection/ reissue	*Date inspection/ reissue	Receiver initials
1.Safety helmet							
2.Safety goggles							
3.Safety spectacles							
4.Face shields							
5.Toxic gas respirator							
6.Dust mask							
7.Breathing apparatus							
8.Chemical gloves							
9.Coverall							
10.Chemical suit							
11.Safety shoes/ boot							

**Strikethrough wherever applicable*