Australian/New Zealand Standard™

Selection, use and maintenance of respiratory protective equipment

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee SF-010, Occupational Respiratory Protection. It was approved on behalf of the Council of Standards Australia on 2 December 2008 and on behalf of the Council of Standards New Zealand on 18 December 2008.
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Australian/New Zealand Standard™

Selection, use and maintenance of respiratory protective equipment

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PREFACE

This Standard was prepared by the Joint Australia/New Zealand Standards Committee SF-010, Occupational Respiratory Protection, to supersede AS/NZS 1715:1994, *Selection, use and maintenance of respiratory protective devices*.

The objective of this revision is to take into account changes to AS/NZS 1716, *Respiratory protective devices*, and problems of interpretations that have arisen since AS/NZS 1715 was last published in 1994. It also aims to provide some guidance for respirator use by emergency service personnel for special response HAZMAT incidents.

As most readers will not need to refer to the performance and testing specification, the listings of definitions and referenced Standards have been expanded to include several new definitions and Standards to aid the reader's understanding of the text. Requirements for the performance and testing of respiratory protective devices are specified in AS/NZS 1716.

The main changes to this edition of the Standard are an increased, formalized emphasis of the risk management approach and systems management. To achieve this, the sequence of the text has been re-ordered.

The list of advisory authorities has been deleted. It is considered such information is quickly out of date so any such list may become misleading. Similar information on state advisory OHS bodies can be accessed electronically at the website of the Office of the Australian Safety and Compensation Council (ASCC)— http://www.ascc.gov.au

Throughout the text, examples of types of chemicals or other technical concepts have been expanded. Additional warnings about the possible misuse of respirators have also been included. Qualitative facial fit testing has been retained as a suitable means of monitoring a respiratory protection program.

It has been the aim of the Committee to further explain that the provision of an item of respiratory protective equipment (RPE) is only part of ensuring an overall system of respiratory protection for all employees.

Additional relevant Standards that may assist with the selection, care and use of respiratory devices have been listed under the heading of 'Related documents' (Clause 1.4).

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out the principles of respiratory protection, requirements and recommendations for the selection, use and maintenance of personal respiratory protective equipment (RPE) in the workplace.

This Standard does not deal with military applications for RPE, but includes special needs of personnel involved in a special response hazardous material (HAZMAT) incident where respiratory concerns need to be addressed.

This Standard does not deal with the special circumstances associated with the use of RPE in diving and underwater breathing (see AS/NZS 2299 and AS 2815), the use of RPE in aircraft, or the use of life support respirators for medical or resuscitation purposes (see AS 2488).

1.2 OBJECTIVE

The objective of this Standard is to assist users with the selection use and maintenance of suitable RPE to protect the body against atmospheres deficient in oxygen or against dusts, mists, fumes, smokes, gases, vapours, micro-organisms or combinations of these substances which could enter the body through the respiratory system.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1210	Pressure vessels
1319	Safety signs for the occupational environment
1345	Identification of the contents of pipes, conduits and ducts
2030	The verification, filling, inspection, testing and maintenance of cylinders for the storage and transport of compressed gases
2030.1	Part 1: Cylinders for compressed gases other than acetylene
2337	Gas cylinder test stations
2337.1	Part 1: General requirements, inspections and tests—Gas cylinders
2488	Resuscitators intended for use with humans
2815	Training and certification of occupational divers (series)
3848	Filling of portable gas cylinders—Filling of portable cylinder for self-contained underwater breathing apparatus (SCUBA) and non-underwater self-contained breathing apparatus (SCBA)
3848.2	Part 2: Safe procedures
MP 69	Explosion-protected electrical equipment—Certification scheme—Policy

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1020	The control of undesirable static electricity
1716	Respiratory protective devices
1801	Occupational protective helmets
2243	Safety in laboratories
2243.3	Part 3: Microbiological aspects and containment facilities
2299	Occupational diving operations (series)
2865	Safe working in a confined space
60079	Explosive atmospheres
60079.1	Part 1: Equipment protection by flameproof enclosures 'd'
60079.11	Part 11: Equipment protection by intrinsic safety 'i'
AS/NZS ISO	
6529	Protective clothing—Protection against chemicals—Determination of resistance of protective clothing materials to permeation by liquids and gases
ISO	
7708	Air quality—Particle size fraction definitions for health-related sampling
16976	Respiratory protective devices—Human factors
16976-1	Part 1: Metabolic rates and respiratory flow rates
NOHSC*	Adopted National Exposure standards for atmospheric contaminants in the occupational environment (NOHSC: 3008)

1.4 RELATED DOCUMENTS

The following documents provide guidance to assist with the selection, care and use of respiratory devices:

AS	
2985	Workplace atmospheres—Method for sampling and gravimetric determination of respirable dust
3640	Workplace atmospheres—Method for sampling and gravimetric determination of inhalable dust
3848	Filling of portable gas cylinders—Decant filling of medical air and oxygen into portable cylinders
3848.1	Part 1: Safe procedures
AS/NZS	
2986	Workplace air quality—Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography
2986.1	Part 1: Pumped sampling method
2986.2	Part 2: Diffusive sampling method
4804	Occupational health and safety management systems—General guidelines on principles, systems and supporting techniques
EN	
27243	Hot environments. Estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature)

* National Occupational Health and Safety Commission. All NOHSC exposure standards and amendments can be found in the Australian Safety and Compensation website at http://www.ascc.gov.au

BS
4275 Guide to implementing an effective respiratory protective device programme

ASTRAND, PO and RODAHL, K. *Textbook of Physiology*. New York, McGraw-Hill. 1970, 1977 and 1986 eds.

1.5 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.5.1 Aerosol

A suspension of fine solid or liquid particles in a gas, e.g. smoke, fog, or mist.

1.5.2 Air-hose respirator

A device, used with a facepiece or a head covering, through which clean air from a source remote from the workplace is made available to the wearer through an air-hose at near atmospheric pressure.

1.5.3 Air-line

Tubing used to provide breathable air from a source of compressed air at a maximum pressure of 10 bar.

1.5.4 Air-line respirator

A device capable of providing breathing air to the wearer from a source of compressed air at greater than atmospheric pressure by means of an air-line.

1.5.5 Air-purifying respirator

A device that filters contaminants from inhaled air.

1.5.6 Atmospheric contaminant

Any substance, either gaseous or particulate, that is not a constituent of the normal atmosphere, or that is present in a concentration greater than that found in the normal atmosphere.

1.5.7 Biological material

Any preparation of living organisms or the products of living organisms.

1.5.8 Blouse

An extended part of a head covering that includes sleeves and extends to the waist. It is generally elasticized at the waist and cuffs.

1.5.9 Breathing tube

A flexible tube connected to a facepiece or head covering through which breathable gas enters at a pressure slightly above or below atmospheric pressure.

1.5.10 Body temperature pressure saturated (BTPS)

A standard condition for the expression of ventilation parameters. Body temperature (37°C), atmospheric pressure (1013.25 hPa) and saturated air.

1.5.11 Chemical, Biological, Radiological, Nuclear (CBRN)

See 'Special response HAZMAT incident'.

1.5.12 Chemical oxygen (KO_2) self contained self-rescuer

A device that generates oxygen by means of a chemical reaction for use by a wearer during escape from a contaminated atmosphere or one lacking in oxygen.

NOTE: This does not include devices for work, rescue or diving applications.

1.5.13 Cleaning

The removal of contaminants and the reduction in the number of micro-organisms from a surface, by the process of washing in water and detergent without prior processing.

1.5.14 Combination filter respirator

A device combining the filtration capabilities of gas or vapour and particulate filters. The filters may be a single unit (integral) or consist of separate filters in series to form one unit (combination).

1.5.15 Demand valve

A device for the controlled release of air or oxygen actuated by a reduction in pressure created by the action of inhalation. The regulation may be such that the pressure inside the facepiece is maintained above atmospheric pressure (positive pressure type) or falls below atmospheric pressure (negative pressure type) during inhalation phase.

1.5.16 Disinfection

The reduction of non-sporing micro-organisms by chemical means.

1.5.17 Disposable respirator

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

1.5.18 Dusts

Solid particles generated and dispersed into the air by, for example, handling, crushing, grinding of organic or inorganic materials such as rock, ore, coal, wood and grain.

1.5.19 Equivalent Aerodynamic Diameter (EAD)

The diameter of a spherical particle of unit density (1 g/cm^3) which exhibits the same aerodynamic behaviour as the particle in question.

1.5.20 Emergency Breathing Device (EBD)

Also known as an auxiliary protection system. However, when used as an EBD the equipment is intended to provide protection when the primary respirator fails e.g. the air supply to an air-line respirator is interrupted.

1.5.21 Escape type respirator

A device for emergency escape from a respiratory hazard, e.g. fire. The device may either be fitted with P3, gas or combination P3 filters or supply breathable gas as required for the given environment.

NOTE: Each of these alternatives is used in special situations following risk assessment.

1.5.22 Exposure standard

An exposure standard as defined by NOHSC, represents an airborne concentration of a particular substance in the worker's breathing zone, exposure to which, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all workers. The exposure standard can be of three forms: peak limitation, Time-Weighted Average (TWA), or Short Term Exposure Limit (STEL), see NOHSC 3008.

1.5.23 Exposure standard—peak limitation

A maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time which does not exceed 15 min.

1.5.24 Exposure standard—Short Term Exposure Limit (STEL)

A 15 min TWA exposure which should not be exceeded at any time during a working day even if the eight-hour TWA average is within the TWA exposure Standard. Exposure at the STEL should not be longer than 15 min and should not be repeated more than four times per day. There should be at least 60 min between successive exposures at the STEL.

1.5.25 Exposure standard—Time-Weighted Average (TWA)

The average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week.

1.5.26 Extended usage period

The time, in minutes that a chemical oxygen self-contained self-rescuer (when tested on a closed-circuit breathing machine) continues to produce oxygen past the rated duration, when tested and assessed in accordance with this Standard.

1.5.27 Facial fit check

A simple check to ensure the respirator fits each time it is worn.

1.5.28 Facial fit test

A validated method of matching a respirator to an individual.

1.5.29 Filtration type escape respirator

A device incorporating filters which removes certain particulates and gases or vapours from the air inhaled by the wearer for a limited time during escape from a respiratory hazard.

1.5.30 Flow regulator

A device for controlling air flow.

1.5.31 Full facepiece

A close fitting device to cover the eyes, nose and mouth and be secured in position by suitable means.

1.5.32 Fume

Extremely fine particles, usually less than 1.0 μm in diameter, formed from a volatilized solid that has condensed in cool air. In most cases the hot vapour reacts with air to form an oxide. Fume is often associated with molten metals especially in processes such as welding. At high fume concentrations, agglomeration of particles may result in particles with much larger dimensions.

1.5.33 Gases

Formless fluids that expand to occupy the space or enclosure in which they are confined. Examples are nitrogen, oxygen and carbon dioxide.

1.5.34 Gas filter respirator

A device consisting of a half facepiece, full facepiece, head covering or mouthpiece with a filter that removes certain gases or vapours from the air to be inhaled by the wearer for a limited period of time. It may also incorporate a filter to remove particulates.

1.5.35 Half facepiece

A close fitting device to cover the nose, mouth and chin and be secured in position by suitable means.

1.5.36 HAZMAT

Hazardous material such as radioactive, flammable, explosive, corrosive or poisonous material that is to be handled, stored or transported.

1.5.37 HAZMAT incident

An incident, such as a spillage, involving hazardous material.

1.5.38 Head and face covering

A hood, faceshield, visor or helmet covering all or part of the head and extending where appropriate to the shoulders or waist. It is secured in position by suitable means and may include sleeves.

NOTE: Head and face coverings are commonly called 'head coverings'.

1.5.39 Immediately Dangerous to Life and Health (IDLH)

A situation that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate permanent adverse effects on health or prevent escape from such an environment.

1.5.40 Material Safety Data Sheet (MSDS)

A detailed information bulletin prepared by the manufacturer or importer of a chemical that describes its physical, environmental and chemical properties, health hazards, routes of exposure, precautions for safe handling and use, emergency and first-aid procedures, and control measures.

1.5.41 Micro-organism

Any microscopic entity capable of carrying on living processes. Examples include protozoa, fungi, bacteria or viruses.

1.5.42 Minimum Protection Factor (MPF)

The level of respiratory protection that an item of properly functioning respiratory protective equipment (RPE) or class of RPE would be expected to provide to properly fitted, and trained users in the workplace when used in accordance with the manufacturer's information and instruction. The MPF takes into account all expected sources of facepiece penetration (e.g. face seal protection, valve leakage).

1.5.43 Minute ventilation

The volume of air exchanged in the lungs during 1 min, VE in L/min BTPS. Also known as usage rate or sometimes, minute flow or minute volume.

1.5.44 Mists

Mists are suspended liquid droplets generated by condensation of vapour back to liquid state or by breaking up as a liquid into a dispersed state such as by splashing, spraying or atomising. Mist is the term applied to a finely divided liquid suspended in the atmosphere. Examples are an oil mist produced during cutting and grinding operations, acid mists from electroplating, acid and alkali mists from pickling operations and the condensation of water vapour to form a fog.

1.5.45 Mouthpiece

A device, designed to be held in the mouth, through which all air passes.

1.5.46 Nominal Effective Life (NEL)

The time in minutes, for a compressed air self-contained breathing apparatus to provide protection to the wearer at a usage rate of 40 L/min and at cylinder pressures above 1 MPa as described in AS/NZS 1716.

1.5.47 Nominal duration

The time, in minutes, that a chemical oxygen self-contained self-rescuer is effective, as specified by the manufacturer.

1.5.48 Nose clip

A device designed to occlude the nostrils to prevent air inhalation. Used in conjunction with a mouthpiece.

1.5.49 Nuisance dust mask

A lightweight mask that does not meet the requirements of AS/NZS 1716 with a filter intended only for extremely coarse non-toxic particulates. These masks do not give protection against gases or vapours.

1.5.50 Nuisance odour mask

A lightweight mask that does not meet the requirements of AS/NZS 1716 with a filter intended only for nuisance odours. These masks do not give protection against particulates, gases or vapours.

1.5.51 Particles

A generic term used to describe airborne solid or liquid substances in the finely divided state, i.e. particulate aerosols, such as dusts, mists, fumes, fibres, and fog as well as micro-organisms.

1.5.52 Particulate filter respirator

A device consisting of a half facepiece, full facepiece or head covering with particulate filter which removes finely divided solids or liquid matter from the air to be inhaled by the wearer. The filter medium may be replaceable or be an integral part of the construction.

1.5.53 Peak inspiratory flow

Also known as peak inhalation rate. Instantaneous flow rate during the inhalation phase of a breath cycle in L/s BTPS. L/s is the preferred unit as the flow takes place only during a short fraction of the breath cycle.

1.5.54 Personal Protective Equipment (PPE)

Any device or equipment designed to be worn or held by a person on its own, or as part of a system, to protect against one or more health and safety hazards.

1.5.55 Powered Air-Purifying Respirator (PAPR)

A device incorporating a half facepiece, full facepiece or head covering which provides the wearer with air filtered through a powered filtering unit, comprising a filter or filters, and an electrically operated blower unit. The respirator is referred to as a PAPR.

1.5.56 Protection factor

A measure of the degree of protection afforded by the respirator, defined as the ratio of the concentration of contaminant outside the respirator to that inside the respirator.

1.5.57 Qualitative fit test

A facial fit test giving pass/fail results and relying on the subject's response to a test agent.

1.5.58 Quantitative fit test

A facial fit test giving numerical results and not relying on the subject's response to a test agent.

1.5.59 Rated duration

The time, in minutes that a chemical oxygen self-contained self-rescuer is able to deliver breathable gas to a wearer within a suitable range of temperature, humidity, breathing resistance, and carbon dioxide and oxygen content, when tested and assessed in accordance with AS/NZS 1716.

1.5.60 Regulator

A device for controlling air flow.

1.5.61 Regulatory authority

A minister of the Crown, a government department or commission, or a statutory or public authority having power to issue regulations, orders or other instructions having the force of law in respect of any subject covered by this Standard.

1.5.62 Required minimum protection factor

The protection factor required to reduce exposure to an accepted level. It is expressed as a ratio of the measured ambient airborne concentration of a contaminant to an acceptable exposure level or standard.

1.5.63 Respirable air

Air of quality intended to be suitable for human respiration. This is also sometimes called breathable air or breathing air.

1.5.64 Respirable dust

The proportion of airborne particulate matter that, when inhaled, penetrates to the unciliated airways. This fraction is further described in ISO 7708 as the percentage of inhalable matter collected by a device conforming to a sampling efficiency curve which passes through the points shown in Table 1.

Alternatively it can be described by a cumulative log-normal distribution with a median EAD of 4.25 µm and a geometric standard deviation of 1.5 µm.

TABLE 1

RESPIRABLE DUST

Equivalent aerodynamic diameter, µm	Respirability %
0	100
1	100
2	97
3	80
4	56
5	34
6	20
7	11
8	6
10	2
12	0.5
14	0.2
16	0.1
18	0

1.5.65 Respiratory protective equipment (RPE)

A personal respiratory protective equipment that is designed to prevent the inhalation of contaminated air. The term replaces and is identical to 'respiratory protective device' or 'respirator'.

1.5.66 Safety coupling/connector

An air-line coupling/connector that requires at least two deliberate actions to separate the coupling or connector.

1.5.67 Self-Contained Breathing Apparatus (SCBA)

A portable respirator that supplies oxygen, air or other respirable gas from a source carried by the user.

1.5.68 Shall

Indicates that a statement is mandatory.

1.5.69 Should

Indicates a recommendation.

1.5.70 Single use low-boiling point filter

A category of filter intended to be used solely against low boiling point organic compounds during a single eight-hour shift, where the total logged period of use does not exceed the minimum specified absorption time of the filter. It is intended that the filter be discarded after such a period of use.

1.5.71 Smoke

Smoke consists of carbon or soot particles or tarry droplets less than 0.1 micrometer in size, and suspended in air, which results from the incomplete combustion of carbonaceous materials such as wood, coal, oil or paper.

NOTE: Normally, the combustion process producing smoke also produces gases.

1.5.72 Special response HAZMAT incident

A hazardous materials incident that has occurred with deliberate intent to contaminate the public or emergency service personnel and their property. It may include one or a combination of a warfare type chemical, industrial chemical, biological material and radioactive contaminant. Such an incident will often involve a large number of casualties or potential casualties.

1.5.73 Supplied-air RPE

A device that supplies air to the wearer from a source other than the ambient atmosphere.

1.5.74 Supplied-oxygen RPE

A device that supplies oxygen from a source of liquid or compressed oxygen carried by the wearer.

NOTE: Liquid oxygen sets, which supply oxygen from a source of liquid oxygen carried by the wearer are no longer covered by the requirements of AS/NZS 1716 and so are no longer recommended for use in this Standard.

1.5.75 Thermally generated particulates

See 'fume' and 'smoke'.

1.5.76 Usage rate

See 'minute ventilation'.

1.5.77 Vapour

Vapour is the gaseous form of a substance which is normally in the solid or liquid state at room temperature and pressure.

1.5.78 Work sets

Self contained breathing apparatus designed for general entry to or working in an area with airborne contaminants or oxygen deficiency.

1.6 GENERAL PRINCIPLES

No person should be exposed to potentially harmful atmospheres without suitable protection. Personal exposures should not exceed occupational exposure standards. The following principles should be observed in the protection of the body against the effects of harmful substances:

(a) Where the workplace atmosphere is unknown and may be harmful, testing by a properly trained and responsible person using suitable equipment should be undertaken.

(b) Every effort should be made to prevent the release of harmful substances into the working environment. This may be achieved through the design of buildings, plant and equipment; or by work procedures and controls (e.g. extraction systems) to obviate the need for RPE, and other PPE as required.

(c) If measures to prevent or control the hazard at the source are inadequate, suitable RPE and other PPE as required should be provided and used.

In emergencies where contaminants may be released into the atmosphere, suitable RPE should be available for use.

1.7 HAZARD IDENTIFICATION, RISK ASSESSMENT AND CONTROL

1.7.1 General

The effective management of risks to health is achieved by identifying the hazards, assessing the risk associated with those hazards and controlling the risks to health.

Airborne contaminants generated during various processes may present a risk to a person's health through inhalation.

1.7.2 Hazard identification

The identification of airborne hazards/contaminants requires knowledge of the following:

(a) Work processes.

(b) Substances used, their physical form and properties.

(c) Intermediates or products formed.

Further information can be obtained by observing the process in operation, talking to operators, supervisors and referring to material safety data sheets (MSDS) and manufacturers or importers of the substances. In observing the process, the effectiveness of any controls, such as local exhaust ventilation, would also need to be evaluated as part of the risk assessment process. Some processes produce dusts that may be readily seen in the general work environment or the operator's breathing zone. However, other processes may produce dusts that are not visible but are respirable and can cause harm. Therefore the absence of significant visible dust does not necessarily mean that the atmosphere is safe and free of dust particles of respirable size.

1.7.3 Risk assessment of airborne contaminants

A risk assessment is the process of determining the likelihood of a person's health (consequences) being affected by exposure to atmospheric contaminants. The risk assessment may also be used to determine whether the controls currently in place are adequate and whether additional controls, such as respiratory protection, are required.

A risk assessment of airborne contaminants needs to take into account the substance and nature of the work. The nature of the substances and work would not only affect the level and duration of exposure but also affect the route of exposure.

Measurements of the concentration of airborne contaminants or the level of oxygen in the workplace atmosphere can be used to establish the degree of risk associated with an airborne hazard by reference to current exposure standards (see Clause 3.1). Evaluation of a person's exposure may involve both personal and biological monitoring as follows:

(a) *Personal monitoring*

The exposure of a person through inhalation is estimated by measuring the concentration of an airborne substance in the person's breathing zone (air near the nose and mouth) and the duration of the exposure.

(b) *Environmental (static) monitoring*

Measuring air contaminants in the working environment can give an indirect estimate of a person's exposure and indicate the existence of a potential risk to health.

(c) *Biological monitoring*

Biological monitoring involves the measurement of the levels of chemical substances, their metabolites, or other biochemical indicators in the appropriate biological medium of the body (e.g. urine, blood or exhaled air). Biological monitoring takes all routes of exposure into account and can also be used to indicate the effectiveness of worker protection programs. Such monitoring can, in some circumstances, detect unexpected exposure of a person who was not suspected of being in contact with the particular chemical substance.

1.7.4 Controls of risks

Where there is a risk to people's health, such a risk should be controlled.

An effective way of controlling any risk to health associated with the use of hazardous substances is to apply the hierarchy of controls. The hierarchy of controls, which is often adopted in legislation, is a preferred order of control measures to be implemented in eliminating or controlling (minimizing) people's exposure. Elimination is considered the most effective measure, while PPE is regarded as the least effective. Administrative controls and PPE are regarded as being less effective because there is more reliance on human behaviour and these types of controls do not remove or contain the contaminant at the source. In practice, however, a combination of control measures are often required to effectively control risks to health.

The hierarchy of controls, shown in the preferred order, is described below.

(a) *Elimination*

Elimination is a permanent solution and should be attempted in the first instance. The hazard is eliminated altogether, e.g. eliminating the use of a hazardous substance by changing the process. Unless a particular hazard is removed, the potential risk associated with the hazard can never be completely removed.

(b) *Substitution*

Substitution involves eliminating or minimizing the risk to health by substituting the process, equipment or using a less hazardous substance or using a substance in a less hazardous form. Examples of substitution type controls are:

(i) Substituting a dry cutting process by a wet cutting process to minimize or eliminate the generation of dust.

(ii) Manually cutting a product instead of using power saws, which generate a lot of fine dust.

(iii) Using a water-based cleaner instead of a solvent based one.

(iv) Using a more dilute product or less hazardous form of the product (e.g. using a product that is in a pellet or paste form instead of a dusty fine powder.)

(c) *Isolation*

Isolation involves separating people from the substance to prevent or minimize exposure.

Isolation may be achieved by—

(i) installation of a physical barrier between the hazardous operation and the operator;

(ii) locating the operator further away from the processes; or

(iii) using a time delay so that the operator does not need to be in attendance while the process is in operation.

(d) *Engineering controls*

Engineering controls are physical controls that eliminate or reduce the generation of substances, suppress or contain substances or limit the area of contamination in the event of spills and leaks. Engineering controls may include full or partial enclosures, exhaust ventilation or automation of processes. Examples of engineering controls include:

(i) The use of robotics for spray painting.

(ii) Spray booths.

(iii) Fully enclosed processing systems.

(e) *Administrative controls*

Administrative controls are systems of work or safe work practices which help to reduce employee exposure or the duration of exposure. Examples of administrative controls include:

(i) Job rotation to reduce the duration of employee exposure.

(ii) Reducing the number of employees that may be potentially exposed.

(iii) Prohibiting eating, smoking and drinking in contaminated areas.

(iv) Keeping lids on containers to reduce evaporation of solvents.

(f) *Personal protective equipment (PPE)*

PPE is used to prevent inhalation and contact with hazardous substances. It includes equipment such as protective clothing, gloves, goggles and RPE.

High order controls (i.e. elimination, substitution, isolation and engineering controls) shall be adopted as far as practicable to eliminate or minimize people's exposure and reduce the need for or the reliance on administrative type controls and PPE.

SECTION 2 RESPIRATORY PROTECTION PROGRAM

2.1 RESPIRATORY PROTECTION PROGRAM

Where RPE is required to be worn, a respiratory protection program shall be established.

The program shall develop procedures in relation to the following:

(a) Appointment of program administrator.

(b) Selection of RPE.

(c) Medical screening of users of RPE.

(d) Training.

(e) Issue of RPE.

(f) Fitting of equipment.

(g) Wearing of RPE (where required).

(h) Maintenance of RPE.

(i) Disposal of equipment.

(j) Record keeping.

(k) Program evaluation.

2.2 APPOINTMENT OF PROGRAM ADMINISTRATOR

Management shall designate an individual to head the program. This person shall have background enabling him or her to make sound decisions based on an evaluation and understanding of workplace hazards. The individual should be an OHS professional such as safety engineer, occupational hygienist, or occupational physician. In a small company, especially where RPE usage is limited, the program may be directed by the employer, foreperson, or other supervisory personnel. Regardless of who assumes responsibility for the program, the responsible person shall have the full support of management.

2.3 SELECTION OF RPE

RPE selection needs to consider the following:

(a) Conformance with the requirements of AS/NZS 1716.

(b) Medical evaluation of wearers for psychological and physical suitability (see Clause 5.1).

(c) Contaminant factors including toxicity, exposure standards, skin absorption etc.

(d) Operator factors, including comfort, other PPE, vision, communication etc., (see Section 4).

(e) Task factors, including mobility, harsh environments etc., (see Section 4).

(f) RPE maintenance requirements including cleaning and availability of appropriate equipment and spare parts.

Section 4 provides guidance for selection of the appropriate RPE while Section 5 describes the various RPE types.

All RPE shall conform with the requirements of AS/NZS 1716 where there is an appropriate category. RPE selection shall be based on requirements of this Standard and limitations of Australian and New Zealand legislation and regulations.

Where a recommendation is not available from Australian or New Zealand authorities information governing the use of RPE may be drawn from recognized international authorities or standardization bodies.

NOTES:

1 Recognized international authorities include:
   (a) National Institute for Occupational Safety and Health (NIOSH) and Mine Safety and Health Administration (MSHA) in the USA.
   (b) Health and Safety Executive (HSE) in the UK.
2 Standardization bodies include:
   (a) International Organization for Standardization (ISO).
   (b) European Committee for Standardization (CEN).

RPE is designed and tested as a system. To ensure that RPE provides the intended protection, all RPE shall be purchased and maintained as a system. Mixing and matching components such as filters and facepieces may not only invalidate any manufacturer's warranty but may not provide the respiratory protection required. Substitution of components is not acceptable unless the components have been tested as a whole, comply with AS/NZS 1716 and there is an ongoing quality assurance program to ensure that relevant performance requirements continue to be met.

2.4 RPE TRAINING

Occupational health and safety legislation requires employees to be trained and supervised to carry out their work safely.

Where RPE is to be used, training shall be provided in the safe use and limitations of the RPE. Training shall be provided at the commencement of employment, and at routine intervals thereafter. The frequency of retraining will depend on the complexity of the program and the degree of the hazard, but as a minimum shall be considered at least annually.

Supervisors also shall be trained in their responsibilities in ensuring the correct use of RPE and other established safe work procedures as required.

Training shall take into account employees who do not speak English or those whose English is poor to ensure that instructions are fully understood. Practical demonstrations or the use of interpreters is suggested in such cases.

A suggested format for a RPE training program is given in Section 7.

2.5 ISSUE OF RPE

Where practicable, RPE shall be issued for a wearer's exclusive use. Records of RPE issue and usage as specified in Clause 2.9, shall be established and maintained.

Where equipment is issued to an individual, each RPE should bear an identifying mark, which may be the user's name, initials, employee number or other similar identification.

Filters that are to be re-used shall be permanently marked with the date of issue. Non-PAPR filters shall be individually issued, and also marked with the user's identification.

RPE not issued on a personal basis, for example SCBA, shall be cleaned and disinfected after each use. Prior to re-issue, RPE shall be inspected in accordance with the manufacturer's instructions to ensure correct operation.

2.6 FITTING OF RPE

For RPE with a close fitting facepiece to provide its designed protection, it is essential that an adequate face seal is achieved, i.e. it be properly fitted to the wearer.

There are two types of facial fit test—qualitative and quantitative. Qualitative tests are usually simple and fast but may be influenced by the wearer. The quantitative test is not subjective but requires the purchase of special equipment, and a trained operator.

Clause 8.5 describes the various types of fit test. The program administrator shall ensure a suitable fit test is carried out for all users of RPE with a close fitting facepiece.

2.7 WEARING OF RPE

The respiratory protection program shall require that RPE is used in accordance with the manufacturer's instructions, and to be worn at all times in specified areas and during specified tasks. See also Clause 4.4.3.2.

2.8 MAINTENANCE

2.8.1 General

Maintenance shall be carried out following the manufacturer's instructions and include—

(a) cleaning and disinfection of equipment;

(b) inspection;

(c) repair and replacement of components (including replacement of filters); and

(d) storage and disposal.

Improperly maintained RPE provides wearers with a false sense of security. The life of a wearer may be dependent on the effective operation and ready availability of a suitable respirator. RPE is more likely to be worn if it is clean and functional.

For further details see Section 9.

2.8.2 Cleaning and disinfection

RPE shall be cleaned after each use. The cleaning procedure should be according to the manufacturer's instructions or, where these are not available, refer Appendix C.

A centralized cleaning operation can ensure that properly cleaned and disinfected RPE are available for use. However, where respirator use is infrequent or where the number of RPE in use is small, central facilities may be inappropriate.

Cleaning and disinfecting equipment, supplies, facilities and time for the job to be done shall be provided, ensuring that cleaning and, where required, disinfection is done properly and that only properly cleaned and disinfected RPE are used.

Disinfection shall be performed where one or both of the following usage conditions exist:

(a) The respirator or facepiece will be used by more than one person.

(b) There is a chance of the respirator or facepiece being contaminated with biological materials.

Disinfection should be carried out after cleaning of the RPE.

Disinfection may be achieved by using a broad-spectrum disinfectant. The choice of disinfectant should be made based on recommendations of the RPE manufacturer and medical authorities. Such advice may also assist where protection against the transmission of a specific pathogen is required. Use disinfectants in accordance with the manufacturer's instructions, e.g. dilution, temperature, and exposure time.

2.8.3 Inspection

Inspection and testing are both important parts of RPE maintenance to identify damaged or malfunctioning RPE.

All RPE should be inspected—

(a) before and after each use; and

(b) during cleaning.

Some types of RPE require periodic testing (e.g. equipment designated for emergency use) in accordance with the manufacturer's or regulatory requirements. See also Section 9.

2.8.4 Repair and replacement of components

2.8.4.1 *General*

Repair shall be carried out in accordance with the manufacturer's recommendations. See Clause 9.

2.8.4.2 *Replacement of filters*

Filters shall be regularly replaced in accordance with the filter replacement schedule.

Advice shall be sought from the manufacturer of the RPE in conjunction with an OHS professional, e.g. an occupational hygienist, on an acceptable change-over time based on likely exposure patterns so that an adequate safety margin is allowed.

2.8.5 Storage and disposal of equipment

RPE shall be stored to prevent contamination, damage and deterioration and should be located as close as practicable to where it is required. See Clause 9.6.

Respirator filters that have been utilized for potential or actual responses to toxic or harmful substances shall be considered as being contaminated with that substance and be disposed of in a safe manner so as to prevent possible exposure to others. Unused filters that are out of date shall not be used and shall be disposed of, to prevent re-use.

Where legislative requirement exist or there are relevant manufacturers' or suppliers' guidelines for appropriate disposal of contaminated filters, these should be followed.

2.9 RECORD KEEPING

Records for a respiratory protection program shall include records related to:

(a) Issue of RPE (non-disposable)

  (i) Date.

  (ii) Identifying mark (where used).

(b) User records

  (i) Training.

  (ii) Fit test.

  (iii) Medical screening.

(c) Maintenance

  (i) Filter replacement schedule.

  (ii) RPE maintenance schedule.

  (iii) Supplied air RPE maintenance records.

(d) Program records

(i) Procedures.

(ii) Audits/evaluations.

(iii) Atmospheric monitoring records.

(iv) Health surveillance.

Records need not be kept for disposable RPE or for filters used in half or full facepiece RPE where these are changed regularly. (See Clause 9.5).

2.10 PROGRAM EVALUATION

To ensure the continued effectiveness of the respiratory protection program, it shall be audited.

The respiratory protection program should be evaluated at least annually, with adjustments made as appropriate, to reflect the evaluation results. Evaluation of the respiratory protection program should include a review of the risk assessment and the results of any biological or atmospheric monitoring.

NOTE: Appendix D contains a checklist to assist in conducting and evaluating the program.

SECTION 3 ENTRY OF CONTAMINANTS INTO THE BODY

3.1 GENERAL

Employees may be exposed to a variety of airborne substances which may be in the form of gases, vapour, dust, mists, fume and smoke. Not all substances that are present in the working environment have been tested for their toxicological effects; however, all substances may be capable of causing harm if exposure is sufficiently high.

The Australian Safety and Compensation Council (ASCC), formerly the National Occupational Health and Safety Commission (NOHSC) publishes occupational exposure standards for atmospheric contaminants. These standards represent levels of airborne contaminants which according to current knowledge, are considered to neither impair the health of, nor cause undue discomfort to, most persons. These or other standards may be included in state legislation or codes of practice.

Individuals vary in their susceptibility to a given contaminant and exposure of some persons to contaminant concentrations at or even well below the exposure standard may result in discomfort, aggravation of a pre-existing condition or development of an occupational illness. The adverse effect of exposure to one contaminant may be increased or enhanced if the person is exposed to another. For example, the effects of asbestos are exacerbated by tobacco smoke.

The aim is to minimize any potential risk by keeping concentrations of all airborne contaminants as low as is reasonably practicable regardless of whether they are known to present a health hazard and irrespective of their assigned exposure standard.

The major routes of entry of substances into the body are inhalation, skin absorption and ingestion.

3.2 INHALATION OF AIRBORNE CONTAMINANTS

Inhalation is by far the most common means by which contaminants enter the body. The main anatomical features of the respiratory system are shown in Figure 3.1. Air inhaled through the nose and mouth is warmed and moistened. The large airways, or bronchi, are protected by a thick layer of mucus which is moved to the throat by millions of hair-like projections called cilia.

The small airways or bronchioles have attached to them three to six clusters of extremely small sacs called alveoli. There are approximately 300 million alveoli in the lungs, providing a very large surface area. The air in the alveoli is separated from blood capillaries by a thin membrane (0.2 μm), which allows almost instantaneous transfer of gases to and from the bloodstream.

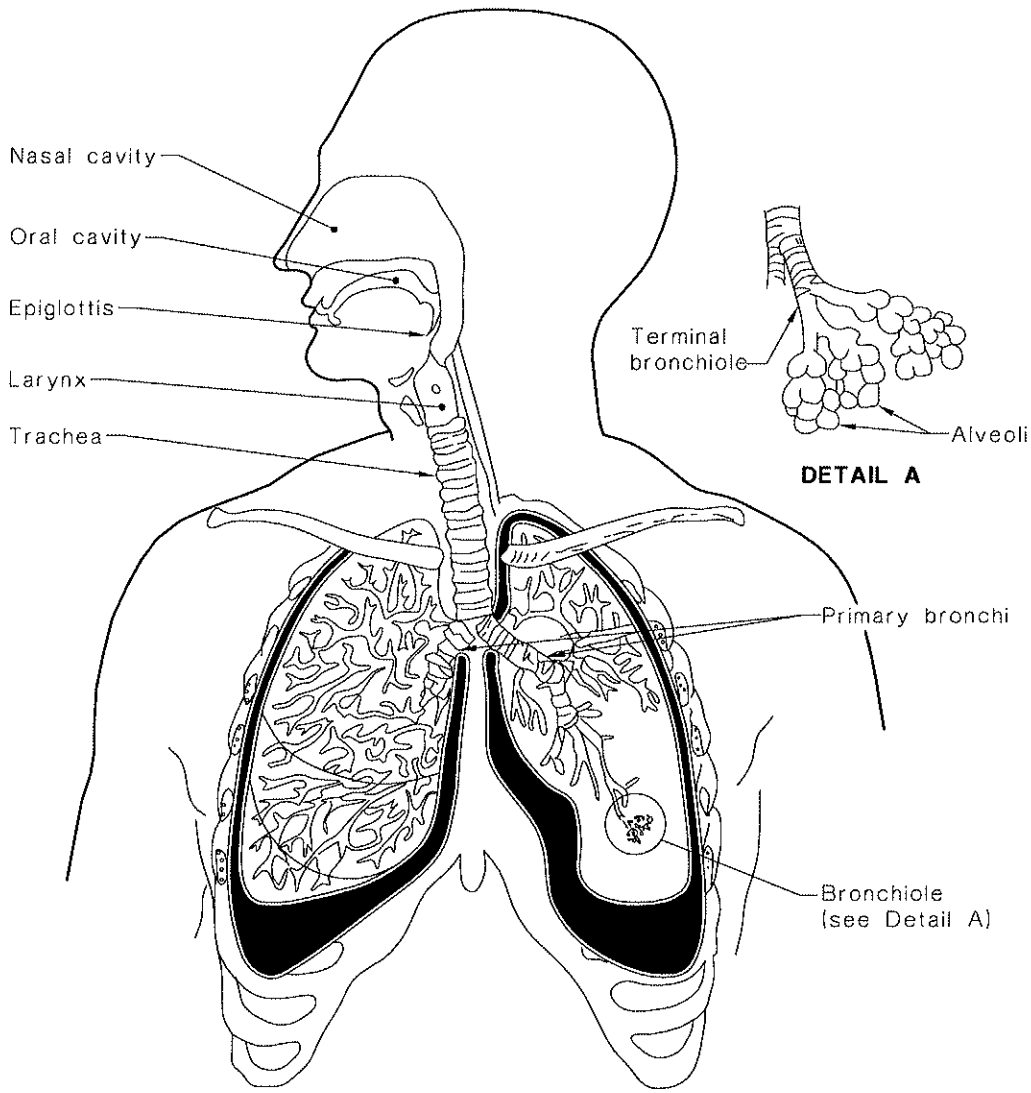


FIGURE 3.1 THE HUMAN RESPIRATORY SYSTEM

3.3 SKIN AND EYE ABSORPTION

3.3.1 Skin absorption

The intact skin normally acts as the primary barrier to many substances entering the body. However, some substances, may enter through the intact skin, e.g. parathion, styrene, tetraethyl lead, xylene, while others enter only through abraded skin, e.g. methomyl. These types of absorption may make a significant contribution to overall exposure.

3.3.2 Eye absorption

The effects of exposure of the eye to substances can vary from minor irritation of the eye to total loss of vision, depending on the substance and extent of exposure. Some substances that do not cause irritation following contact with the eye can be absorbed into the body in sufficient amounts to cause systemic poisoning, e.g. hydrogen cyanide, sodium cyanide.

3.4 INGESTION

Ingestion is the process by which substances enter the body through the mouth (by swallowing). Depending on its physical and chemical properties, an ingested substance may exert its effect on the tissue of the digestive tract or may be absorbed and enter the bloodstream. A toxic substance may be ingested while eating, drinking or smoking in contaminated areas or by transfer to the mouth with contaminated hands. Inhaled particles that have been deposited on the mucus in the respiratory tract will be ingested if the mucus is swallowed.

3.5 HEALTH EFFECTS OF AIRBORNE CONTAMINANTS

Airborne contaminants may cause immediate (acute) or long term (chronic) effects. These effects may occur at the site of contract (local effects) or they may be absorbed into the body and cause an affect (systemic) at a site other than the initial site of contact.

Airborne contaminants may affect various organs or cause a range of health affects depending on the level of (atmospheric concentration) and the duration of exposure. These health effects may include the following:

(a) *Irritation*

Irritants are readily water soluble can cause irritation of the nose and upper respiratory tract, for example ammonia (NH_3) and hydrogen chloride (HCl). Alternatively, irritant gases which are relatively water insoluble, e.g. nitrogen dioxide (NO_2), will reach deeper into the lungs where irritation and absorption into the bloodstream will occur.

Upper respiratory tract irritants generally have some warning properties—they are immediately noticed and the worker will usually leave the area promptly. Lower respiratory tract irritants, however, are difficult to perceive initially. Often the exposed worker is unaware of their presence, as symptoms may not become apparent until hours later.

(b) *Nuisance particulates and nuisance odours*

Produce no tissue changes but may cause discomfort or minor irritation, e.g. limestone. Large quantities, however, may overwhelm the lung protection mechanisms and, in the long term, produce injury by blocking the bronchioles.

(c) *Asphyxiation*

Asphyxiants act by interfering with the supply or use of oxygen by the body. They may be simple asphyxiants which act by diluting the available oxygen, e.g. nitrogen (N_2). Alternatively, they may be chemical asphyxiants that, even in low concentration, will be absorbed by the blood in preference to oxygen, e.g. carbon monoxide (CO) and hydrogen cyanide.

(d) *Sensitization*

Inhalation of sensitizing agents, such as toluene di-isocyanate (TDI), may cause severe allergic reactions in some individuals who may or may not have been previously exposed. Once an individual has become sensitized, even very low levels of exposure to the sensitizer would induce a reaction, e.g. asthmatic condition. The process is seldom reversible. Allergic type reactions may also be caused by moulds and pollen.

(e) *Central nervous system effects*

Anaesthetics result in the partial or complete loss of sensation. Their effects are similar to alcohol as such gases depress the central nervous system, initially causing mild intoxication with dizziness and loss of coordination. Continued exposure causes unconsciousness and may lead to respiratory paralysis and death. Examples include many common organic solvents, e.g. methyl ethyl ketone; trichloroethylene; n-hexane, which can affect the nerves of the fingers and toes (peripheral neuropathy); organophosphorous insecticides, which are readily absorbed through inhalation and skin absorption and affect the nervous system.

(f) *Cancer*

Cancer of various organs, e.g. mesothelioma caused by inhalation of asbestos; liver cancer caused by vinyl chloride monomer gas.

(g) *Fever*

Fever producing particles cause chills followed by intense fever or influenza-like symptoms. Such effects may be delayed for several hours after exposure, e.g. fumes evolved by welding of zinc and copper giving rise to 'metal fume fever'

(h) *Infection*

Infections may occur as a result of exposure to micro-organisms.

(i) *Effects on the lungs*

Lung-damaging particles reduce lung capacity by causing physical changes in the lung structure. Such particles may act by giving rise to scar tissue which is not capable of gas exchange, e.g. silica and asbestos particles.

(j) *Other organ effects (liver, kidneys, etc.)*

Systemic poisons, once absorbed into the blood, target specific organs or body systems.

For example, carbon tetrachloride (CCl_4), which causes liver damage; lead can also cause kidney, nerve and brain damage.

3.6 PARTICLES

3.6.1 General

Particles are much larger than individual molecules and their inhalation and damage causing properties depend on physical and chemical characteristics such as size, shape and density. The visibility of particles is a function of many factors including size, concentration and ambient lighting conditions.

3.6.2 Particle size

Particles may be dusts, mists, fumes or fibres. These may range in size depending on the nature of the substances (e.g. fine powder or granular) or the nature of the process that generated these contaminants. Particles may be mechanically generated (e.g. grinding and spraying) or they may be thermally generated (e.g. welding fumes and bushfire smoke). Thermally generated particulates are much smaller than mechanically generated particles. This needs to be taken into account in the selection of respiratory protection.

Large particles that are up to 100 μm in size are referred to as inspirable or inhalable particles. Small particles (<10 μm) are referred to as respirable particles. Refer to Figure 3.2 for further information on the size range of common particulates.

Inspirable particles do not enter the lungs as deeply as respirable ones but they may be associated with sensitization (e.g. animal protein) or systemic poisoning after being absorbed into the blood (e.g. lead dust).

Particles in the respirable range can penetrate deep into the lungs. Depending on the substance, they may dissolve and be absorbed into the blood stream or they may remain in the lungs if they cannot be cleared by the lungs defence and clearance mechanisms (see Figure 3.2). Respirable particles are of particular importance when considering respiratory protection. It was generally considered that very small particles (less than 0.1 μm) are inhaled and exhaled and may not be retained anywhere in the lungs, but new evidence indicates some physiological hazard may be posed by such 'ultra-fine' particulates.

Respiratory protection for ultra-fines or nanoparticles raises the question of the performance of particular filters meeting AS/NZS 1716 against such a contaminant.

Ultra-fine particles are generally defined as particles with aerodynamic diameters less than 100 nanometres (1 nm = 1/1000th of a micrometre). Many industrial processes produce particles in this size range e.g. welding, diesel emissions, gas cooking.

Little work has been done to quantify the performance of respirator filters against ultra-fine particles but is still widely accepted that the efficiency of filters complying with AS/NZS 1716 requirements will be high. The need for respiratory protection for all ultra-fines has not been established, however RPE can be used to help reduce risk by lowering exposure. At this time there is no evidence to suggest that filter performance will be limiting factor in the use of air-purifying RPE against ultra-fines. Rather, proper fit testing and wearing the RPE during all times of exposures will continue to be the more significant consideration for reducing exposure.

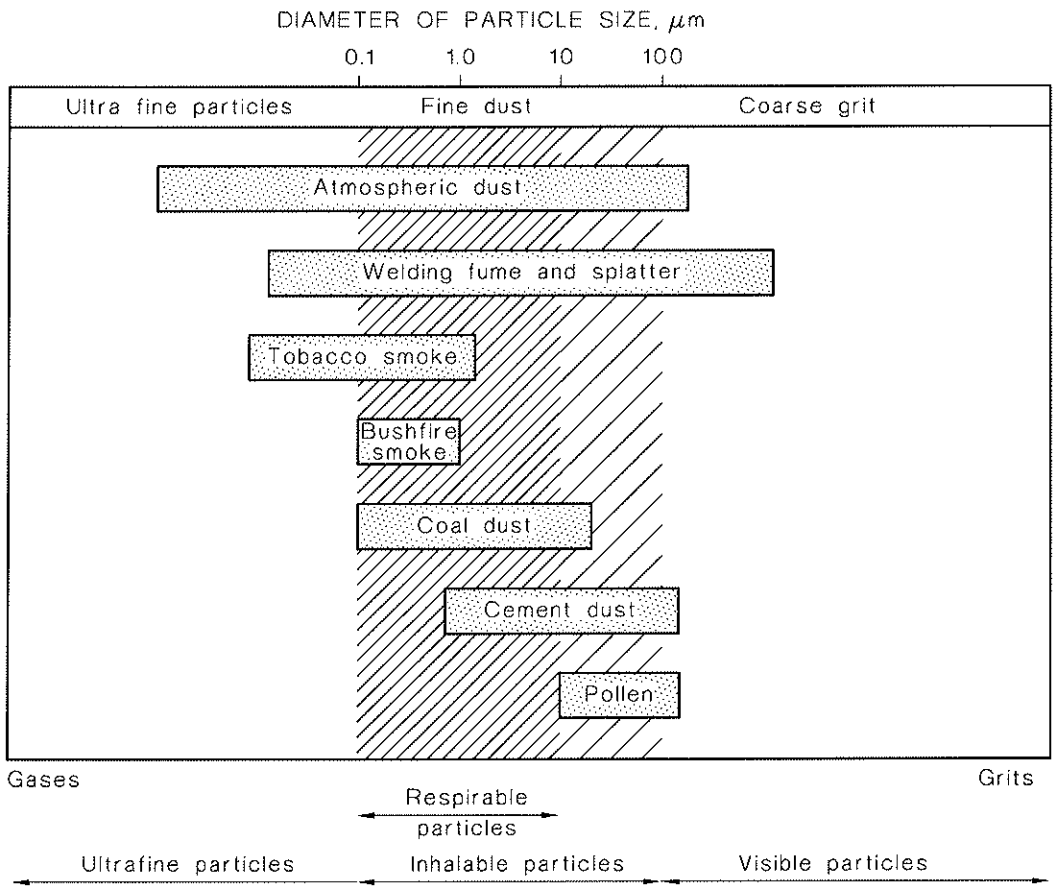


FIGURE 3.2 SIZE RANGE OF COMMON PARTICULATES

3.6.3 Micro-organisms

While most micro-organisms are harmless and pose no threat, there are some that are infectious to humans resulting in ill health. These infective micro-organisms have been classified into different risk groups by various international groups. These classifications are based on the following criteria:

(a) Is the organism pathogenic i.e. disease-producing in man?

(b) Is it a hazard to workers?

(c) Is it transmissible in the community?

(d) Is effective prophylaxis and treatment available?

There are four hazard groups:

(i) Risk group 1 (low individual and community risk)—a micro-organism that is unlikely to cause human disease.

(ii) Risk group 2 (moderate individual risk, limited community risk)—a pathogen that can cause human disease and which might be a hazard in occupational environments but is unlikely to spread in the community. Occupational exposures rarely produce specific infection and effective preventative and treatment measures are readily available.

(iii) Risk group 3 (high individual risk, limited community risk)—a pathogen that may cause severe human disease and may be a serious hazard in occupational environments. It could present a risk if spread to the community, but there are usually effective preventative or treatment measures available.

(iv) Risk group 4 (high individual and community risk)—a pathogen that usually produces life threatening human disease, and is a serious hazard in occupational environments. It is readily transmissible into the community and effective preventative and treatment measures are not usually available.

Further details covering microbiological safety specific to laboratories can be found in AS/NZS 2243.3. Information concerning micro-organisms may be available from regulatory authorities or recognized experts in the field.

3.7 OXYGEN DEFICIENCY

3.7.1 General

Entry into or work in oxygen-deficient atmospheres (ODA) is dangerous. Such atmospheres may exist in confined spaces, e.g. as a result of a chemical reaction or displacement. These conditions generally exist in areas with limited ventilation, e.g. tanks, vats, reaction vessels, wells, tunnels, pipes, conduits, access holes, silage pits and deep earthen trenches.

Safe procedures for working in confined spaces are not covered in this Standard. These are specified in AS/NZS 2865.

There are four basic mechanisms by which oxygen-deficient atmospheres, or their equivalent, may occur. These are:

1 Ascending to altitude.

2 Chemical reaction with solid products, e.g. the formation of rust or other corrosion products.

3 Chemical reaction gaseous, e.g. respiration, fire.

4 Displacement (dilution) by some other gas or vapour.

Of these, only the first two may result in an oxygen deficiency without the introduction of, or an increase in concentration of, some other gas or vapour. In the latter two cases, a significant oxygen deficiency will usually be caused with the simultaneous production of a toxic concentration of such a gas or vapour.

3.7.2 Atmospheric composition

At high altitudes, although oxygen percent by volume remains constant, the amount of oxygen available for breathing is reduced owing to the lower pressure. This may produce effects similar to those of lack of oxygen by action of a simple asphyxiant.

Earth's atmosphere has an essentially fixed composition of the gases shown in Table 3.1.

TABLE 3.1

TYPICAL COMPOSITION OF EARTH'S ATMOSPHERE (DRY STATE CONDITION)

Gas	Composition by volume %
Nitrogen	78.09
Oxygen	20.95
Carbon dioxide	0.04
Other gases	0.92

Other gases present in small amounts include neon, helium, and krypton. Water vapour, an important constituent of the normal atmosphere, may be present up to 5% of the total volume.

No single definition (value) of an oxygen-deficient atmosphere has been universally accepted. Where a definition is required however, local legislation should be followed.

A safe oxygen range is defined in AS/NZS 2865.

3.7.3 Symptoms of oxygen deficiency

The symptoms of oxygen deficiency depend on the oxygen concentration present.

It is difficult for the exposed person to realize the effect of oxygen deficiency. Lack of oxygen can cause gradual depression of the central nervous system. This affects powers of discrimination, logic and hearing, with attendant muscular weaknesses and lack of coordination. Extremely low levels of oxygen will lead to death in minutes without intervention.

SECTION 4 SELECTION OF RPE

4.1 FACTORS IN SELECTION

Many factors need to be considered when selecting a suitable respirator for a particular situation. It is important to ensure that only RPE complying with AS/NZS 1716 be used and, where there is any doubt, expert occupational hygiene advice should be sought.

To protect effectively, RPE needs to be worn whenever the person is exposed to excessive levels of the contaminant.

The selection of RPE will be influenced by the following factors:

(a) Contaminant.

(b) Task.

(c) Operator.

(d) Equipment limitations.

(e) Special response HAZMAT incidents.

Figure 4.1 is a work-through flow chart to determine which table to use for a given situation. Selection guides based on identified and quantified contaminants are given in Tables 4.1 to 4.6. Tables 4.2 to 4.6 recommend RPE for specific contaminants based on the level of protection required. Table 4.1 specifically covers micro-organisms.

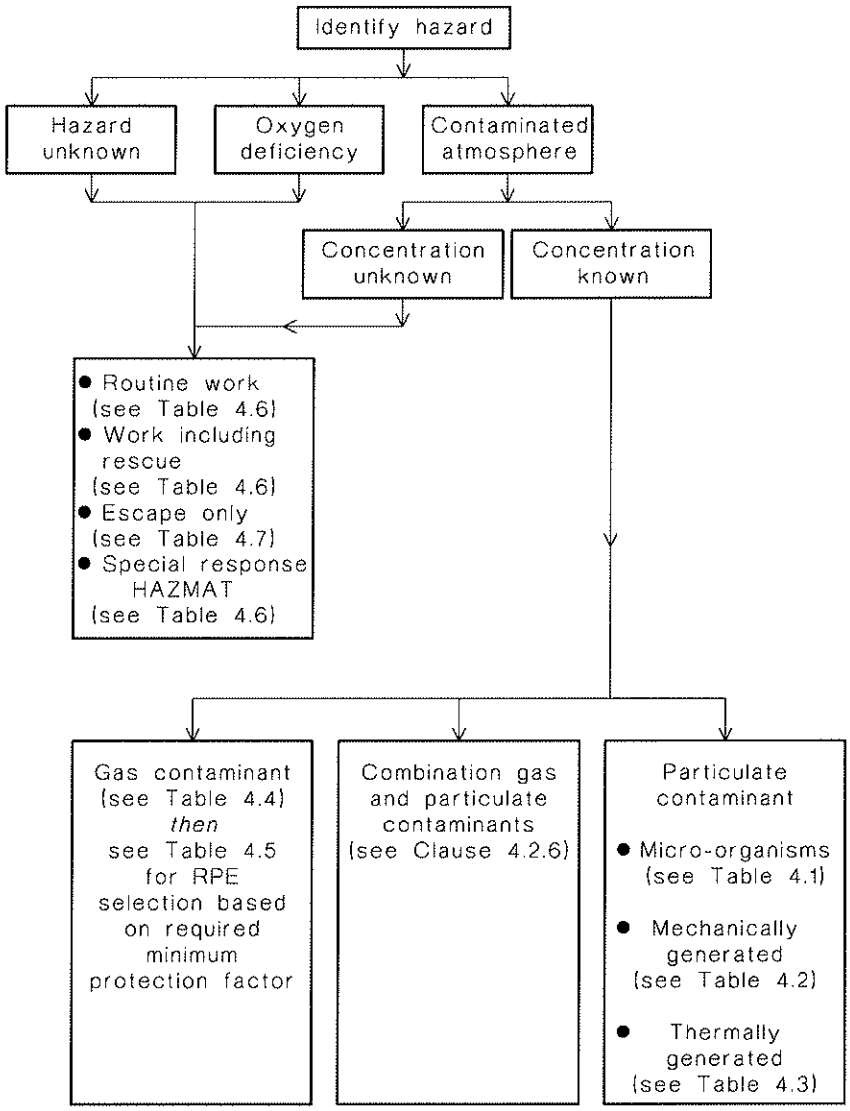


FIGURE 4.1 FLOW CHART FOR RPE SELECTION

Further explanation of the recommendations is given in the rest of this Standard and should be read in conjunction with Tables 4.1 to 4.6. Where there is doubt about the correct selection, expert advice should be sought from persons experienced in respiratory protection.

The devices selected should be suitably matched to individual wearers, their duties, the likely duration of wear and the nature of the environments e.g. personal characteristics, physical fitness, work rate, posture, space restrictions, ambient temperature, relative humidity. The selected devices should not impose unacceptable discomfort on the wearers.

The device selected should be compatible with any items of PPE, which may have to be worn simultaneously with the RPE.

This section provides guidance on selection of adequate protection. The information should not be viewed as minimum protection requirements. Over-specifying is warned against as generally this will result in increased body burden without any improvement in protection, e.g. for mechanically generated particulates such as silica dust and chrysotile, a P1 respirator will provide adequate protection. Recommendation of a P2 respirator will provide little or no improvement in filtration of these dusts but may have a higher breathing resistance and therefore may force the wearer to work harder for no additional protection.

To ensure adequate protection is achieved at all times, it is essential that a full respiratory protection program is conducted using the guidelines provided in Section 2.

CAUTION: MIXING AND MATCHING COMPONENTS SUCH AS FILTERS AND FACEPIECES MAY NOT ONLY INVALIDATE ANY MANUFACTURER'S WARRANTY BUT MAY NOT PROVIDE THE RESPIRATORY PROTECTION REQUIRED.

SUBSTITUTION OF COMPONENTS IS NOT ACCEPTABLE UNLESS THE COMPONENTS HAVE BEEN TESTED AS A WHOLE, COMPLY WITH AS/NZS 1716 AND THERE IS AN ONGOING QUALITY ASSURANCE PROGRAM TO ENSURE THAT RELEVANT PERFORMANCE REQUIREMENTS CONTINUE TO BE MET.

4.2 SELECTION FACTORS—CONTAMINANT-RELATED

4.2.1 General

The following contaminant-related factors shall be considered as part of the RPE selection process:

(a) The nature, toxicity, physical form and concentration of each contaminant.

(b) Whether failure of the device can result in a situation which is immediately dangerous to life or health (IDLH).

(c) The need to wear other PPE, e.g. eye or skin protection to protect against irritants.

(d) The possibility of the contaminated atmosphere being flammable/explosive.

4.2.2 Nature, toxicity, physical form and concentration of the contaminant

4.2.2.1 *General*

Before selecting RPE, the physical characteristics of the contaminant or combination of contaminants needs to be known, i.e. whether it is a particulate, a gas or a combination of them, and such properties as the boiling point and vapour pressure.

Where the type or extent of atmospheric contamination (gaseous or particulate) remains unknown and a safe level of oxygen cannot be assured, then supplied air RPE shall be used.

4.2.2.2 *Protection factors and exposure standards*

A major factor when selecting a respirator is to determine the reduction in exposure which a particular respirator type can be expected to provide. This reduction, termed 'protection factor', is defined as the ratio between the concentration of a contaminant outside the respirator to the concentration inside the respirator, i.e. breathed by the wearer. The 'protection factor' can also be expressed by the following equations:

$$\text{Protection factor} = \frac{\text{Ambient airborne concentration}}{\text{Concentration inhaled inside respirator}}$$

$$\text{Required minimum protection factor} = \frac{\text{Ambient airborne concentration}}{\text{Acceptable exposure level/standard}}$$

The required minimum protection factor (MPF) for any given situation is that factor necessary to reduce the exposure of the wearer below an accepted level or exposure standard or to minimize the potential exposure. A choice based upon the desired protection may be made by referring to Tables 4.2 to 4.6.

If the exposure standard of a substance is designated as a peak limit, then measurement should be taken of the peak ambient concentration. Similarly, if the exposure standard is a time-weighted average, measurements should be taken to estimate the eight-hour exposure level.

A respirator shall be selected to ensure that the exposure level is reduced below the accepted level. In practice, the maximum contamination level of the ambient atmosphere for which a given respirator or class of respirator is appropriate may be recommended by a regulatory authority.

4.2.2.3 *Concentration of contaminant*

In estimating the required minimum protection factor, evaluation of the likely range of contaminant concentration in the atmosphere shall be made. (Advice should be sought from occupational hygienists on the type of equipment, method of measurement and interpretation of test results). The assessed levels of contaminants, taking into account peak levels, can then be used to determine the required protection both on a routine basis and for emergencies.

Filter *class* refers to the capacity of the filter. Table 4.5 considers class (capacity) only and is to be read in conjunction with Table 4.4 when selecting a gas filter.

Both the required minimum protection factor and the maximum gas/vapour concentration present in air should not exceed those listed, e.g. where the exposure standard is 200 p.p.m. (by volume) and the workplace concentration is 1200 p.p.m. (by volume), the required minimum protection factor is 6 (1200/200). However, the ambient concentration is greater than 1000 p.p.m. (by volume), so the appropriate respirator is chosen from the section of the Table commencing, 'required minimum protection factor up to 50'. This is because a Class 1 filter would have insufficient capacity to be of practical use in such an ambient contaminant concentration.

Table 4.4 lists some examples of compounds for which the different types of filter should be suitable.

As sorbents vary from one manufacturer to the next, it should be ensured that the filter *type* selected is appropriate for all contaminants present. When in doubt, check with the manufacturer.

4.2.2.4 *Micro-organisms*

While there is no simple correlation between the Risk Group of micro-organisms and the type of respirator that is required, Table 4.1 may be used for some guidance. There has been considerable discussion internationally about respiratory protection against infectious micro-organisms and the fact that it is not possible to define occupational exposure limits for micro-organisms, as has been done for chemicals. This is for many reasons, e.g. the infectious inhalation dose and the air concentrations of infectious particles to which the workers may be exposed are usually uncertain. These vary with the micro-organisms being worked with (mode of transmission, procedure being used, etc.) and will vary from one organism to another within each Risk Group. Clause 3.2 of AS/NZS 2243.3 describes the four Risk Groups. The recommended PAPR for Risk Group 4, is an option needed for people working in the field in the tropics, where they will dehydrate in the full body suits. The most appropriate type of PAPR has a soft/lightweight hood with cape (to protect against splashes).

For further reading see:

Steven W Lenhard, Teresa Seitz, Douglas Trout, and Nancy Bollinger. Issues Affecting Respirator Selection for Workers Exposed to Infectious Aerosols: Emphasis on Healthcare Settings. *Applied Biosafety: Journal of the American Biological Safety Association*, Vol. 9, No. 1, 2004, pp20–36. This article contains references to many other useful papers.

TABLE 4.1

SELECTION CONSIDERATIONS—CONTAMINANT: MICRO-ORGANISMS

Micro-organism risk group	Suitable RPE
Risk Group 1	Nil required
Risk Group 2	Not usually required. Only required for work with some RG2 organisms when performing certain procedures. P1 and P2 filters suitable: half facepiece—replaceable filter or disposable RPE
Risk Group 3	RPE with P2 or P3 filters may be required, depending upon the organism worked with, its mode of transmission etc. P2 or P3 filters suitable: half or full facepiece—replaceable filter or disposable RPE
Risk Group 4	PAPR—P3 filters in PAPR with full facepiece or head covering and blouse or full body air-supplied positive pressure suit

NOTE: The selection of the appropriate RPE varies not only with the Risk Group, but also the nature of the organism, its mode of transmission, procedure being used, etc. AS/NZS 2243.3 should be consulted and a risk assessment carried out to assist in determining the correct device.

TABLE 4.2

SELECTION CONSIDERATIONS—CONTAMINANT: MECHANICALLY GENERATED PARTICULATES

Required minimum protection factor	Suitable RPE
Up to 10	• P1, P2 or P3 (see Clause 4.2.3.5) filter half facepiece—replaceable filter • P1 or P2 disposable facepiece • PAPR—P1 filter in PAPR with any head covering or facepiece
Up to 50	• P2 filter in full facepiece • PAPR-P2 filter in PAPR with any head covering or full facepiece • PAPR-P3 filter in PAPR with any head covering • Half facepiece with positive pressure demand or continuous flow air-line • Half facepiece—air-hose RPE with electric blower
Up to 100	• P3 filter in full facepiece • Full facepiece air-hose (hose mask) natural breathing type
100+	• PAPR-P3 filter in PAPR with full facepiece or head covering and blouse • Head covering air-hose with electrical blower • Head covering air-line respirator—continuous flow • Full facepiece air-line respirator—positive pressure demand or continuous flow modes • Full facepiece air-hose with electric blower
WARNING: WHERE EXPOSURE TO THE CONTAMINANT COULD BE IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH), SEE TABLES 4.6 AND 4.7.	

NOTES:

1 The required minimum protection factor is explained in Clause 4.2.2.2.

2 Respirators listed as suitable for the higher protection factors are also suitable for lower protection factors.

3 Tables 4.1 to 4.6 do not cover all considerations for all applications of respiratory protective devices and should be read in conjunction with Section 5.

4 Where the process also liberates toxic gases, see Clause 4.2.6.

5 See Appendix F for a respirator selection example.

6 Examples of processes which would result in the mechanical generation of particles:

Grinding, blasting, sanding, mixing powders, chipping, spraying.

7 Examples of mechanically generated particulates: Silica dust, coal dust, asbestos fibres, lead dust, sodium hydroxide mist.

TABLE 4.3

SELECTION CONSIDERATIONS—CONTAMINANT: THERMALLY GENERATED PARTICULATES

Required minimum protection factor	Suitable RPE
Up to 10	• P2 or P3 (see Clause 4.2.3.5) filter half facepiece—replaceable filter • P2 or disposable facepiece
Up to 50	• P2 filter in full facepiece • PAPR-P2 filter in PAPR with any head covering or full facepiece • PAPR-P3 filter in PAPR with any head covering or full facepiece • Half facepiece with positive pressure demand or continuous flow air-line • Half facepiece air-hose with electric blower
Up to 100	• P3 filter in full facepiece • Full facepiece air-hose (hose mask) natural breathing type
100+	• PAPR-P3 filter in PAPR with full facepiece or head covering and blouse • Head covering air-hose with electric blower • Head covering air-line respirator—continuous flow • Full facepiece air-line respirator—positive pressure demand or continuous flow modes • Full facepiece air-hose with electric blower
WARNING: WHERE EXPOSURE TO THE CONTAMINANT COULD BE IDLH, SEE TABLES 4.6 AND 4.7	

NOTES:

1 The required minimum protection factor is explained in Clause 4.2.2.2

2 RPE listed as suitable for the higher protection factors are also suitable for lower protection factors.

3 Where the process also liberates toxic gases, see Clause 4.2.6.

4 Examples of processes that result in the thermal generation of particles:

Smelting, welding, brazing, heating.

5 Examples of thermally generated particles:

Lead fume, zinc oxide fume, chromium fume, manganese fume, welding fume, and bushfire smoke.

4.2.3 Protection against particulates

4.2.3.1 *General*

In most circumstances adequate respiratory protection against non-volatile particulates can be obtained by the use of particulate filtering RPE. The degree of protection is governed by the type of filter and RPE (see Tables 4.2 and 4.3) and facepiece and the effectiveness of the individual's facial seal (see Section 8 and Appendix B).

WARNING: NUISANCE DUST MASKS ARE LIGHTWEIGHT MASKS WITH A FILTER INTENDED ONLY FOR EXTREMELY COARSE PARTICULATES. THEY DO NOT MEET THE REQUIREMENTS FOR AS/NZS 1716 AND SHALL NOT BE USED TO CONTROL OCCUPATIONAL EXPOSURES AND SHALL NOT BE USED WHERE RPE IS REQUIRED.

THEY DO NOT GIVE PROTECTION AGAINST GASES OR VAPOURS.

IN SOME STATES, LABELS INDICATING THE LIMITED USE OF THESE DEVICES ARE REQUIRED BY REGULATORY AUTHORITIES.

4.2.3.2 *Classification of filters*

Particulate (i.e. dust, mist, smoke and fume) filters are classified according to their ability to filter a test cloud of particles having a size distribution as defined in AS/NZS 1716.

NOTE: Respirator users are advised that an additional gas filter or filters will be required where the process responsible for generating particulates also liberates toxic gases.

4.2.3.3 *Class P1 filters*

RPE with P1 filters are used against mechanically generated particulates, e.g. silica and chrysotile.

Three types of Class P1 filter RPE are generally available, i.e. powered type, replaceable filter type and disposable type.

4.2.3.4 *Class P2 filters*

RPE with P2 filters are used for protection against mechanically or thermally generated particulates or both, e.g. metal fumes.

Three types of Class P2 RPE are generally available, i.e. powered type, replaceable filter type and disposable type.

4.2.3.5 *Class P3 filters*

These are used for protection against highly toxic or highly irritant particulates, such as beryllium. Two types of Class P3 RPE are generally available, e.g. powered type and replaceable filter type. For P3 filter classification, a full facepiece is required for non-powered RPE, but either a head covering or full facepiece for a PAPR. When a P3 filter is used in a half facepiece, a protection factor equivalent to a P2 filter is achieved.

4.2.3.6 *Use of air-hose or air-line RPE*

Where the particulate concentration causes rapid clogging of the filter or the task is a routine one and does not require great mobility, the use of an air-hose or an air-line respirator may be more suitable.

An air-line or air-hose respirator, used in conjunction with an emergency breathing device (EBD) is suitable for long-term use in potentially dangerous or unknown situations where an air supply failure would cause loss of protection, and possible death or serious injury.

4.2.4 Respiratory protection against bushfire smoke

Respiratory protection from smoke may be required in a bushfire. Such smoke consists predominantly of thermally generated particulates and suitable protection against such particulates (i.e. P2 or P3 filter half facepiece with a replaceable filter or a P2 disposable facepiece) serves to reduce exposure. Eye protection may also be needed.

TABLE 4.4

SELECTION CONSIDERATIONS—CONTAMINANT: FILTER TYPES FOR GASES AND VAPOURS

Filter type	Description name	Examples of contaminants/uses
A (All classes)	Organic vapours	Solvents (with boiling point above 65°C)
B AUS or B1	Acid gases	Chlorine/sterilization of water; chemical manufacture; hydrogen chloride/chlorinated organic chemical manufacture; steel pickling
B2	Acid gas and hydrogen cyanide (HCN)	Plastics manufacture; gold ore refining
B3	Acid gas and hydrogen cyanide (HCN)	HCN fumigation
E	Sulfur dioxide (SO_2)	SO_2/casting of metals; bleach manufacture; manufacture of sulfuric acid; fertilizer manufacture; metal cleaning; petroleum refining
G	Agriculture chemicals	Low vapour pressure (below 1.3 Pa at 25°C) organic vapours, pesticide spraying, mixing, manufacture
K	Ammonia (NH_3)	NH_3/refrigeration; manufacture of fertilizers, explosives, plastics; low boiling point amines/chemical manufacture
Hg	Mercury	Metallic mercury/chemical industry; inorganic-mercury compounds
NO	Oxides of nitrogen	Oxides of nitrogen
MB	Methyl bromide	Fumigation
AX	Low boiling point organic compounds (below 65°C)	As specified by the manufacturer, e.g. dimethyl ether, vinyl chloride
Specific chemical type	Specific chemical name	For use against specific chemicals not falling in the above type description as specified by the manufacturer, e.g. hydrogen fluoride

NOTE: See Appendix E for a respirator selection example.

TABLE 4.5

SELECTION CONSIDERATIONS—CONTAMINANT: GAS AND VAPOUR CONCENTRATION

Required minimum protection factor	Maximum gas/vapour concentration present in air p.p.m. (by volume)	Suitable RPE
Up to 10	1 000	• Class AUS, 1, 2 or 3 filter with half facepiece—replaceable filter or disposable facepiece • Class PAPR-AUS, PAPR-1 or PAPR-2 filters in PAPR with any head covering or facepiece
Up to 50	1 000	• Class AUS or Class 1 filter with full facepiece
Up to 50	5 000	• Half facepiece air-line respirator with positive pressure demand—or continuous flow • Half facepiece air-hose with electric blower
Up to 100	5 000	• Class 2 filter with full facepiece • Class PAPR-2 filters, with full facepiece PAPR
Up to 100	10 000	• Class 3 filter with full facepiece • Full facepiece air-line respirator—negative pressure demand • SCBA negative pressure demand • Full facepiece air-hose (hose mask) natural breathing type (see Note 6)
100+		• Full facepiece, head covering or air-supplied suit with air-line respirator—positive pressure demand or continuous-flow • SCBA positive pressure demand • Full facepiece air-hose with electric blower

WARNING: WHERE EXPOSURE TO THE CONTAMINANT COULD BE IMMEDIATELY DANGEROUS TO LIFE OR HEALTH, SEE TABLES 4.6 AND 4.7

NOTES:

1 The required minimum protection factor is explained in Clause 4.2.2.2.

2 RPE listed as suitable for the higher protection factors are also suitable for lower protection factors.

3 Eye protection may be required.

4 See Appendix F for a respirator selection example.

5 Negative pressure demand RPE no longer meets the requirements of AS/NZS 1716 and should no longer be used.

6 In the case of hose mask respirators, the upper limit of 10 000 ppm may not be relevant. Consult the relevant authorities.

4.2.5 Protection against gases and vapours

4.2.5.1 *General*

Protection against gases and vapours may be obtained by the use of air-purifying RPE or by a supplied-air device. The degree of protection provided is governed by the type of filter used in the RPE and the effectiveness of the individual facial seal (see Section 8 and Appendix B).

4.2.5.2 *Gas filter RPE*

The different types of filters are specified in Table 4.4 and AS/NZS 1716. The classes are distinguished by their gas absorptive capacity and, in general, by their size and mass. (See Table 4.5 and also Appendix E).

Class AUS and Class 1, the lowest capacity filters, are generally combined with a half facepiece, the limiting factor of which is the adequacy of facial seal, gas capacity or lack of eye protection. Where contaminants are present in high concentrations which may cause adverse reactions or which may be allergenic, even in low exposures, half facepiece RPE may not provide an adequate facial seal.

A high standard of respiratory protection may be obtained in toxic atmospheres not deficient in oxygen, provided that the following requirements are met:

(a) The filter used is appropriate to the specific contaminant encountered.

(b) The concentration of contaminant in the atmosphere is below the maximum for which the filter is suitable.

(c) The RPE fits the wearer correctly.

(d) The protection factor afforded by the respirator is sufficiently high.

(e) The RPE is worn while the wearer is in the contaminated area.

(f) Maintenance of the RPE is carried out when required.

4.2.5.3 *Gas filter life*

The life of a filter is difficult to assess under normal working conditions, being dependent on the concentration of contaminant in the atmosphere, the humidity and the work rate of the wearer. Filter change schedules shall be established (see Clause 9.5). All classes of gas filter shall be discarded no longer than six months after opening, irrespective of the number of periods of use.

The manufacturer's instructions shall be observed, particularly when specific chemical type filters (See Table 4.4) are used.

4.2.5.4 *Supplied-air RPE*

Supplied-air RPE would be required in one or more of the situations described below:

(a) Where there is an oxygen deficiency.

(b) Where the level of toxic gases or contaminants exceeds the capability of an air-filtering device.

(c) Where the level of contamination is unknown but the level of toxic gases or other contaminants may be high.

(d) Where the operator is required to remain in the contaminated environment for longer than the estimated life of the filter.

(e) Where environments are immediately dangerous to life and health.

(f) Where there is no filter suitable for use against the contaminant.

(g) Contaminated atmosphere in a confined space.

Full face supplied-air RPE, used in connection with self-contained breathing apparatus of the escape type, is recommended for use in potentially dangerous or unknown situations where an air supply failure would cause loss of protection (see also Clause 4.2.7).

Negative pressure demand RPE is no longer covered by AS/NZS 1716 and does not comply with it, and should not be used.

4.2.6 Protection against combined particulates, gases and vapours

Subject to the limitations explained in Clauses 4.3 and 4.4, protection against the combined hazards of particulates, gases and vapours, e.g. spray painting, can be obtained by the use of RPE with a combined particulate and gas filter(s), or RPE which is fitted with a combination of filters in series, or by the use of any of the supplied-air devices.

4.2.7 Protection against oxygen-deficient atmospheres

Entry to places where the normal level of oxygen has been depleted or is unknown (see Clause 3.7) requires either the wearing of—

(a) a SCBA of sufficient operational duration; or

(b) air-line RPE with escape SCBA attached to the person.

Particular care should be taken in choosing an appropriate air-line or air-hose- see Clause 4.3.8.

Where work including rescue and special response HAZMAT is to be carried out in an oxygen-deficient atmosphere or the concentration of a contaminant may be high, RPE should be chosen in accordance with the Table 4.6.

TABLE 4.6

SELECTION CONSIDERATIONS —
RPE FOR EXTENDED PERIODS OF USE IN OXYGEN DEFICIENCY OR IDLH ATMOSPHERE OR UNKNOWN CONCENTRATIONS OF CONTAMINANTS

Expected use	Equipment	Remarks
Escape	SCBA, quickfill type	Mines-continuous supply/rechargeable for long escape route
Work, routine	Air-hose (hose mask) natural breathing type Full facepiece air-line or air-hose with EBD	Limited mobility and distance to source of respirable air
Work, including rescue use	Compressed air SCBA duration: >15 min Compressed oxygen SCBA Air-line with SCBA	 Limited duration Specialist training essential Limited mobility and distance to source of respirable air
Special response HAZMAT incident No O_2 deficiency	Combined gas and particulate P3 full facepiece, PAPR or air-line with filter	Assessed as suitable by emergency service personnel See Clause 4.6
Special response HAZMAT incident O_2 deficiency	Compressed air SCBA duration: >15 min	
Work in confined spaces	Refer to Clause 3.7.1 for confined spaces and AS/NZS 2865.	If oxygen deficiency is suspected then supplied-air equipment is suitable Limited duration only Specialized training required

4.2.8 Protection against airborne radioactivity

Airborne radioactivity may be present, for example, at uranium and mineral sands mines, contaminated sites, during the production and use of unsealed radioactive sources and while using welding rods that contain thorium. The selection of respiratory protection depends on the airborne radioactive concentration, the exposure time, the form of the contaminant, the breathing rate and the recommended annual limit of intake (ALI) for the particular radionuclide.

Radioactive gases such as xenon, various forms of iodine, tritium, radon and thoron and their daughter products can be in the gaseous and/or particulate form and also attached to other airborne material.

Advice should be sought from the relevant regulatory authorities—State, Territory or Commonwealth.

4.2.9 Resistance to flame

Where equipment is used substantially for fire-fighting, or likely to be exposed to flame, specifying compliance to the heat and flame test Appendix C of AS/NZS 1716 should be included in the selection criteria for the respiratory protection.

4.2.10 Additional protection

4.2.10.1 *General*

The extent of the precautions required to exclude the contaminated atmosphere will depend on its effect on the body. Contaminants may have to be kept away from the eyes and skin as well as from the respiratory tract owing to immediate irritation (see Section 3).

Depending on the type and amount of contamination in the atmosphere, a number of respirator types with varying facial and body coverage can protect, and if necessary progressively isolate the RPE user from the contaminated atmosphere. The RPE types range from a simple mouthpiece to full-body encapsulation. Attention is also drawn to AS/NZS ISO 6529.

The degree to which the contaminant atmosphere may be excluded depends upon the effectiveness of the facial and body seal.

4.2.10.2 *Use with goggles or spectacles*

Most types of filter respirator use a half facepiece and this may interfere with the wearing of protective goggles or prescription spectacles. Some models of half facepiece may be more compatible with the use of eyewear. The need for separate eye protection may be avoided by the use of a full facepiece or a hood or helmet respirator. Prescription lens spectacles can be incorporated within certain types of full facepiece.

4.2.10.3 *Use with head coverings*

In situations where head protection from irritants is required in addition to respiratory protection, a hood or head covering is recommended. It may be worn in conjunction with a full facepiece respirator or may have integral respiratory protection.

4.2.10.4 *RPE for use in flammable or explosive atmospheres*

In the selection of RPE for use in potentially flammable or explosive atmospheres, care shall be taken to select equipment that is not likely to be an ignition source. Such ignition sources can include the use of certain alloys which may produce sparks on impact with rusted iron or steel, the use of plastics and fibres with unsuitable antistatic properties, electrical components without a recognized method of protection or communications equipment.

Alloys suitable for use in this situation are those in which the total content of aluminium magnesium or titanium does not exceed 15% by mass and in which the content of magnesium and titanium together does not exceed 6% by mass.

Non-metallic materials used in RPE including air-lines shall have antistatic properties complying with AS/NZS 1020.

The intrinsic safety or flameproof properties of electrical components of the RPE shall comply with and be certified to the requirements of AUS ex scheme as appropriate.

NOTES:

1 'Intrinsic safety' is defined in AS/NZS 60079.1 in the following terms: a type of protected based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects.

2 'Flameproof enclosure' is defined in AS/NZS 60079.11 as an enclosure in which the parts which can ignite an explosive gas atmosphere are placed and which can withstand the pressure developed during an internal explosion of an explosive mixture, and which prevents the transmission of the explosion to the explosive gas atmosphere surrounding the enclosure.

3 'Antistatic' is defined in AS/NZS 1020 as indicating that a material is, by virtue of its low resistivity, incapable of retaining a significant static charge when in contact with earth.

4 Attention is drawn to the availability of a scheme for the certification of explosion-protected electrical equipment. Equipment so certified conforms to one of the explosion-protected electrical equipment Standards listed in publication MP 69.

4.3 SELECTION FACTORS—TASK-RELATED

4.3.1 General

The following task-related factors shall be considered as part of the RPE selection process:

(a) Whether the device is for regular use or for emergency or rescue purposes.

(b) The probable length of time during which the wearer will be in the contaminated atmosphere.

(c) The expected level of activity and mobility required of the wearer.

(d) The access to, and nature of the working environment and its location with respect to a source of air suitable for breathing.

(e) The need for clear vision and communication.

(f) The facilities available to maintain the device.

4.3.2 Frequency and length of usage

The most commonly used RPE for regular use are half facepiece non-powered air-purifying RPE, because of their comfort and convenience. However, where full facepiece non-powered air-purifying RPE are used, consideration should be given to limiting their use to minimize discomfort and the possibility of heat stress.

Half facepiece non-powered air-purifying RPE are not suitable for rescue purposes.

When selecting an appropriate gas filter, the contaminant concentration, required minimum protection factor and period of exposure should first be addressed (see Clause 4.2.2.2 and the filter manufacturer's instructions).

With particulate filters, extended use (or even moderate use in a heavily dust-laden atmosphere) will result in the wearer detecting an increase in breathing resistance caused by progressive clogging of the filter. Depending upon the severity of this phenomenon, users may prefer to employ supplied-air equipment. Supplied-air RPE is also chosen where facilities to change filters are not immediately available.

For some filters, the efficiency of the filter deteriorates in the presence of substances such as oil mists, commonly encountered in the workplace. They need to be changed frequently or other RPE used. The filter's performance may degrade without noticeable increase in breathing resistance therefore clogging will not give guidance for filter replacement.

Powered air-purifying RPE is also restricted by filter life, the necessity for filter changes and battery charging facilities and, in addition, the battery life shall be taken into account.

Compressed air SCBAs are suitable for routine or emergency work where air-supplied RPE is required, but are restricted to short-term use owing to an average supply life of 15 to 50 min. See Tables 4.6 and 4.7. Where longer duration is required, such as for mines rescue and firefighting, compressed oxygen SCBAs are preferred. However, the use of such equipment is limited to trained and experienced personnel. Such equipment is not suitable for rescue work where it is fitted with a slow-release orifice.

4.3.3 Degree of activity and mobility

Although non-powered air-purifying RPE does not restrict the mobility of the wearer, it imposes a load upon the breathing process that may increase markedly with higher efficiency filters. Where strenuous activity is required, supplied-air RPE or powered air-purifying RPE may be more comfortable. The PAPR has an advantage over air-hose or air-line equipment as there is no restriction of mobility. If SCBA is preferred, the weight and bulk of the apparatus should be considered as these may present difficulties to the users.

4.3.4 Location of the task

When contemplating supplied-air RPE, consideration shall be given to the problems which may be presented by the air-hose or air-line limiting the distance between the task and a source of respirable air. In addition, such hoses or lines may be a source of danger to others working in the area and may themselves be damaged or severed through accident. Where compressed air-line RPE is indicated, these problems may be alleviated by supplying air from a large cylinder which may be moved to the task location. Air supplied from cylinders only lasts for a short period when used in a continuous flow mode.

4.3.5 Working environment conditions

4.3.5.1 *General*

When selecting suitable RPE, the effect of the working environment upon the user and the RPE should be considered. This can establish whether, when wearing a particular type of RPE, the user will be subject to adverse effects from environmental hazards other than atmospheric contamination. If this proves to be the case, a different design which retains sufficient respiratory protection, may mitigate such hazards and increase comfort afforded to the wearer.

4.3.5.2 *Low temperatures*

Use of RPE in low temperatures can create several problems. The lenses of the full facepiece equipment may fog owing to condensation of the water vapour in the exhaled breath. Coating the inner surface of the lens with an anti-fogging compound will reduce fogging.

4.3.5.3 *High temperatures*

Respirator usage in hot environments can put additional stress on the user. The stress may be minimized by using a respirator with low breathing resistance. In this respect, an air-line respirator equipped with a cooling system may be used.

4.3.5.4 *Environmental effects on air-hose or air-line*

Particular care should be taken in choosing an air-line or air-hose intended to be used in temperature extremes, or likely to come in contact with solvents or other deleterious materials Solvents may permeate certain types of hose material or destroy them. Heat may also cause the release of objectionable odours into the hose.

Anti-static air-lines shall be chosen for use in potentially explosive atmospheres.

4.3.6 Emergency escape

During the course of work that may not require respiratory protection, situations may arise that require immediate escape, using an appropriate piece of RPE, as given in Table 4.7.

TABLE 4.7

SELECTION CONSIDERATIONS—TASK-RELATED: RPE FOR ESCAPE

Expected use	Suitable RPE	Remarks
Escape from smoke	Smoke-mask respirator	If suspected oxygen deficiency then supplied-air equipment shall be used
Escape from smoke and carbon monoxide (in an underground fire, explosion)	Filter self-rescuer (mines)	Provide limited protection against some other gaseous contaminants The duration is dependent on the amount of water vapour in the atmosphere
Escape from gases (industrial)	Filter self-rescuer (industrial) class 2 or 3 filters	
Escape, easy access	SCBA, escape type (hood) duration: 5 to 8 min	Access to respirable atmosphere achievable at walking (6.5 km/h) pace within the nominal effective life of the apparatus of choice
Escape	SCBA, escape type (full facepiece) duration: 5 to 15 min Oxygen generating set duration: 30 to 90 min	Duration of set limited to 5 to 15 min (SCBA escape type) and 30 to 90 min (oxygen-generated type). No work or rescue usage
Escape	SCBA, quickfill type	Mines—continuous supply/rechargeable for long escape routes

4.4 SELECTION FACTORS—OPERATOR-RELATED

4.4.1 General

The following operator-related factors shall be considered as part of the respirator selection process:

(a) Basic physiological considerations.

(b) Facial fit.

(c) User acceptance.

4.4.2 Basic physiological considerations

All workers who are required to wear RPE should be assessed. Pre-existing conditions, which may include lung and circulatory problems—see Section 6, should be taken into account.

4.4.3 Facial fit

4.4.3.1 *General*

Facial fit is a prime factor in obtaining good protection when utilizing half or full facepiece RPE and needs to be taken into account in the selection of a RPE.

Respirators incorporating close fitting facepieces rely on facial fit to prevent inward leakage of contaminants. Such RPE employing a full facepiece or half facepiece shall not be used by males who are not clean shaven about the cheeks, neck and jaw. Half facepiece RPE of this type shall not be used by those with moustaches where there is any chance of hair coming between the facepiece and the skin. Long hair may also impair the function of valves (see Clause 8.3) and positioning of head harness. Nevertheless, even with an excellent facial fit, all RPE will have some inward leakage of the ambient atmosphere as well as leakage through the outlet valve or valves.

RPE that maintains a positive pressure in the facepiece at all times provide a higher degree of protection than can be achieved with negative pressure types.

Positive pressure RPE may diminish the effect of poor facial fit but will not obviate the effect of leakage caused by facial hair (see Clause 8.3). Where conservation of the air supply is important, e.g. self-contained breathing apparatus, it should be recognized that any leakage, e.g. from the facial seal, increases air consumption and decreases service time. At high rates of work, beards and other facial hair may cause inward leakage even when using positive pressure RPE.

Clause 8.3 and Appendix B provide further information and requirements on facial fit.

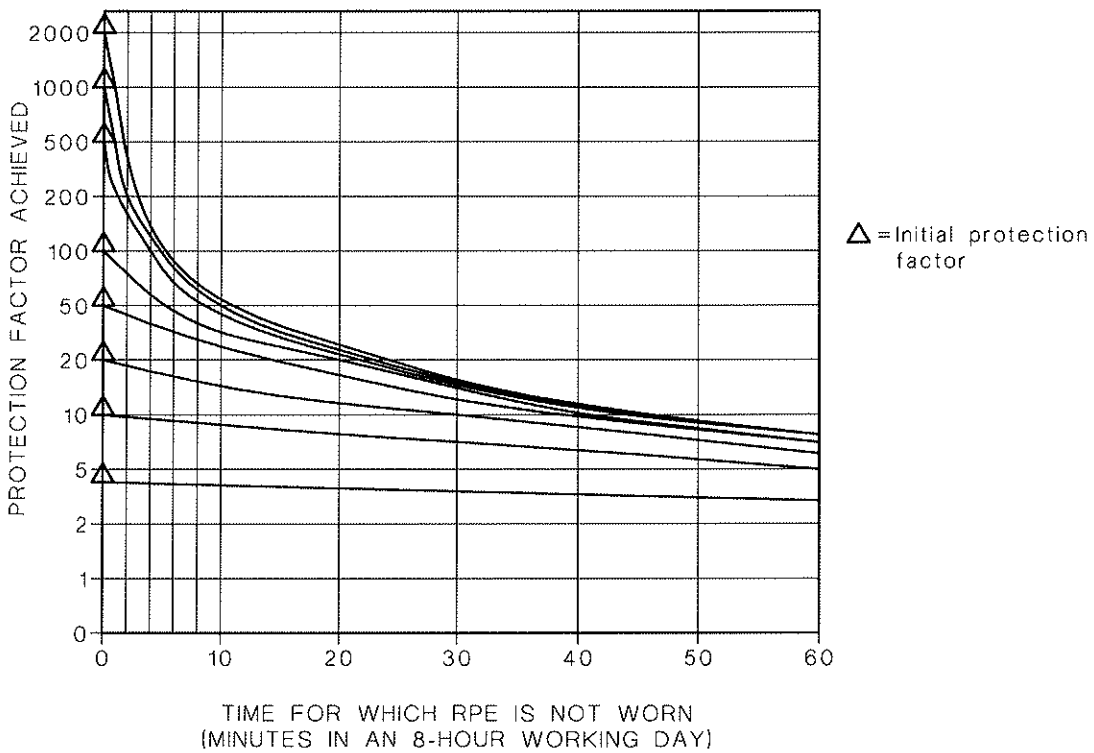


FIGURE 4.2 COMPARISON OF PROTECTION FACTOR ACHIEVED FOR VARIOUS WEAR TIMES

4.4.3.2 *User acceptance*

RPE is more likely to be worn where it fits well, is comfortable, and is accepted by the user. The appropriate respirator should be worn the entire time that a person is at risk of exposure. In practice, the user's adherence to this principle will be influenced by the wearability of the individual respirator; influencing factors include comfort, field of vision and the need to communicate without removing the device.

A simple calculation emphasizes the importance of wearing the respirator at all times of exposure. See Figure 4.2. This is the case irrespective of the protection factor provided by the respirator during the wearing period. The increase in concentration of the contaminant increases the wear-time factor required for adequate protection.

When a respirator is worn routinely or for extended periods, the significance of weight, tight-fitting straps, and skin chafing will increase to the extent that the user may not concentrate adequately on the work in hand. This translates into an increased risk of accident and a reduction in job satisfaction with an attendant drop in productive output. For some non-powered particulate air-purifying respirators, breathing resistance will increase progressively as the filter pores become blocked with contaminants. Increasing breathing resistance in such particulate filters is thus taken to indicate the end of the filter's effective life. Continued use, although not resulting in contaminant penetration through the filter, will impose greater discomfort on the user.

4.5 SELECTION FACTORS—EQUIPMENT LIMITATIONS

4.5.1 General

The limitations of the respiratory equipment need to be taken into consideration when selecting a respirator for a particular application or circumstances. Limitations may include the complexity and duration of training, maintenance requirements, restricted vision and communication, failure of air supply or, in certain circumstances, an inadequate rate of air supply.

In some circumstances, the use of a specific type of construction of RPE, e.g. supplied-air, may be necessary because of the adverse effects of the immediate environment on parts of the body other than the respiratory system. For example, work in a corrosive or solvent-laden atmosphere may require the use of a full facepiece or head covering and body protection.

The materials from which the RPE is made would have to be resistant to attack from the specific gases or vapours present.

More detailed discussion of the limitations of a different type of equipment is contained in Section 5.

4.5.2 Vision and communication

Depending upon detailed design, all full facepiece RPE restrict the wearer's vision to a certain extent. This should be considered if the user needs to be near moving machinery. Corrective lenses with temple bars or straps should not be worn if these will interfere with facial seal. Manufacturers of RPE can provide kits for installing eyeglasses in full facepieces. These glasses or lenses should be mounted strictly in accordance with instructions to ensure proper fitting.

Where precise communication is important, consideration should be given to selecting a facepiece with appropriate speech transmission facilities, otherwise the tendency will be for the wearer to remove the respirator to speak. Speech can cause facepiece or component leakage and should be limited, particularly when a half facepiece is being worn. Some facepieces are provided with speech amplification or transmission devices. If a facepiece is fitted with a mechanical speech transmission device, the diaphragm should be handled carefully to prevent puncture. Electrically operated speech transmission devices are available.

4.5.3 Limitations of rate of air supplied

It is important that peak inspiratory flow of the equipment is matched to the expected demands of the user. This depends on many factors including work rate, type of movements, breathing pattern, speech and breathing resistance.

Manufacturers can provide information as to the performances of their equipment. Peak inspiratory flows are especially important in positive pressure demand equipment as the equipment may fail to maintain positive pressure at peak flows even though it meets minute ventilation rates.

Table 4.8 provides some guidance in choosing adequate supply rates of breathable gas by comparing typical peak inspiratory flow rates to different levels of work. Current research indicates these figures may be somewhat conservative. A fuller discussion of this topic can be found in ISO/TS 16976-1. Minute ventilation measure an average volume of air used per minute. Peak inspiratory flow rates are between 3 and 10, or more, times higher than minute ventilation.

TABLE 4.8

ASSESSMENT OF REQUIRED BREATHABLE GAS SUPPLY RATES

Work level	Examples	Peak inhalation rate L/min
Low	Sitting at ease: Light manual work (writing, typing, drawing, sewing) Hand and arm work (small bench tools, inspections, sorting light material Arm and leg work: Driving in normal conditions, operating foot switch or pedal Standing: Drilling or milling small parts, coil winding Walking at <3.5 km/h on the level	100
Moderate	Sustained hand and arm work: Hammering in nails, filing; off-road driving, manual asbestos removal below shoulder level Arm and trunk work: Pneumatic hammer, weeding, hoeing picking fruit or vegetables, pulling or pushing light carts or wheel barrows Walking <5.5 km/h on the level	150
High	Intense hand and arm work: Carrying heavy materials, manual asbestos removal above shoulder level, shovelling, sledge hammer work, hand mowing, digging Walking at 5.5 km/h to 7 km/h on the level Pushing or pulling heavy cart or barrow	200
Very high	Very intense activity at fast to maximum pace: Working with axe, intense shovelling or digging, climbing ladder, stair or ramp Walking at >7 km/h on the level	250

NOTES:

1 Table derived from Astrand and Rodahl, and EN 27243, see Clause 1.4.

2 In extreme cases, peak inhalation rates may exceed 660 L/min (Astrand and Rodahl).

4.5.4 Limitations of loose fitting head coverings

In case of failure of the air supply to loose fitting head coverings, breathing zone concentrations of carbon dioxide can exceed 6% and oxygen concentrations can decrease to less than 14% within 1 min. These concentrations constitute a life threatening asphyxiation risk, requiring immediate removal of the head covering.

In case of failure of the air supply to the device and the immediate removal of the head covering, wearers may be exposed to full ambient contaminant concentrations unless a suitable emergency breathing device (EBD) is incorporated and used correctly. In addition, if decontamination procedures cannot be followed during removal and escape, wearers and others may be exposed to contaminants and the environments may be contaminated.

Loose fitting devices without an EBD shall therefore be used only when it is known that exposure will not exceed IDLH, and where contamination on the wearer's body and clothing does not pose a risk to others or the environment.

Training and supervision of wearers shall include removal of devices, use of the EBD and emergency egress procedures to protect others and the environment adequately.

Appropriate maintenance and inspection procedures shall be in place, due to the potential consequences of the failure of the air supply.

4.5.5 Limitations of close fitting facepieces

4.5.5.1 *Negative pressure or negative pressure demand devices*

During inhalation when wearing negative pressure or negative pressure demand devices, the lungs generate a negative pressure within the facepiece. This can allow contaminated air to leak through any gaps between the facepiece and the wearer's face, thus reducing the protection afforded by the device. Negative pressure devices shall be fitted to minimize any leakage between the facepiece and the face. It is important that no facial hair such as beards, moustaches or side burns is allowed between the face seal and face since it can adversely affect the fit of the facepiece. Stubble can affect the seal more than established facial hair since it holds the facepiece off the face.

Negative pressure devices impose additional work on the wearer and can thus impose discomfort, and limit the rate at which the wearer can work and the duration of wear.

WARNING: NEGATIVE PRESSURE DEMAND RPE IS NO LONGER COVERED BY AS/NZS 1716 AND NO LONGER COMPLIES WITH IT AND SHOULD NOT BE USED.

4.5.5.2 *Continuous flow PAPRs or air-supplied RPE*

Although clean air is supplied into the facepiece of the device, negative pressure within the facepiece can be created if the wearer's peak breathing rate exceeds the rate at which clean air is supplied. With PAPRs, the degree of negative pressure may not be severe and the wearer can still draw in filtered air through the filter even if the power supply fails completely.

With continuous flow devices, however, it is not possible to draw in clean air at a higher rate than the supply rate. If such devices are drawn negative, the facepiece sucks onto the face and severe inward leakage can occur.

Powered, continuous flow or positive pressure demand devices should therefore be matched to the wearer's foreseeable work rates. (See Table 4.8 to ensure that the likelihood of generating negative pressure within the facepiece is minimized).

Facepieces shall be correctly fitted to minimize any leakage between the facepiece and the face. It is important that no facial hair, such as beard, moustache or sideburns, is allowed between the face seal and the face since it can adversely affect the fit of the facepiece. Stubble can affect the seal more than established facial hair since it holds the facepiece off the face.

4.5.5.3 *Positive pressure demand devices*

Positive pressure demand devices are designed to maintain a pressure slightly above atmospheric inside the mask, even when the wearer is inhaling. If facepiece leakage occurs, any leakage is *more likely* to be outward, and contaminants are not inhaled by the user. In the case of high air flow demand by the user, the pressure inside the facepiece can, in principle, become negative. However, the increased degree of safety is reflected in the assigned protection factors given.

4.5.6 Limitations of supplied-air equipment in IDLH atmospheres

Where supplied-air RPE is used in IDLH situations, it is essential that training maintenance, inspection procedures and other suitable systems are in place to minimize the consequence of failure of the air supply.

Training and supervision of wearers should include removal of devices, use of the EBD and removal procedures to adequately protect others and the environment.

In any instance of failure of the air supply wearers may be exposed to full ambient contaminant concentration unless a suitable EBD is incorporated and correctly used. In addition, if decontamination procedures cannot be followed during removal and escape, wearers and others may be exposed to contaminants and the environment may be contaminated.

4.6 SELECTION OF RPE FOR SPECIAL RESPONSE HAZMAT INCIDENTS BY EMERGENCY SERVICE PERSONNEL

4.6.1 General

The purpose of this Clause (4.6) is to provide guidance to personnel selecting respiratory protection for emergency service personnel responding to Special Response HAZMAT incidents. The nature of the incident will require emergency service personnel to work in unusual and demanding situations that present risks to personnel that are not present in the normal work place such as chemical, biological, radiological and nuclear (CBRN) hazards. Many of these hazards may pose greater danger of serious injury or death by means other than inhalation. The equipment selection process therefore will include some risk assessment (even if qualitative) of all the hazards that may be associated with the task of the emergency service personnel.

See Table 4.6.

4.6.2 Protection factors and exposure standards

Due to the nature of the incident, establishing hazard types and possible level of exposure may not be done until after some personnel have completed their task in the environment. Therefore it will be very difficult to determine protection factors and relevant exposure standards. A judgement of the total risks therefore needs to be made with a broad range of protection being provided.

4.6.3 Combined gas and particulate filter RPE

Where the atmosphere is not deficient in oxygen, a high level of respiratory protection may be obtained using a combination gas and particulate filter provided the following are met:

(a) The RPE includes a full facepiece or maintain positive pressure over the face and eyes.

(b) The RPE provides combined protection against specific gas or vapour as well as particulates at the highest level, e.g. gases and vapours of known warfare chemical agents, industrial chemicals, biological organisms and radiological dust.

(c) The eye pieces and main body of the RPE does not absorb the contaminants for the intended duration of use.

(d) The RPE is designed to be able to be decontaminated.

(e) The RPE is designed such that it will not be dislodged from the wearer in the expected activity of the emergency personnel.

See Tables 4.1 to 4.7 for RPE selection considerations.

4.6.4 Gas filter life

The life of the filter is difficult to assess due to the unknown nature of the hazardous material and its concentration levels. Therefore the filters are for single use only. Used filters shall be disposed of in a safe manner so as to prevent possible exposure to others.

4.6.5 Degree of activity and mobility

Although non-powered RPE does not restrict the mobility of the wearer, it imposes a load upon the breathing process which may increase markedly with higher efficiency filters. Where strenuous activity is required a PAPR may be more suitable.

4.6.6 Protection against oxygen-deficient atmospheres

Entry to places where the normal level of oxygen has been depleted or is unknown (see Clause 3.7.1) requires the use of supplied-air equipment (see Table 4.6).

SECTION 5 TYPES OF RPE AND THEIR LIMITATIONS

5.1 GENERAL

5.1.1 Method of providing personal respiratory protection

There are two ways of providing personal respiratory protection against atmospheric contaminants:

(a) *Purifying the air that a person breathes*

The inhaled air is drawn through a filter that removes the atmospheric contaminant. The type of filter required depends upon the composition and physical state of the contaminant. Such devices do not provide protection in an oxygen-deficient atmosphere, or give protection against all contaminants, e.g. there are some gases and vapours that cannot be removed by any available filter.

(b) *Supplying the person with respirable air*

Providing a source of respirable air, which is independent of the working environment, conveying respirable air to the person through an air-line, air-hose, or by the person carrying an apparatus that provides the air.

5.1.2 Types of RPE

The classification of the major types of respirator described in this Section is set out in Figure 5.1.

NOTE: Figure 5.1 excludes auxiliary protection systems (see Clause 5.3.6).

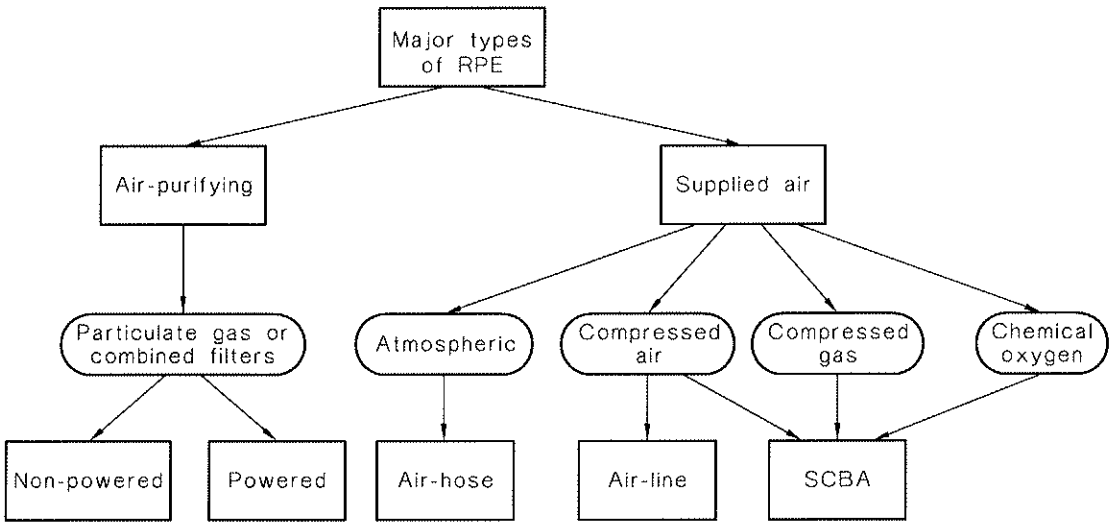


FIGURE 5.1 MAJOR TYPES OF RPE

5.2 AIR-PURIFYING RPE

5.2.1 General

There are two main types of air-purifying RPE:

(a) *Particulate*

RPE that filter out thermally and mechanically generated particulates. The particulate filter is rated according to its efficiency; P1 the lowest efficiency to P3 the highest efficiency.

(b) *Gas*

RPE that only filter out certain gases and vapours. The filters are coded with letters to indicate the gas or types of gases for which the filter provides protection, e.g. 'E' filters provide protection against acid gases. See Table 4.4. The filters also have a number to indicate the tested capacity; 'AUS' being the smallest capacity to '3' the highest capacity.

In addition, filter combinations (particulate and gas) are used where both hazard types exist.

The mode of air delivery may be either one or a combination of the following:

(i) *Non-powered*

Air is drawn through the filter or filters by wearer inhalation. The respirator may consist of a half facepiece with one or more replaceable filters, a filtering (disposable type) half facepiece, a full facepiece or head covering with one or more replaceable filters, or a mouthpiece and nose clip, with integral filter.

(ii) *Powered*

The contaminated air is drawn through a filter by means of a fan and delivered to the space enclosed by the head covering. This respirator may be a half facepiece, full facepiece or head covering with one or more replaceable filters and an electrically operated blower unit. The air delivery to a wearer may be continuous or on demand with a positive pressure. A low-flow warning device may be fitted to indicate a reduced air supply.

5.2.2 Non-powered air-purifying RPE—Routine use

5.2.2.1 *General*

The types of non-powered RPE are shown in Figure 5.2. To comply with AS/NZS 1716, the mass supported by a half-facepiece should not exceed 300 g and that supported by a full facepiece should not exceed 500 g.

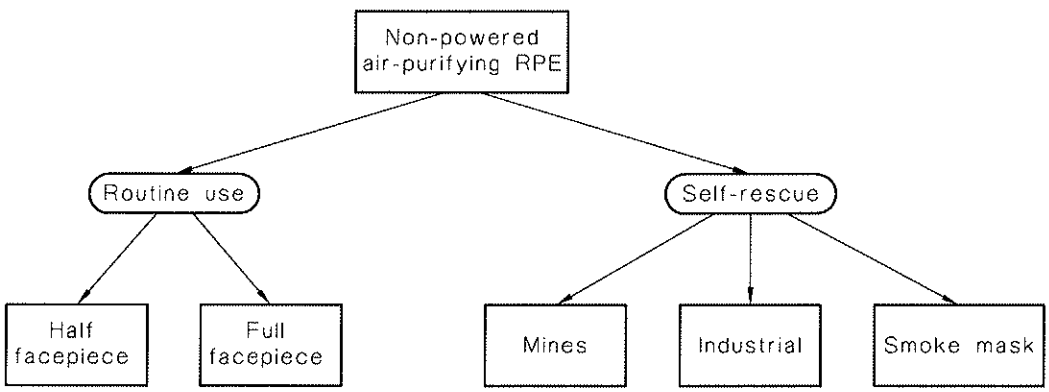


FIGURE 5.2 NON-POWERED RPE

5.2.2.2 *Half facepiece RPE*

(a) *Description*

The facepiece encloses the lower half of the face including the breathing zone and can be fitted with one or more filters. The filters may be replaceable or the filter may be integral to the facepiece. The inhaled air is drawn through the filter(s) and through an inhalation valve if fitted. The exhaled air passes through an exhalation valve, where fitted, to the environment.

The overall performance of the device depends on the class and type of filter fitted or integral to the mask.

(b) *Limitations*

Due to the very complex shape of the face, in particular, the nose and chin area, it can be difficult to achieve a satisfactory face seal on some wearers. Performance can be markedly reduced by facial hair between the facepiece and the face. The nosepiece can affect the ability to achieve satisfactory fit for safety or prescription spectacles. The facepiece can affect the intelligibility of the wearer's speech.

(c) *Performance*

Low performance devices. Minimum protection factor (MPF) of up to 10:

(i) When fitted with gas filters, with a maximum gas/vapour concentration in air of 1000 p.p.m.

(ii) When fitted with any particulate filters.

(iii) When fitted with any combination gas and particulate filters.

5.2.2.3 *Full facepiece RPE*

(a) *Description*

These RPE cover the eyes, nose and mouth. All facepieces for use in non-powered devices are fitted with inner orinasal cups which cover the mouth and nose. The inner cup reduces steaming-up of the visor and re-inhalation of the air exhaled by the wearer. Some facepieces are fitted with speech diaphragms to improve the ability to transmit the wearer's speech; some also have a means to fit special spectacles within the facepiece. The visor provides protection for the eyes against dusts and gases. However, RPE should not be used in situations where impact or other protection for the eyes is required, unless the RPE itself provides the appropriate level of eye protection.

(b) *Limitations*

Performance can be markedly reduced by facial hair between the facepiece and the face and by the arms of spectacles. Close fitting facepieces may cause discomfort and/or heat build-up during hard work, or in hot environments.

(c) *Performance*

Low to moderate performance. MPFs vary from up to 10, to up to 100 depending on the type of filter fitted to the facepiece.

(i) When fitted with particulate filters only, the MPF against particulates is:

(A) Up to 10 when fitted with P1 filter(s).

(B) Up to 50 when fitted with P2 filter(s).

(C) Up to 100 when fitted with P3 filter(s).

(ii) When fitted with gas filters only, the MPF against gases is:

(A) Up to 50 when fitted with Class AUS or Class 1 gas filter only, and with a maximum gas/vapour concentration in air of 1000 p.p.m.

(B) Up to 100 when fitted with Class 2 gas filters only, and with a maximum gas/vapour concentration in the air of 5000 p.p.m.

(C) Up to 100 when fitted with Class 3 gas filters only, and with a maximum gas/vapour concentration in air of 10 000 p.p.m.

(iii) When fitted with gas and particulate filters the MPF of the device is given by the MPF assigned to the relevant filter class, e.g. with A1 gas filters (MPF up to 50) and P3 particulate filters (MPF up to 100).

5.2.2.4 *Filtering RPE with non-facepiece mounted filters*

(a) *Description*

Non-powered close fitting facepiece devices with particulate or gas and combined filters typically mounted on a body harness with the facepiece connected to the filter via a flexible breathing tube. This permits the possibility of a higher capacity, and thus heavier, filter to be used than could be mounted on the facepiece. The increased gas capacity permits longer filter lifetime for a given contaminant concentration and work rate.

(b) *Limitations*

As described for the facepiece, see Clause 5.2.2.2 for half facepiece or Clause 5.2.2.3 for full facepiece.

(c) *Performance*

Low to moderate performance devices. The MPFs are the same as mask mounted filters given in the relevant clauses above.

5.2.2.5 *Nuisance dust masks*

(a) *Description*

A lightweight mask that does not meet the requirements of AS/NZS 1716 having a filter intended only for extremely coarse particulates. These masks do not give protection against gases or vapours.

(b) *Limitations*

These masks should not be used to control occupational exposures.

(c) *Performance*

No filtering performance requirements in AS/NZS 1716 have been set for these devices. No MPF has been assigned. These devices do not meet the requirements of AS/NZS 1716 and should not be used where RPE is required.

5.2.2.6 *Nuisance odour masks*

(a) *Description*

A lightweight mask that does not meet the requirements of AS/NZS 1716, with a filter intended only for nuisance odours. These masks do not give protection against particulates, gases or vapours.

(b) *Limitations*

These masks should not be used to control occupational exposures.

(c) *Performance*

No filtering performance requirements in AS/NZS 1716 have been set for these devices. No MPF has been assigned. These devices do not meet the requirements of AS/NZS 1716 and should not be used where RPE is required.

5.2.3 Non-powered air-purifying RPE—Filter self-rescuers

5.2.3.1 *General*

This form of filter RPE is designed solely for escape purposes. It does not provide any protection against oxygen deficient atmospheres. There are three types as follows:

(a) Filter self-rescuer (mines).

(b) Filter self-rescuer (industrial).

(c) Smoke mask.

5.2.3.2 *Filter self-rescuer (mines)*

(a) *Description*

The carbon monoxide self-rescue device is RPE for emergency use by underground miners. In the event of an explosion or fire, this equipment provides protection against particulates such as dust or smoke, and low concentrations of carbon monoxide and other gases as specified by the manufacturer, and enables the wearer to withdraw to a safe atmosphere.

(b) *Limitations*

The filtering elements are particularly sensitive to damage by exposure to moisture and shall be kept sealed until use. Regular inspection and testing is required to ensure that the RPE is still sealed and has not been affected by moisture. During use the temperature of the inhaled air increases and can become uncomfortably hot.

(c) *Performance*

No MPF has been set for this RPE.

5.2.3.3 *Filter self-rescuer (industrial)*

(a) *Description*

The filter self-rescuer (industrial) is designed for use when escaping from chemical hazards that may occur in either industrial or laboratory incidents. The RPE includes a head covering such as a hood or a nose clip and mouthpiece together with an appropriate gas filter and, depending on the nature of the likely hazard, may also include a particulate filter.

(b) *Limitations*

Filter self-rescuer industrial should only be used where the foreseeable contaminant concentrations and exposure time during escape will be within the capacity of the filter to protect the user. Regular inspection is required to ensure that the RPE is still sealed.

(c) *Performance*

No MPF has been set for this RPE.

5.2.3.4 *Smoke mask*

(a) *Description*

The smoke mask is RPE intended to be used only for a short time, e.g. escape from fires. It is not intended as a substitute or replacement for SCBA apparatus or for routine use by workers. This RPE provides protection against particulates, such as dust or smoke, and low concentrations of carbon monoxide. Additional protection is provided against other gases commonly encountered in building fires. The smoke mask may be built into a simple hood made of impervious flame-retardant material.

(b) *Limitations*

Smoke masks should only be used where the foreseeable contaminant concentrations and exposure time during escape will be within the capacity of the filter to protect the user.

The filtering elements are particularly sensitive to damage by exposure to moisture and shall be kept sealed until use. Regular inspection is required to ensure that the RPE is still sealed and has not been affected by moisture. During use the temperature of the inhaled air increases and can become uncomfortably hot.

(c) *Performance*

No MPF has been set for this RPE.

5.2.4 Powered air-purifying RPE

The types of powered air-purifying RPE are shown in Figure 5.3.

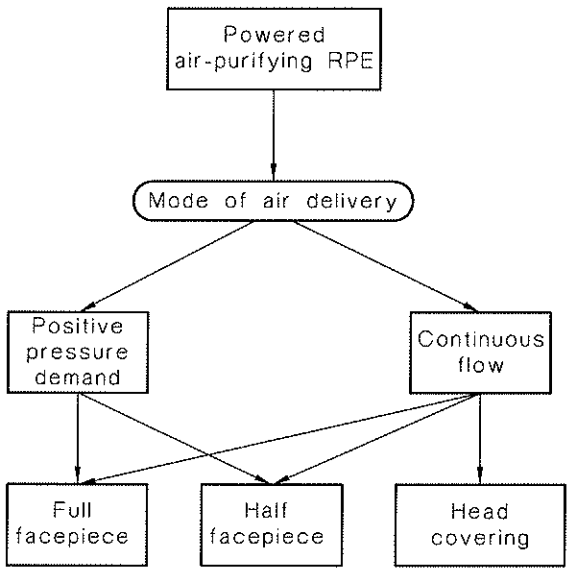


FIGURE 5.3 POWERED AIR-PURIFYING RPE

5.2.5 Powered air-purifying RPE

5.2.5.1 *General*

The types of powered air-purifying RPE are shown in Figure 5.3.

5.2.5.2 *PAPR with full facepiece or half facepiece*

(a) *Description*

These consist of a fan, filter(s) and battery pack(s) which supply filtered air to the facepiece. The fan and filters can be carried on the belt or can be mounted directly onto the facepiece. The battery, if separate from the fan and filter unit, is generally carried on the belt. Battery life is a minimum of 4 h with up to 12 h on some units. The facepiece is either a half facepiece or full facepiece.

Not all full facepieces are fitted with an orinasal cup. The visor of a full facepiece provides protection for the eyes against dusts and gases. However, RPE should not be used in situations where impact or other protection for the eyes is required, unless the RPE itself provides the appropriate level of eye protection.

All devices are supplied with a means to check that the manufacturer's minimum design condition, e.g. air supply rate, is met or exceeded prior to use.

Inhalation resistance of such devices is generally lower than for equivalent negative pressure devices.

The lower inhalation resistance is advantageous during hard physical work or for long wear durations. The flow of air over the wearer's face is advantageous during hard work, in hot environments, or when wearing protective clothing (which reduces the body's ability to lose heat).

The air delivery may either be continuous or positive pressure demand.

Continuous flow—The volume of air supplied is more than that required by the wearer. The pressure inside the facepiece or head covering is greater than that of the immediate environment. The pressure is controlled mainly by the degree of restriction to the escaping air, e.g. facial fit, outlet valve resistance, the presence of a neck bib and shoulder cape or integral jacket or suit.

Positive pressure demand—The pressure within the facepiece remains greater than the immediate environment during use. The demand valve opens to supply air to the wearer when the positive pressure inside the facepiece decreases to a preset minimum. This type of system is used with a close fitting facepiece.

In case of a fan unit failure, the wearer is able to inhale through the filters and so receive emergency respiratory protection, although at a greater inhalation resistance considerably reduced protection levels than the power-on-mode.

(b) *Limitations*

Close fitting facepieces can cause discomfort during hard work or in hot environments. These devices tend to be bulkier and heavier than the equivalent facepiece used in the negative pressure mode due to the presence of either a facepiece-mounted fan unit or a breathing tube connecting the facepiece to the fan unit.

(c) *Performance*

Low to moderate performance devices available with three levels of protection. Used for gas, particulate or combined protection. The MPFs are:

(i) Up to 10 for PAPR-P1 devices.

(ii) Up to 50 for PAPR-P2 devices with full facepiece.

(iii) 100+ for PAPR-P3 devices with full facepiece.

(iv) Up to 10 for PAPR-AUS, PAPR-1, PAPR-2 gas filters with a half facepiece with maximum gas/vapour concentration of 1000 p.p.m. in air.

(v) Up to 100 for PAPR-AUS or PAPR-1 gas filters with a full facepiece with a maximum gas/vapour concentration of 1000 p.p.m. in air.

(vi) Up to 100 for PAPR-2 gas filters with a full facepiece with a maximum gas/vapour concentration of 5000 p.p.m. in air.

(vii) Up to 100 for PAPR-3 gas filters with a full facepiece with a maximum gas/vapour concentration of 10000 p.p.m. in air.

5.2.5.3 *PAPR with head covering*

(a) *Description*

Consists of a fan and filter and battery pack that supplies filtered air to the head covering. The head covering can be a faceshield, a hood, helmet or a head covering and blouse, and generally the design is such that air is exhaled at the edges of any face or head sealing or through exhalation valves. The fan and filter can be carried on the belt or built into the headpiece in the case of some visors or hoods. The battery, if separated from the fan and filter unit is generally carried on the belt. Battery life is a minimum of 4 h with up to 12 h on some units. This information is given in the instructions for use. Helmet devices, unless marked in accordance with AS/NZS 1801, do not offer head protection.

The flow of air over the face can be advantageous during hard work or in hot environments.

(b) *Limitations*

The protection afforded by some semi-hood devices can be seriously reduced by wind velocities over the body that exceed about 2 m/s. These devices should not be used unless the manufacturer can guarantee their performance under the foreseeable wind conditions.

In the case of battery or fan failure there is a risk of a build-up in the breathing zone of the carbon dioxide exhaled by the wearer. This can result in an asphyxiation risk. Devices fitted with a supplementary form of protection, such as an EBD, can reduce these effects, but should only be used to allow immediate escape, and not to continue to stay in the area. Carbon dioxide build-up in the breathing zone can reach dangerous levels in a minute or so; thus all devices not fitted with an EBD have to be removed immediately. This limits the use of such devices to concentrations of contaminant that are not immediately dangerous to life or health.

(c) *Performance*

Low to moderate performance devices available with three levels of protection. Used for gas, particulate or combined protection.

The MPFs are:

(i) Up to 10 for PAPR-P1 devices with any head covering.

(ii) Up to 50 for PAPR-P2 devices with any head covering.

(iii) 100+ for PAPR-P3 devices with head covering and blouse; and

(iv) Up to 10 for PAPR-1, and PAPR-2 gas filters with any head covering with a maximum gas/vapour concentration of 1000 p.p.m. in air.

5.3 SUPPLIED-AIR RPE

5.3.1 General

5.3.1.1 *Sources of breathable gas*

Supplied-air respirators deliver breathable gas, i.e. air or oxygen to the wearer from an independent source—see Figure 5.1.

Sources of breathable gas (air or oxygen) include the following:

(a) *Atmospheric*

The RPE is arranged so that it connects the user to the normal atmosphere in an area known to be free from contaminants.

(b) *Compressed gas*

The RPE uses compressed air or oxygen to provide breathable air to the user. The compressed gas may be stored in cylinders or compressed as required by a compressor. The cylinders may be either carried by the user or maintained outside the contaminated area.

(c) *Chemical generators*

Specialised RPE generates oxygen using a chemical reaction. This reaction also absorbs water vapour and carbon dioxide.

Where routine work is to be undertaken in an IDLH atmosphere, using supplied-air RPE, an Emergency Breathing Device (EBD) should be carried for movement within the work area or to facilitate escape if the primary RPE or air supply fails, see Clause 5.3.6.

5.3.1.2 *Categories of supplied-air RPE*

There are three major categories of supplied-air respirator:

(a) *Air-hose RPE*

The air supplied in this type of RPE is not pressurized, i.e. it is at or near atmospheric pressure. A wide bore air-hose is used.

(b) *Air-line RPE*

The air supplied to this type of RPE is pressurized, i.e. it is greater than atmospheric pressure. Air-line RPE could utilize a compressor or compressed gas cylinders. The air should be of the quality defined in Appendix A. An air-line respirator may be used in conjunction with an SCBA to guard against air-line failure.

(c) *Self-contained breathing apparatus (SCBA)*

The breathable gas supplied to this type of RPE is pressurized, i.e. it is greater than atmospheric pressure. This apparatus uses cylinders strapped to the user's body.

5.3.1.3 *Mode of air delivery*

The mode of air delivery may be one or a combination of the following:

(a) *Natural breathing*

The pressure inside the facepiece is near atmospheric. The normal breathing action of the wearer draws the air into the close fitting facepiece. These respirators are normally termed hose masks. They may also incorporate a manually-operated blower.

(b) *Continuous flow*

The volume of air supplied is more than that required by the wearer. The pressure inside the facepiece or head covering is greater than that of the immediate environment. The pressure is controlled mainly by the degree of restriction to the escaping air, e.g. facial fit, outlet valve resistance, the presence of a neck bib and shoulder cape or integral jacket or suit. The source of air may be either—

(i) through a compressed air-line or cylinder and reduced to near atmospheric pressure by the use of a regulator or control valve; or

(ii) through an air-hose connected to a low pressure electrically-operated blower.

NOTE: Some self-contained breathing apparatus units of the escape type incorporate continuous flow.

(c) *Positive pressure demand*—The pressure within the facepiece remains greater than the immediate environment during use. The demand valve opens to supply air to the wearer when the positive pressure inside the facepiece decreases to a preset minimum. This type of system is used with a close fitting facepiece. Both types of demand system may receive air either from a compressed air-line or from a self-contained source. An air-hose respirator cannot be fitted with a demand valve.

(d) *Negative pressure demand*—The pressure inside the facepiece is less than that of the immediate environment during inhalation, causing the demand valve to open, supplying air to the wearer. The demand valve shuts off completely during exhalation. This type of system is used with a close fitting facepiece.

NOTE: Negative pressure demand devices are no longer covered by AS/NZS 1716 and so no longer comply with it and should not be used.

5.3.2 Air-hose RPE

5.3.2.1 *General*

Air-hose RPE consists of a facepiece connected by a large diameter air-hose to a source of breathable air. The hose inlet is fitted with a strainer remove coarse particulates and needs to be securely anchored in an area of breathable air. The air for respiration may be drawn into the facepiece by the breathing action of the wearer, or may be forced through the hose by a manually-operated or a low pressure electrically-operated blower. See Figure 5.4.

Care should be taken with components, particularly trailing supply hoses, as hazardous chemicals may penetrate through the hose and contaminate the breathing air.

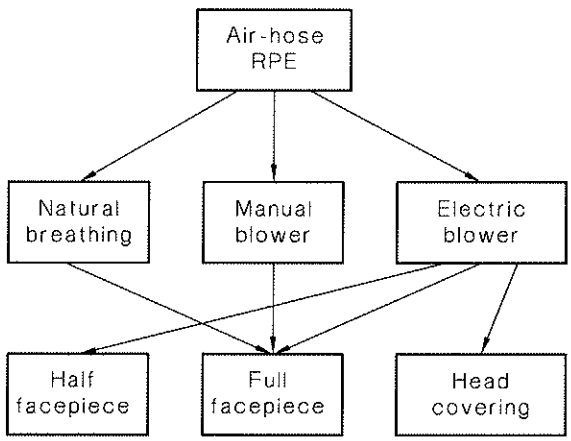


FIGURE 5.4 SUPPLIED AIR RPE—AIR-HOSE RPE

Air-hose RPE is available with either close fitting facepieces or with a headcovering. Air-hose RPE, without an electrically-operated blower may only be used with a full facepiece.

In case of failure of the manual or electrically-operated blower, the wearer of close fitting facepieces can inhale through the hose, although the inhalation resistance is higher than when the blower is operating.

Manually assisted or devices with an electrically-operated blower may be fitted with a breathing bag to compensate for variation in the air flow supply and to provide for peak inhalation requirements.

5.3.2.2 *Air-hose RPE for use with full facepiece or half facepiece*

(a) *Description*

Air-hose RPE may have either a half facepiece or full facepiece assembly connected by a wide bore air-hose to a source of breathable air. The hose inlet is fitted with a strainer to remove coarse particulates and needs to be securely anchored in an area of breathable air.

(b) *Limitations*

The limited length of the air-hose and its bulk can restrict wearer mobility. Air-hose equipment, without an electrically-operated blower may only be used with a full facepiece. The air intake needs to be located in an uncontaminated area and observed during use to ensure the air quality is not compromised.

Where the device does not have an EBD, the user should assess the overall suitability of the RPE for the task.

(c) *Performance*

Low to moderate performance devices with MPFs—

(i) up to 50 for half facepiece with an electrically-operated blower;

(ii) up to 100 for a natural breathing type (hose mask); and

(iii) 100+ for full facepiece air-hose with an electrically-operated blower.

5.3.2.3 *Air-hose RPE incorporating a hood*

(a) *Description*

Air-hose RPE with a hood connected by a wide bore air-house to a source of breathable air and powered by electrically-operated blower. The hose inlet is fitted with a strainer to remove coarse particulates and needs to be securely anchored in an area of breathable air.

(b) *Limitations*

In case of failure of the blower no guaranteed protection is afforded by these devices and there is also a rapid build-up in the breathing zone of the carbon dioxide exhaled by the wearer.

Where the RPE does not have an EBD, the user should assess its overall suitability for the task.

In case of failure of devices not fitted with an EBD, it is essential that the hood is removed within one minute of air flow failure. This limits the use of such devices to situations where removal of the device in the contaminated atmosphere does not constitute an unacceptable risk. Devices not fitted with an EBD which supplies breathable gas should not be used in oxygen deficient atmospheres or in IDLH atmospheres and observed during use to ensure the air quality is not compromised.

(c) *Performance*

Moderate performance devices with MPF of 100+.

5.3.3 Compressed air-line RPE

5.3.3.1 *General*

Compressed air-line RPE consists of a facepiece or headcovering and air-line connected to a source of compressed air. The source of the compressed air may be a compressor, centrally located compressed air cylinders or compressed air cylinders carried on a mobile trolley. If the air is supplied from compressed air cylinders, the source has to be fitted with an alarm device which warns the wearer or an attendant when the cylinder pressure falls below a predetermined level.

Air-lines used should have a rated test pressure of not less than twice the maximum working pressure of the air supply requirements of the RPE.

All connectors and safety couplings on air-line respirators systems should be designed so that it is not possible to connect a low pressure (near atmospheric) breathing tube directly to a higher pressure part of the circuit without passing through a regulator.

The supply of air to the facepiece can be continuous or governed by a negative or positive pressure demand valve. Headcoverings are supplied by continuous means. See Figure 5.5.

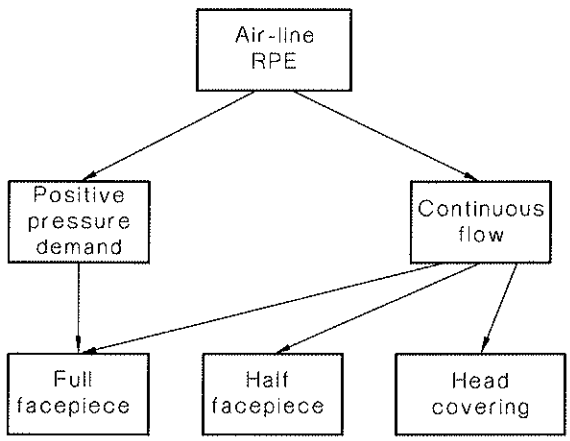


FIGURE 5.5 SUPPLIED AIR RPE—AIR-LINE RPE

In case of failure of either the compressor or main compressed air storage unit, or in case of operation of the low pressure alarm, sufficient compressed air should be available in storage to enable every wearer to stop work in a safe manner travel to a place of safety, undergo decontamination as necessary and remove the equipment.

An alarm device should be provided to warn that the primary air supply has failed when the amount of air in reserve falls to a predetermined level.

The flow of compressed air can be advantageous during hard work or in hot environments. A 'vortex' device may be carried on the belt and used in conjunction with an excess air supply to achieve either cooling or heating of the body as required.

Where a compressor is used, the air intake needs to be located in an uncontaminated area and where necessary, monitored during use to ensure the air quality is not compromised.

5.3.3.2 *Compressed air-line RPE with facepiece*

(a) *Description*

RPE with a full or half facepiece to which compressed air is supplied. The exhaled air passes through an exhalation valve to the ambient atmosphere.

Apparatus can be continuous flow or negative or positive pressure demand equipment. Negative pressure demand RPE no longer meets the requirements of AS/NZS 1716.

(b) *Limitations*

In case of failure of the compressed air supply, the facepiece should be removed immediately unless the device is fitted with a suitable EBD. Where the device does not have an EBD, the user should assess the overall suitability for the task. This limits the use of such devices to situations where removal of the device in the contaminated atmosphere does not constitute an unacceptable risk.

(c) *Performance*

Low to potentially high performance devices. The MPFs are:

(i) Up to 10 for half facepiece with negative pressure demand.

(ii) Up to 50 for half facepiece with continuous flow.

(iii) Up to 100 for full facepiece with negative pressure demand.

(iv) 100+ for full facepiece with positive pressure demand or continuous flow.

5.3.3.3 *Compressed air-line RPE incorporating a head covering*

(a) *Description*

Continuous flow compressed air-line RPE with a loose fitting head covering.

(b) *Limitations*

In case of failure of the compressed air supply the head covering should be removed immediately unless fitted with an EBD. This limits the use of such devices to situations where removal of the device in the contaminated atmosphere does not constitute an unacceptable risk. Devices not fitted with an EBD which supplies breathable gas should not be used in oxygen deficient atmospheres or in IDLH atmospheres.

(c) *Performance*

Moderate performance devices with MPF of 100+.

5.3.3.4 *Compressed air-line or powered fresh air-hose RPE incorporating a head covering used in abrasive blasting operations*

(a) *Description*

RPE that incorporates a hood or semi-blouse that provides protection for the wearer's head, shoulders and the upper part of the chest against rebounding abrasive materials.

The hood can be supplied with breathable air by either a power operated blower through a fresh air-hose or from a compressed air-line. The compressed air can be supplied by a compressor or a compressed air reservoir. If the air is supplied from a compressed air reservoir, the source should be fitted with a warning device which warns the wearer or the attendant when the pressure falls below a predetermined level.

(b) *Limitations*

In case of failure of the fresh air or compressed air supply the abrasive blasting operation should be stopped immediately and the head covering removed within a minute unless fitted with an EBD.

(c) *Performance*

Moderate performance devices with MPFs of 100+.

5.3.4 Self-contained breathing apparatus (SCBA)

5.3.4.1 *General*

SCBA is available in two styles:

(a) Open circuit.

(b) Closed circuit. See Figure 5.6.

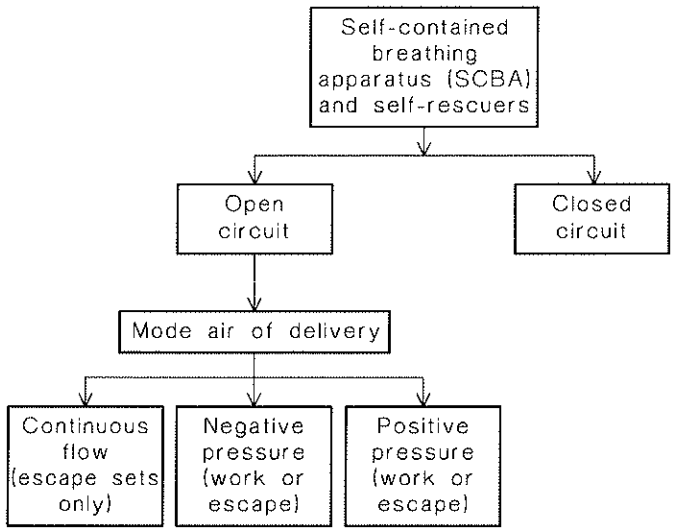


FIGURE 5.6 SELF CONTAINED BREATHING APPARATUS

5.3.4.2 *SCBA—open-circuit*

(a) *Description*

Breathing apparatus in which the wearer is supplied with breathable air on demand via a lung governed demand valve and/or pressure reducer connected to compressed air cylinder(s) carried by the wearer. The apparatus can be either negative or positive pressure demand. Negative pressure demand respirators are no longer covered by AS/NZS 1716 and do not comply with it.

Only full facepieces or headcoverings are used with open-circuit SCBA. As SCBA with headcoverings are continuous flow, they allow a significant leakage of air, and are generally suitable only for escape use.

The period of protection of such apparatus is limited by the breathing air supply and the wearer's work rate. SCBA is classified by duration:

(i) Sets with 15 min or less duration are classified as escape sets and are not suitable for routine work.

(ii) Sets with duration of more than 15 min are classified as work sets. A warning device draws the attention of the wearer to the remaining supply of breathable gas if it falls below a predetermined level during use.

Work sets may have a fitting to connect to an air-line thereby conserving the air in the cylinders and thus extending the duration of use.

The maximum permissible weight of the fully charged equipment and facepiece is limited to 18 kg.

(b) *Limitations*

Duration is limited by the weight of the equipment acceptable to the user and by the wearer's workload. The equipment can cause difficulty if the wearer is required to bend, stoop or repeatedly raise and lower the torso. The bulk of the equipment can cause difficulty in confined spaces. SCBA should only be worn by medically screened, well-trained and well-supervised wearers.

The equipment is complex and should be cleaned, serviced, maintained and inspected only by competent persons.

(c) *Performance*

Moderate to high performance apparatus. MPFs are 100+ for positive pressure full facepiece.

5.3.4.3 *SCBA—closed-circuit*

(a) *Description*

Devices in which the wearer exhales through a scrubber that removes carbon dioxide and water vapour into a breathing bag. Oxygen from a compressed gas cylinder, a liquid gas container or a chemical source is added to the recirculated, cleaned, exhaled air to replace the oxygen absorbed by the wearer. The inhaled gas can be very hot due to the chemical reaction which absorbs the carbon dioxide and water and/or the reaction which generates oxygen. RPE with a liquid oxygen container are no longer covered by AS/NZS 1716 and do not comply with it.

Only full facepiece or mouthpiece assemblies may be used with closed-circuit SCBA. Durations up to 4 h can be achieved by some devices, including equipment designated as being for escape.

This is unusual equipment which is only used for special purposes.

(b) *Limitations*

Duration is limited by the weight of the equipment acceptable to the user and by the potential for heat storage in the wearer's body. The bulk of the equipment can cause difficulty in confined spaces. The equipment should be worn only by medically screened, well-trained and well supervised wearers.

The equipment is complex and should be cleaned, serviced, maintained and inspected only by competent personnel.

The presence of oxygen-enriched air inside the facepiece can cause additional risk in situations where highly flammable substances may be present.

(c) *Performance*

Moderate to high performance apparatus. MPFs have not been assigned for this RPE.

5.3.5 Self-contained self rescuers (SCSR)

5.3.5.1 *General*

The SCSR provides oxygen to the wearer and removes carbon dioxide in a closed circuit so its operation is completely independent of the surrounding atmosphere. Once properly donned, the SCSR can assist the wearer to escape from an area containing smoke, toxic gases or an oxygen deficient atmosphere.

5.3.5.2 *Self-contained closed circuit chemical oxygen devices*

(a) *Description*

The oxygen required for breathing is obtained from a chemical source, usually superoxide, which reacts with carbon dioxide and water vapour contained in expired air. These two components of the expired air, react with the superoxide, whereby chemically bound oxygen is released.

Some devices are provided with a chlorate candle starter which is manually fired to generate sufficient oxygen to support the wearer until the normal chemical reaction can generate sufficient oxygen. Other devices are fitted with a small compressed oxygen cylinder which is also manually fired to produce an initial source of oxygen.

(b) *Limitations*

Some devices can be slow to start to generate oxygen. The inhaled gas can be uncomfortably hot to breathe. Breathing resistance has the potential to become high enough to cause discomfort to the wearer.

The oxygen generators of such devices are hermetically sealed to prevent degradation and cannot be reused if the full capacity has not been used.

These devices are used for escape purposes.

The unit needs to be periodically tested to check the performance of the oxygen-generating chemicals.

(c) *Performance*

Moderate to high performance apparatus. An MPF has not been assigned for this RPE.

5.3.6 Auxiliary protection systems

5.3.6.1 *General*

Auxiliary protection systems may be an emergency breathing device (EBD) or a device that may provide additional functionality or warnings to users, e.g. a low flow warning device.

Warning devices and increased functionality shall not be used in place of an EBD in IDLH environments.

5.3.6.2 *Emergency Breathing Device (EBD)*

Where routine work is to be undertaken in an atmosphere which may reach IDLHs levels, an EBD should be carried for movement within the work area or to facilitate escape. This system should provide a short-term back-up to the main, air-hose or air-line respirator. There are two types of auxiliary EBD:

(a) *SCBA type*

In this auxiliary protection system, the SCBA which may be of the escape type is attached to the wearer's air-line system. It is designed to provide adequate protection for a short period, thereby allowing the wearer to retreat from the contaminated atmosphere should the air-line system fail.

(b) *Filter type*

This may be either a particulate and gas filter or a gas filter attached to a supplied-air system as an escape device. It is designed to provide, for short periods, adequate protection from the contaminants for which it is specifically designed.

CAUTION: THIS FILTER TYPE EBD IS NOT SUITABLE FOR USE IN OXYGEN-DEFICIENT ATMOSPHERES.

5.3.6.3 *Additional functionality or warning devices*

(a) *Active warning devices*

This is a device that provides the wearer with a warning when the cylinder pressure drops to a predetermined level. Active warning devices are required on work set SCBAs.

(b) *Low flow warning devices*

Some types of RPE such as PAPRs and air-line respirators, are equipped with a means of detecting low flow rates and providing an alarm, or are supplied with test equipment to verify an adequate flow rate before use.

(c) *Auxiliary air-line connection*

This provides means for the apparatus to be supplied from an auxiliary source of compressed air and may require the use of ancillary devices such as a waist belt aid a junction block.

5.4 OTHER DEVICES

Some devices are sold for the use of anyone to escape from smoke from fires of a non-industrial nature such as in hotels. Where such equipment does not meet the requirements of AS/NZS 1716, it may be dangerous to use, as carbon dioxide build-up within the breathing zone can rapidly occur in poorly designed masks or inadequate filtration may give the wearer a false sense of security encouraging inappropriate risk-taking. The use of such devices should be discouraged.

SECTION 6 MEDICAL AND PHYSICAL CONSIDERATIONS

6.1 MEDICAL ASSESSMENT

Any type of respirator may impose some physiological and psychological stress on the user. Persons who are routinely required to wear respirators should have an initial medical assessment prior to use to determine if they are able to wear respirators.

Further medical assessment may be required when there is a change in circumstances that may affect the worker's ability to wear the RPE.

As part of the medical assessment, the following considerations should be evaluated:

(a) *Physiological considerations*

Regular wearing of non-powered air-purifying RPE and negative pressure demand air-supplied RPE imposes an extra burden on cardiac and respiratory systems. Thus, a person with a history of disorders in these areas should be medically assessed by a medical practitioner or an occupational health physician, especially where heavy work or prolonged wearing of RPE is anticipated.

When assessing RPE users, consideration should also be given to the individual employee's ability over prolonged periods to support the weight of certain RPE (e.g. SCBA) or to handle up to 30 m of line, if equipped with air-line RPE.

(b) *Psychological considerations*

Helmet, hood and full facepiece RPE, especially when combined with full body protection, may give rise to feelings of claustrophobia, isolation and anxiety in some people. Such people will find it difficult to perform their work satisfactorily under these conditions. Training programs are available to assist users in overcoming such feelings of anxiety.

6.2 SPECIFIC FACTORS AFFECTING PERFORMANCE

Some factors which may preclude the use of RPE in situations other than escape are as follows:

(a) Chronic lung conditions such as—

(i) emphysema—the individual may be unable to breathe adequately against the additional resistance of RPE; and

(ii) asthma—a user suffering an asthma attack would be likely to remove the RPE because of an inability to breathe properly.

(b) Circulatory diseases such as—

(i) heart disease; and

(ii) anaemia.

(c) Epileptic seizures.

(d) Facial hair (see Clauses 4.4.3, 8.3 and Appendix B).

(e) Psychological factors such as claustrophobia.

(f) Facial characteristics such as scars, hollow temples, very prominent cheekbones, deep skin creases, a misshapen nose, lack of a nose bridge and lack of teeth or dentures may cause RPE facepiece sealing problems. Lack of dentures or missing teeth may cause problems in sealing a mouthpiece in a person's mouth. Full dentures should be retained when wearing a RPE, but partial dentures may or may not have to be removed, depending upon the possibility of swallowing them.

SECTION 7 TRAINING

7.1 GENERAL

Training shall be provided by a competent person such as a consultant, someone in-house or a representative from a RPE manufacturer or supplier.

This Section is set out in the format of a guide to allow the instructor to adapt the training program to the individual requirements of the facility. This may be accomplished in the following way:

(a) Where indicated, record the appropriate information for your facility, e.g. the locations of operations where RPE are required, or where exposures to airborne contaminants necessitate the use of RPE.

(b) Refer to specific information in this Standard, for example, a discussion of the various types of RPE available (Section 5). Employees need not be aware of all types, but only those that they will be required to wear. Therefore, when the guide indicates that the information is to be inserted at that point in the presentation, only the relevant parts of this Standard need be utilized.

At the end of training, the user shall demonstrate competency in the use of the RPE.

7.2 FORMAT

When planning the training session, remember that trainees usually retain only about 20% of what they hear, about 40% of what they see, and about 70% of what they both see and hear. For the best results, a program of lectures, supplemented by audiovisual materials and demonstrations, is recommended. The following suggestions are made to help increase the effectiveness of the program:

(a) Cover the material suggested in this section.

(b) Break the lecture into 30–45 min intervals to allow the trainees to stand up and move around.

(c) Use visual aids such as whiteboard to emphasize subject sequence and major points.

(d) Obtain presentations from your trade association, or the manufacturer/supplier of the equipment you use and intersperse them with your own material, as appropriate.

(e) Illustrate specific areas with personal experiences or examples related to your operations.

(f) Have examples of the RPE used in your facility available during the training session and highlight areas concerned with their operation and use.

(g) Supplement the material in this Standard with company operating procedures or instructional material supplied by the equipment manufacturer/supplier.

7.3 INSTRUCTIONS TO TRAINEES

An integral part of the training program is the free exchange of information—and questions—between instructor and trainees. Therefore, the following comments (made by the instructor) are suggested at the beginning of the training session:

(a) During this session your full participation is needed.

(b) If you do not understand what is being discussed, ask questions.

(c) If you have been involved in or are aware of accidents pertaining to specific areas covered, share them with us.

(d) If you are aware of better approaches to reduce hazardous conditions, give us the benefit of your experience.

(e) If there is additional information or guidance we can provide, identify the areas for us.

7.4 EMPLOYEE TRAINING PROGRAM GUIDE

NOTES TO INSTRUCTOR

Discuss only those contaminant atmospheres representing problems in your facility. See following discussion

SUGGESTED PROGRAM FORMAT

(a) *Identification of the hazard*

There are several kinds of hazardous atmosphere that may require the use of a respirator.

(i) *Gaseous contaminants*

Include gases and vapours. Gases are the normal form of substances like carbon dioxide or hydrogen sulfide. These substances are solids or liquids only at very low temperatures or extremely high pressures. Carbon dioxide, for instance, is a gas at room temperature. But it also occurs as solid 'dry ice' formed at low temperatures. Vapours are formed when liquid evaporates at room temperature, e.g. petrol, water.

(ii) *Particulate contaminants*

Particulates are tiny particles, solid or liquid, generated by such processes as grinding, crushing, and mixing of a compound, either a solid or a liquid. There are three types of particulate.

Dusts are solid particles produced by such processes as grinding, crushing, and mixing of powder compounds. Examples are sand and plaster dust. By comparison with the following two types of particulates, dust particles are usually large.

Mists are tiny liquid droplets, usually formed whenever a liquid is sprayed, vigorously mixed, or otherwise agitated. Acid mists around diptanks used for metal cleaning, and oil mists near newspaper printing presses are two examples.

Fumes are solid condensation particles of extremely small size. Fumes are found in the air near soldering, welding, and brazing operations, as well as near molten metal processes such as casting and galvanizing.

The two types of contaminants—gases and particulates—frequently occur together. Paint spraying operations, for example, produce both paint mist (particulates) and solvent vapours.

A further discussion of ODAs can be found in AS/NZS 2865 as well as Clause 3.7

Oxygen-deficient atmospheres (ODAs) are most commonly found in confined spaces which have poor ventilation. Examples are silos, petrochemical tanks, degreasers, and the holds of ships.

(b) *Reasons for RPE*

(i) *State regulatory authorities*

These have set maximum exposure standards for many airborne toxic materials and have set standards governing specific working environments to protect your health. A recent evaluation of your working environment revealed that:

(1) Name work area

(2) List substances

(A) In work areas (1), atmospheric concentrations of substances (2) were found to be above acceptable limits.

(3) Describe activities

(4) Describe exposure

(B) During maintenance activities (3) you are exposed to (4) a high concentration for a short period of time. This will lead to excessive exposure.

(5) Describe

(C) Several areas (5) were found to be 'oxygen deficient'.

(6) Name storage areas

(7) Describe emergency situation which could exist in your plant

(D) Hazardous substances are stored at (6) and if these substances spill or leak, an emergency condition may exist, for example (7).

Suggested phraseology

(ii) *Status of engineering controls*

Describe any steps that the company may be taking in implementing other controls (e.g. engineering and timelines).

(8) Describe what controls are being implemented

(9) Discuss administrative schedules, e.g. rotating work controls, spreading work over two shifts, job rotation

(A) Describe any proposed engineering controls and timelines.

(B) And the following administrative controls (9).

However, while the above steps are being implemented, respiratory protection will be required.

(c) *RPE selection*

Selection of the proper equipment normally involves three steps; the identification of the hazard; the evaluation of the hazard; and finally the selection of the appropriate respiratory equipment based on the first two steps:

After explaining to the employee the type of hazardous atmosphere requiring respiratory protection, you should then discuss the specific hazards. Check vendor literature, toxicologic references, or material safety data sheet.

Refer to Section 4

(i) *Hazard identification*

This includes—

(A) hazard name—

—organic vapour (name);

—particulate (name); or

—gas (name).

(B) toxicity data and effects.

(ii) *Assessment of the risk*

To determine the concentration of the contaminant, as identified above, measurements were made. The concentrations in the work environment examined were compared with the relevant NOHSC standards and code of practice.

(iii) *Selection of the RPE*

After it was determined that respirators were required, this Standard (AS/NZS 1715) was consulted to find out the appropriate respirator.

(d) *Use and proper fitting of RPE*

A poor facial seal can cause contaminants to be inhaled through the respiratory sealing surfaces, instead of through the filters, or air supply system.

Using Section 8 and information supplied by the manufacturer, show the employee how to put on the selected respirator. Show the various component parts of the respirator, and how the respirator functions to remove the contaminants.

(i) *Use of respiratory protective equipment*

So that respirators using tight-fitting facepieces give maximum protection, it is most important to ensure a proper 'match' between the facepiece and your face.

At this time, you should have available at least two different types (from different manufacturers) of RPE for the employee to try on.

(ii) *Proper fitting*

In most cases, there are several different brands of the same type of RPE appropriate for use against a specific hazard.

Refer to Section 8 for discussion of fitting tests.

However, just because a respirator 'feels comfortable' it does not mean it is protecting you to the fullest extent from the hazard. The key word is proper fit. To determine if the fit is proper, several tests can be used. Each facepiece may be available in different sizes.

(e) *Wear time*

The importance of wearing the RPE at all times the user is in the contaminated area shall be emphasized.

Refer to Section 4 for factors in selection which includes use limitations.

(f) *Limitations of RPE*

The RPE you will use does have some limitations affecting it use.

(g) *Maintenance and storage of RPE*

To ensure the continued proper functioning of RPE, they shall be regularly cleaned and disinfected, and stored in a convenient and clean location.

Refer to Clause 9.2 for details concerning the cleaning of equipment. Several suggested cleaning methods are given. Discuss provisions.

(i) *Cleaning*

Your RPE shall be cleaned after use. The company has made provisions for doing this.

Refer to Clause 9.6 and discuss storage provisions by company.

(ii) *Storage*

Equipment should be stored properly at the conclusion of the work shift.

Refer to Clause 9.4 for discussion about inspecting equipment for defects.

(iii) *Inspection for defects*

This is one of the most important functions associated with respirator usage.

These inspections can identify problems with malfunctioning respirators.

Refer to Clause 2.9.

(iv) Record keeping.

Before you discuss this Section with the user, you should first prepare the summary—as it applies to your usage.

(h) *Summary*

A summary of the respiratory protection program in your workplace.

SECTION 8 TYPICAL RPE FIT TESTS AND CHECKS

8.1 GENERAL

The proper fitting of respiratory protective equipment requires the use of some type of fit test to determine an adequate match between the facepiece of the RPE and face of the wearer.

8.2 FREQUENCY OF FIT TESTS

Fit tests should be performed at appropriate intervals, particularly when there is a change in the wearer's facial characteristics, e.g. loss of teeth or excessive changes in weight, or where biological tests, e.g. lead in blood, indicate excessive exposure to a contaminant.

Facial fit tests should be adopted as a routine when any close fitting RPE is being worn.

The following scheme of facial fit testing should be incorporated into the respiratory protection program:

(a) Before the respirator is issued, a qualitative or quantitative fit test as set out in Clause 8.5 should be performed to assure the choice of a suitable respirator.

(b) A further facial fit test should be performed at least annually or whenever there is a change in the wearer's facial characteristics or other features which may affect the facial seal of the respirator.

(c) At each use, the respirator should be donned before entering the contaminated area so the user can perform a simple positive or negative pressure fit check to test the respirator fit.

8.3 FACIAL HAIR IN RPE FITTING

Facial hair lying between the sealing surface of a RPE facepiece and the wearer's skin will prevent a good seal. Beards, moustaches and sideburns prevent satisfactory sealing. Long hair may also interfere with the operation of exhalation valves. The sealing problem is especially critical when close fitting facepieces are used. The reduction in pressure developed in the breathing zone of these respirators during inhalation may lead to leakage of contaminant into the facepiece where there is a poor seal. Therefore, individuals who have stubble (even a few days' growth will cause excessive leakage of contaminant), a moustache, sideburns, or a beard which passes between the skin and the sealing surface should not wear a respirator which requires a facial seal.

Additional requirements and guidance on facial hair are given in Appendix B.

8.4 EYE CORRECTION IN RPE FITTING

Persons using half facepieces in conjunction with spectacles should be tested to ensure the effectiveness of each device is not reduced.

8.5 FIT TEST METHODS

8.5.1 Types

There are two types of test—qualitative and quantitative. The use of one or both types of test depends on the type of RPE to be fit tested, the extent of RPE usage and the available resources of trained personnel and capital. During any fitting test, the facepieces head straps should be as comfortable as possible. Tightening the straps will sometimes reduce facepiece leakage, but the wearer may be unable to tolerate using the RPE for any length of time.

8.5.2 Qualitative fit testing

Qualitative tests are fast, and are easily performed. However, these tests rely on the wearer's subjective response, and so are not entirely reliable. There are two major tests (see Clause 8.5.3.1 and 8.5.3.2). They use a test atmosphere which may be an enclosure into which—

(a) the user can enter wearing the equipment; and

(b) a 'test' contaminant (of low toxicity) can be placed.

Although elaborate enclosures are available commercially, the employer can put together a 'do-it-yourself' qualitative fit test enclosure by the use of a plastic bag (a dry-cleaning bag), several hangers, and a cotton wad (used only for the isoamyl test). Figure 8.1 shows a typical enclosure constructed using these materials.

Care should be taken to avoid carbon dioxide build up.

Clause 8.5.3 sets out procedure for two types of qualitative testing.

8.5.3 Qualitative tests

8.5.3.1 *Isoamyl acetate test*

Isoamyl acetate is a low toxicity substance with a banana-like odour. It is only suitable for testing the face fit of respirators using organic vapour filters. The substance is applied to the cotton wad inside the enclosure. The prospective user should put on the RPE in an area away from the test enclosure so that there is no prior contamination of the filters by 'pre-exposure' to the isoamyl acetate. The user enters the chamber and performs each of the following activities for 30 s:

(a) Normal breathing.

(b) Deep breathing, to simulate heavy exertion. This should not be done long enough to cause hyperventilation.

(c) Side-to-side and up-and-down head movements. These movements should be exaggerated, but should approximate those that take place on the job.

(d) Talking. This is most easily accomplished by reading a prepared text loudly enough to be understood by someone standing nearby.

(e) Other exercises may be added depending upon the situation. For example, if the wearer is going to spend a significant time bent over at some task, it may be desirable to include an exercise approximating this bending.

NOTE: The major drawback of the isoamyl acetate test is that the odour threshold varies widely among individuals. Furthermore, the sense of smell is easily dulled and may deteriorate during the test so the wearer can detect only high vapour concentrations. Another disadvantage is that isoamyl acetate smells pleasant, even in high concentrations. Therefore, a wearer may say the RPE fits although it has a large leak. This may be because the wearer likes the fit of the particular RPE or is following the RPE selection of someone else. Conversely, a wearer may claim that a particular RPE leaks if it is uncomfortable. Therefore, unless the worker is highly motivated toward wearing RPE, the results of this test may sometimes be suspect.

(f) Break facepieces seal and expose wearer to test agent to verify the wearer's sensitivity.

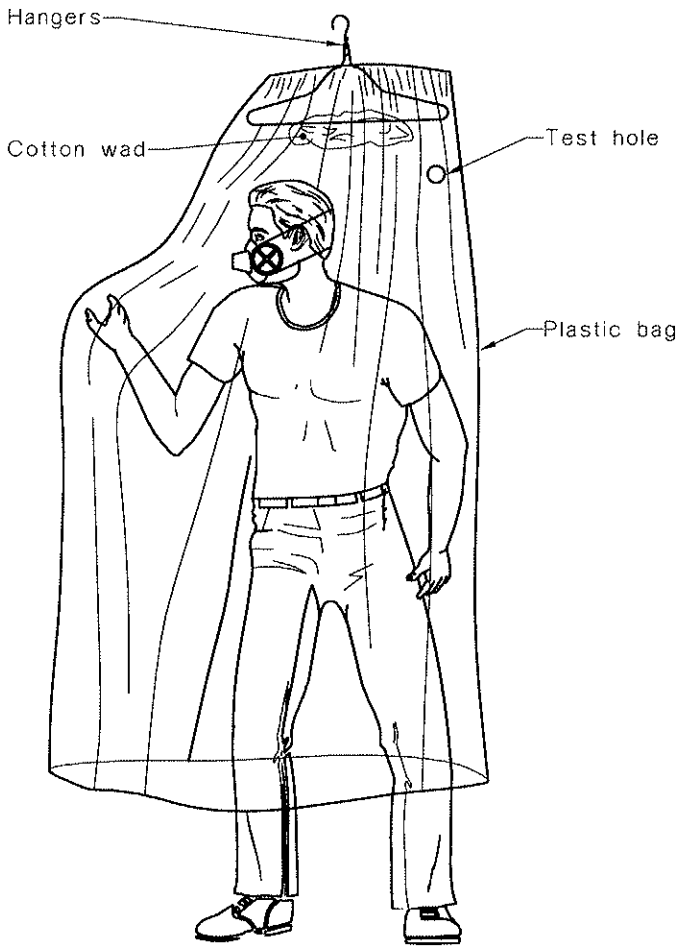


FIGURE 8.1 TYPICAL TEST ENCLOSURE

8.5.3.2 *Saccharin mist test*

This test is suitable for respirators incorporating any particulate filter. It relies upon the wearer's ability to detect a saccharin aerosol by taste. Individuals vary in their taste threshold, therefore a screening procedure is performed to establish suitability.

Prospective test subjects are screened with an aerosol produced from a 0.83% by weight solution of sodium saccharin in water. The test subject remains inside the test enclosure without the RPE and is instructed to breathe through the mouth only. The solution is then puffed, up to 30 times, using a nebulizer through a test hole in the enclosure material. The number of puffs required for the subject to taste the saccharin is recorded. If the subject is unable to taste the saccharin after 30 puffs, a different method of testing facial fit should be used.

A period of at least several minutes should elapse after the sensitivity test before re-testing the subject wearing the RPE.

The test subject, having passed the sensitivity test, is fitted with the appropriate RPE. Since the saccharin mist is an airborne particulate, gas filter RPE should be fitted with a particulate filter for the test. The subject is placed in the test enclosure and an aerosol produced from an 83% by weight solution of sodium saccharin in water is puffed through the test hole.

Initially, the number of puffs is the same as the number taken to produce a response in the screening procedure. Half the number of puffs is delivered each 30 s. The test subject should perform exercises such as those described in Clause 8.5.3.1. If the subject tastes the saccharin, it is interpreted as a leakage of aerosol via the facial seal or through the RPE component parts other than the filter or both.

This test suffers similar disadvantages to the isoamyl acetate test. Sweet food (or sweeteners, e.g. in coffee) should not be consumed 30 min prior to testing.

A similar test involving a bitter aerosol is also commercially available. This was recently evaluated, viz. TJ Nelson, LL Janssen, MD Luinenburg, HE Mullins, *Journal of International Society for Respiratory Protection.* Vol.20 pp 102–109 (2003).

8.5.4 Quantitative tests

8.5.4.1 *General*

Quantitative test methods use equipment to measure the efficiency of a respirator in preventing materials in the atmosphere from entering a user's breathing zone. The measured leakage is expressed as a percentage of the outside concentration. The numbers generated by quantitative fit tests may not reflect the protection factors likely to be achieved in the workplace. The advantage of a quantitative test is that it does not rely on a subjective response.

There are two general techniques for quantitative testing:

(a) Artificial test atmospheres.

(b) Natural atmospheric dusts.

8.5.4.2 *Artificial test atmosphere*

This type of quantitative respirator performance test involves placing the wearer in an atmosphere containing an easily detectable, relatively low toxicity gas, vapour or aerosol. The atmosphere inside the respirator is sampled through a probe. The most commonly available commercially quantitative tests are as follows:

(a) *Sodium chloride (NaCl) test*

In this test, a liquid aerosol is generated continuously from a saltwater solution (using a nebulizer), dried to produce discrete sub-micrometre salt particles, and dispersed into a test chamber or hood. A means is provided for sampling the atmosphere in the chamber or hood and inside the RPE. These samples are fed to the detector section where the aerosol's penetration inside the RPE is determined. The amount of penetration is displayed on a meter or recorder.

(b) *Oil mist test*

This test uses an air-generated oil mist. It differs from the NaCl test only in that the aerosol particle is liquid. The aerosol is generated using a nozzle atomizer, but, being an oil, the mist does not dry into solid particles when injected into a diluting airstream.

8.5.4.3 *Natural atmospheric dusts*

In this test the natural dusts in the atmosphere are used as the test aerosol and a particle counter is used to detect the dust. Although this equipment is relatively simple and easy to use, the operator needs to be familiar with equipment and its operation for a facial fit testing.

8.5.5 Fit checks

8.5.5.1 *General*

The negative pressure check and the positive pressure fit check should be used only as a very gross determination of fit. The wearer should use these fit checks just before entering the hazardous atmosphere. These tests are only suitable for respirators with tight-fitting facepieces.

Although these tests are simple, they have severe drawbacks, the main one being that the wearer may handle the RPE after it has been positioned on the face, possibly modifying the facial seal.

8.5.5.2 *Negative pressure fit checks*

The following methods are suitable for negative pressure fit checks:

(a) *Disposable respirators*

The wearer completely covers the filter with both hands or a non-permeable substance, e.g. a polythene bag, and inhales sharply. The facepieces may sink onto the face with a very vigorous breath indicating an adequate seal. If an unsatisfactory face seal is indicated by the feel of an airstream channelling through the leak, re-adjust the RPE until a satisfactory seal is indicated.

(b) *Reusable facepiece (See Figure 8.2)*

The user closes off inhalation through the filter or filters either by covering the intake or by squeezing the breathing tube so that it does not pass air, inhales gently so that the facepiece collapses slightly, and holds a breath for about 10 s. If the facepiece remains slightly collapsed and no inward leakage is detected, the RPE is probably well fitted.

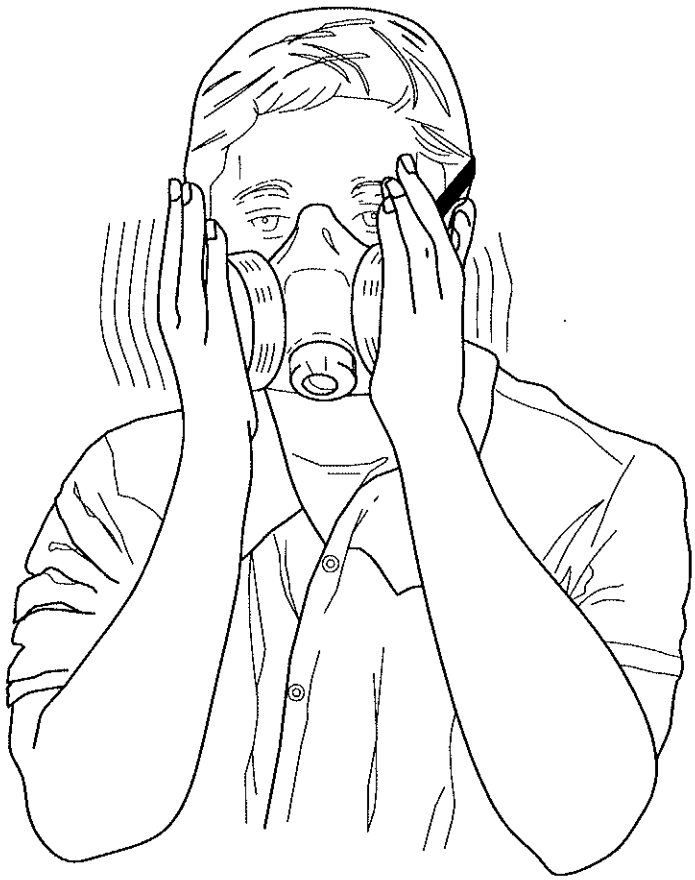


FIGURE 8.2 NEGATIVE PRESSURE TEST

8.5.5.3 *Positive pressure fit checks*

The following tests are suitable only for close fitting respirators:

(a) *Disposable respirators (without exhalation valves)*

The wearer covers the filter or filters either with both hands or a non-permeable substance, e.g. a polythene bag and exhales vigorously. If an unsatisfactory face seal is indicated by the feel of an airstream channelling through the leak, readjust the facepieces until a satisfactory seal is indicated.

(b) *Reusable facepiece*

The wearer closes off the exhalation valve and exhales gently into the facepiece. The fit is considered satisfactory if slight positive pressure can be built up inside the facepiece without any evidence of outward leakage.

For some RPE, this check may require the wearer to remove the exhalation valve cover which often disturbs the fit even more than the negative pressure test. Therefore, this test should be used sparingly if it requires removing and replacing a valve cover. The test is easy for facepieces which has a valve cover with a single small port that can be closed by the palm or a finger.

8.6 FACTORS THAT AFFECT FACIAL FIT

Other factors than personal physiognomy may affect the facial fit of RPE. Caution should be exercised in the wearing of jewellery, long hair styles and make-up.

SECTION 9 MAINTENANCE REQUIREMENTS

9.1 GENERAL

RPE needs to be maintained to ensure that it functions properly and provides its designed respiratory protection. The system of maintenance should be commensurate with the scale of use and the type of RPE used. In some circumstances, a simple and basic system of maintenance may be adequate while in other circumstances a comprehensive and formalised system may be required, particularly where critical or emergency type equipment is relied upon.

A system of maintenance should generally include the following elements as applicable:

(a) Cleaning and disinfection.

(b) Inspection.

(c) Repair and replacement of components.

(d) Proper storage.

Repair and replacement of parts of air-purifying RPE should, in most cases, be fairly simple. Equipment manufacturers supply literature which details the components of their respirators and also includes servicing information. In the case of simple items such as outlet valve rubbers and head harnesses, this should be done by the wearer or RPE maintenance personnel However, the repair and maintenance of more complex RPE, such as air-supplied RPE, SCBA or complex parts such as demand and reducing valves should be performed by trained personnel authorized by the manufacturer.

All parts should be inspected and faulty RPE components (including spent or expired filters) should be replaced with those approved by the manufacturer of the RPE.

> CAUTION: MIXING AND MATCHING COMPONENTS SUCH AS FILTERS AND FACEPIECES MAY NOT ONLY INVALIDATE ANY MANUFACTURER'S WARRANTY BUT MAY NOT PROVIDE THE RESPIRATORY PROTECTION REQUIRED.
>
> SUBSTITUTION OF COMPONENTS IS NOT ACCEPTABLE UNLESS THE COMPONENTS HAVE BEEN TESTED AS A WHOLE, COMPLY WITH AS/NZS 1716 AND THERE IS AN ONGOING QUALITY ASSURANCE PROGRAM TO ENSURE THAT RELEVANT PERFORMANCE REQUIREMENTS CONTINUE TO BE MET.

9.2 CLEANING AND DISINFECTION

Non-disposable RPE shall be cleaned after each use. The cleaning and disinfection should be according to the manufacturer's instructions or, where these are not available, refer to Appendix C. Disassembly and reassembly of RPE shall be carried out in accordance with the manufacturer's instruction. Every effort should be made to obtain such instructions.

A centralized cleaning program may be suitable where there is extensive use of RPE but may not be appropriate where there is infrequent or low use of RPE.

Persons who are required to maintain RPE should be trained in cleaning and disinfection procedures.

After removal of any filters, the cleaning shall be performed in the workplace. This may be done in a number of ways:

(a) The RPE should be washed with detergent in warm water using a soft brush, thoroughly rinsed in clean water, and then air-dried in a clean place. Care should be taken to prevent damage from rough handling. This method is an accepted procedure for a small workplace or where each worker cleans his or her own RPE.

(b) A dedicated domestic type clothes washer or dishwasher may be used if a rack is installed to hold the facepieces in a fixed position. (If the facepieces are placed loose in a washer, the agitator may damage them.) This method is especially useful in large programs where RPE usage is extensive. Alternatively, facepieces may be placed in mesh bags and then placed into the washing machine.

Caution should be observed with respect to the addition of soaps and detergents to the cleaning water. Some of these may damage the equipment or cause irritation to the wearer.

Disinfection may be achieved by using a broad-spectrum disinfectant. The choice of preparation should be made based on recommendations of the RPE manufacturer and medical authorities. Such information should also assist where protection against the transmission of a specific pathogen is required. With all disinfectants, particular attention should be paid to the manufacturer's instructions regarding their use, e.g. dilution, temperature, exposure time.

The cleaned and disinfected RPE should be rinsed thoroughly in clean water to remove all traces of cleaning agent and disinfectant. This is very important to prevent dermatitis or irritation. After rinsing, an anti-fog preparation may be applied to lenses and visors.

The RPE should be allowed to air dry away from direct sunlight, on a clean surface, or dried in a low-temperature oven. They may also be hung from a horizontal wire, like drying clothes, but care should be taken not to damage the facepieces.

Wherever practicable, exhalation valves should be removed from valve seats and cleaned each time the RPE is serviced. Valves and valve seats may be cleaned in cold or warm water; hot water (i.e. greater than 40°C) should be avoided. Valve seats may need to be scrubbed with a suitable brush.

Generally, cleaning and disinfecting solutions used should not be hotter than 40°C as higher temperatures can permanently distort facepieces and cause premature deterioration of individual components or the whole assembly.

Although it is essential that water does not enter adjustment valves, reducing valves, demand valves, pressure gauges and other controlling devices, component parts should be appropriately washed or cleaned in accordance with the manufacturer's instructions.

Clean RPE should be clearly identified as such.

9.3 INSPECTION

9.3.1 General

An important part of a RPE maintenance program is inspection of the devices. When performed properly, inspections will identify damaged or malfunctioning RPE.

9.3.2 Inspection schedules

All respiratory protective equipment shall be inspected before and after each use and during cleaning.

In addition, SCBA and equipment designated for emergency use should be inspected regularly in accordance with the manufacturer's specifications to ensure equipment is always ready for use.

9.4 REPAIR AND REPLACEMENT OF COMPONENTS

9.4.1 General

Table 9.1 itemizes some of the primary defects to look for when inspecting RPE, with suggested action where appropriate under the maintenance subheading. In many cases the manufacturer or supplier of the equipment may need to be contacted.

TABLE 9.1

CHECKLIST FOR DEFECTS

Inspection	Maintenance action
Disposable RPE (see Note 1)	
Physical damage (e.g. holes) to filter	Obtain new RPE
Straps for elasticity and deterioration	Obtain new RPE
Metal nose clip for deterioration.	Obtain new RPE
Air-purifying RPE (re-usable full/half facepiece)	
Facepiece	
Dirt	Clean all dirt from the facepiece
Cracks, tears, holes, hardening or tackiness	Obtain a new facepiece
Cracked, scratched or loose-fitting lenses	Contact manufacturer to see if a replacement is possible; otherwise obtain new facepiece
Distortion	Allow facepiece to 'sit' free from any constraints and see if distortion disappears; if not, obtain a new facepiece
Head straps	
Breaks or tears	Replace head harness
Loss of elasticity	Replace head harness
Broken or malfunctioning buckles or attachments	Obtain new parts or replace head harness
Excessively worn serrations on head harness which may cause facepiece to slip	Replace head harness
Inhalation & exhalation valves (see Note 2)	
Detergent residue, dust particles, or dirt on valve or valve seat	Clean residue with soap and water and rinse thoroughly
Cracks, tears, or distortion in the valve material or valve seat	Contact manufacturer for instructions
Missing or defective valve cover	Obtain new valve cover

(*continued*)

TABLE 9.1 *(continued)*

Inspection	Maintenance action
Filter element(s)	
Increased filter resistance	Replace filter
Missing or worn gaskets	Replace gasket
Worn filter and facepiece connections	Replace filter or facepiece, as applicable
Cracks or dents in filter housing	Replace filter
Deterioration of gas filter support harness	Replace the harness
Service life indicator or end of service date	Replace filter
Clogged pre-filter	Replace pre-filter to extend life of main filter
Breathing tube	
Hardening, cracks or holes	Replace tube
Missing or loose hose clamps	Obtain new clamps
Broken or missing end connectors	Obtain new connectors
PAPR	
General	
Leaks in RPE assembly including worn or missing gaskets	Tighten filter clamps and replace damaged parts
Fan and motor flow rate prior to and after use.	If flow rate is below minimum specified by manufacturer, check battery and recharge if necessary or replace filter or both. If still below minimum, check for major faults and consult manufacturer
Facepiece—as above for air-purifying RPE	Repair or replace defective or missing parts in accordance with the manufacturer's instructions
Head covering/bib in place and free from defects e.g. holes and tears, worn elastic seals	
Rechargeable batteries	
External damage or corroded terminals	Consult manufacturer's care and use instructions
Supplied air RPE	
Facepiece, head straps, valves and breathing tube as for air-purifying RPE	See above
Hood, helmet, blouse or full suit-Rips and torn seams	Replace if unable to repair tear adequately
Headgear suspension	Adjust or replace as required
Cracks or breaks in visor	Replace visor
Integrity and proper fit of protective screen	Adjust or replace facepiece or screen as required
Leaking gloves or boots of full suit	Replace suit or repair in accordance with manufacturer's instructions

(continued)

TABLE 9.1 *(continued)*

Inspection	Maintenance action
Air supply system	
Breathing air quality	See Appendix A and ensure that breathing air filtration systems where required are in accordance with Appendix D
Breaks, kinks, distortions, swellings or obvious wear in air-hoses and end fitting attachments;	Replace hose or fitting
Integrity and correct operation of connections;	Adjust as required
Proper setting of regulators, valves and alarm systems	Consult manufacturer's recommendations
Correct operation of air-purifying elements and carbon monoxide or other warning devices.	Consult manufacturer's recommendations
Self Contained Breathing Apparatus (SCBA) (see Note 3)	
General SCBA: See manufacturer's inspection criteria.	Observe manufacturer's servicing instructions.
Compressed air or oxygen cylinders	Fill, inspect, test and maintain in accordance with AS 2030.1 and AS 2337.1.
Check cylinders of compressed oxygen or air are fully charged to the recommended working pressure	Recharge cylinders before contents drop below 80% of full working pressure
Carbon dioxide absorbent in compressed oxygen breathing apparatus	Renew/recharge at intervals specified by manufacturer and after each use
Filter self-rescue (mines)	
Catalyst	Store in its sealed carrying case to prevent deterioration on exposure to atmosphere
Visually inspect for dents to ensure seal is not broken	If seal is broken return to manufacturer
Weigh complete respirator	If weighing shows an increase greater than 1% in mass, the equipment should be discarded or returned to the manufacturer for filter element replacement and resealing

NOTES:

1 Disposable RPE is not intended to be repaired. Any attempted repair of disposable RPE is to be actively discouraged.

2 Permissible leakage of outlet valves may be exceeded after a relatively short life. This valve defect is not always recognizable by observation and frequent checks should be made for valve leakage and valve be regularly replaced.

3 Oil or grease should not be used on any oxygen or high-pressure air equipment because of risk of explosion. Special lubricants are available for high-pressure (above 100 MPa) air and oxygen equipment.

9.5 REPLACEMENT OF FILTERS

9.5.1 General

There is no overall rule about when filters should be changed. Each situation needs to be treated individually.

Advice should be sought from the manufacturer of the RPE in conjunction with an OHS professional, e.g. an occupational hygienist, on an acceptable change-over time based on likely exposure patterns, so an adequate safety margin is allowed. Based on this advice a filter replacement schedule shall be established and documented.

WARNING: IN SOME FILTER ASSEMBLIES IT MAY BE POSSIBLE TO INSERT THE FILTER IN THE WRONG DIRECTION DESPITE DIRECTIONAL ARROWS OR INSTRUCTIONS. IF A PREVIOUSLY USED FILTER IS REINSERTED THE OTHER WAY ROUND THEN THE USER IS LIKELY TO INHALE CONTAMINANTS DEPOSITED DURING THE EARLIER USE.

9.5.2 Particulate filters

The breathing resistance of the filter will progressively increase in use as it becomes clogged with trapped particles and eventually becomes so high that the filter must be replaced. The time taken for this condition to develop will vary according to the characteristics of the filter, and the type, size and concentration of the particles. If the filter media is of a type that decreases in efficiency when exposed to oil mist, then the filter's performance may degrade without noticeable increase in breathing resistance. Such filters need to be charged frequently.

As a general guide, the breathing resistance can be considered too high when there is a perceived increase in resistance to breathing. Resistance of particulate filters may be considerably increased if used in damp conditions. A damaged or ineffective inlet valve may lead to condensation on the filter, thereby increasing resistance.

In the case of PAPR, clogging of the filters is normally signalled by a fall in the air-flow rate.

The use of a pre-filter is advantageous where coarse particulates would otherwise rapidly clog the filter.

The use of back flushing or other methods to prolong the life of a particulate filter is to be actively discouraged since it will reduce the efficiency of the filter.

9.5.3 Gas filters

9.5.3.1 *General*

The life of gas filters is dependent upon temperature, humidity, concentration of the contaminant, the class of filter and the rate of breathing of the wearer or the flow rate of the blower unit. The breathing resistance does not normally rise during use. Adverse storage conditions such as high humidity, can significantly decrease filter life after filter packaging is open.

Filters should be replaced on a regular basis in accordance with filter replacement schedule. Where rapid failure occurs with a new filter, the adequacy of this equipment for the application should be re-assessed and it may be necessary to use a more effective method of respiratory protection.

Furthermore, if an odour or taste is perceived in the inhaled air or when the wearer coughs or experiences discomfort, e.g. if the contaminant is an irritant, this indicates filters are not being changed often enough and the filter replacement schedule should be adjusted. The sense of smell should not be relied upon.

9.5.3.2 *Limitations of the sense of smell and irritation*

For the purpose of warning users about the end of filter life, the sense of smell is unreliable and shall not be used. Some of the reasons are:

(a) There is considerable variation between individuals, with some persons being unable to detect contaminants by smell, e.g. hydrogen cyanide has a characteristic almond odour that is not detectable by some people.

(b) The sense of smell in an individual may be considerably diminished temporarily by a cold in the nose or other inflammatory conditions of the nasal passages.

(c) The odour of a contaminant may be masked by other smells.

(d) The sense of smell tires (olfactory fatigue) over a period of time and fails to detect high concentrations of many contaminants particularly if such concentrations have built up gradually, e.g. hydrogen sulfide. A person working in a situation where a dangerous concentration of a contaminant has developed slowly may not detect any odour; yet a person entering the situation from outside could be aware of a very strong odour.

(e) The threshold of odour for some materials exceeds the level at which such materials may be considered hazardous. Thus, by the time the contaminant can be smelt, the wearer may already have been exposed to a hazardous situation, e.g. methyl bromide.

(f) Some gases have no odour and therefore are not detectable by this means, e.g. carbon monoxide.

(g) Some gases have very objectionable odours at very low concentrations but do not represent a health hazard at these concentrations, e.g. methyl mercaptan.

Some contaminants, because of their local irritant action on the upper respiratory tract or eyes will give an early indication of their presence in harmful amounts. The warning sensation experienced, although perhaps centred in the nose, is not a smell, but a discomfort, a feeling of burning or irritation, e.g. sulfur dioxide.

With some contaminants, the warning symptoms are so severe that no one would willingly remain in a dangerous atmosphere, e.g. ammonia and hydrogen chloride (HCl).

With other contaminants, the warning may be positive, but insufficient to protect a person who is willing to endure considerable discomfort, e.g. chlorine.

It is therefore of fundamental importance in respiratory protection that the sense of smell should never be relied upon to provide warning against dangerous contaminants.

9.6 STORAGE OF EQUIPMENT

Users should consult manufacturers' instructions, particularly with regard to storage recommendations. The following should be observed for storage and protection:

(a) RPE should be readily available to encourage use.

(b) Cleaned RPE should be clearly identified and separated from used/contaminated RPE.

(c) RPE provided for emergency and rescue work should maintained in a condition ready for immediate operational use and secured to prevent unauthorized use or tampering.

(d) All emergency locations should be clearly marked in green and white in accordance with the requirements of AS 1319. Painting green and white diagonal stripes over an area of about 1 m^2 is a satisfactory method of marking such locations.

(e) RPE should be kept clean and dry and away from dust, corrosive atmospheres, oil and exposure to direct sunlight to avoid deterioration.

(f) Facepieces should be stored so that they are not subject to distortion.

APPENDIX A

REQUIREMENTS FOR AIR QUALITY (COMPRESSORS OR CYLINDERS) FOR SUPPLIED-AIR RESPIRATORS

(Normative)

A1 CAPACITY

The necessary capacity of any air service for respiratory protection shall be calculated on a minimum requirement of 170 litres per minute continuous flow for each person measured at the respirator.

NOTE: Where air cooling or encapsulated suits are used additional air will be required and advice should be sought from a competent source.

A2 QUALITY

Air used to supply respirators shall—

(a) have no objectionable or nauseous odour; and

(b) contain not less than 19.5% and not more than 22% by volume of oxygen.

Additionally, at 15°C and 100 kPa absolute, the air shall—

(i) contain not more than 11 mg/m^3 (10 p.p.m. by volume) of carbon monoxide;

(ii) contain not more than 1400 mg/m^3 (800 p.p.m. by volume) of carbon dioxide;

(iii) contain not more than 1 mg/m^3 of oil; and

(iv) for cylinders, contain not more than 100 mg/m^3 of water when sampled from a cylinder initially filled to pressure of at least 12 MPa.

Regular testing of the air at the respirator shall be undertaken to verify the quality of the air and records kept.

A3 AIR TEMPERATURE

Air supplied from a compressor to a facepiece, hood or helmet should be at a comfortable breathing temperature within the range 15°C to 25°C.

APPENDIX B

FACIAL SEAL OF RESPIRATORS

(Normative)

B1 GENERAL

Beard growth, some hairstyles and other facial features prevent an adequate seal between the wearer's face and the fitting surfaces of a facepiece or mouthpiece. Facial hair may also interfere with inhalation and exhalation valve operation. The complete sealing surface of the respirator mask should be in contact with the wearer's skin.

B2 BEARDS

Bearded persons cannot expect to achieve adequate respiratory protection when wearing a full facepiece or a half facepiece RPE. Accordingly, no one who requires respiratory protection shall wear either a full facepiece or half facepiece RPE over a beard. When the person at risk has a 'bushy' facial hairstyle, hair trapped between the lips and mouthpieces may prevent a satisfactory seal being obtained. For positive pressure supplied air full facepiece RPE, excessive leakage of air may result from the wearing of beards. At high rates of work, beards may cause inward leakage even when using positive pressure RPE.

B3 MOUSTACHES

Moustaches may interfere with the fit of a half facepiece respirator and the peripheral seal of a full facepiece respirator. For positive pressure supplied air full facepiece RPE, excessive leakage of air may result from the wearing of moustaches. At high rates of work, moustaches may cause inward leakage even when using positive pressure RPE. A moustache that interferes with the seal of the orinasal mask of a full facepiece will cause exhaled air to pass from the inner mask to the outer mask, resulting in an unacceptable accumulation of carbon dioxide in the inhaled air.

B4 SIDEBURNS

When a full facepiece is being worn, sideburns shall not extend below a line drawn through the top of the tragion (the notch in the cartilage of the ear just above and immediately in front of the earhole) and the canthus (corner) of the eye. This line is illustrated in Figure B1.

B5 STUBBLE GROWTH AND LONG HAIR

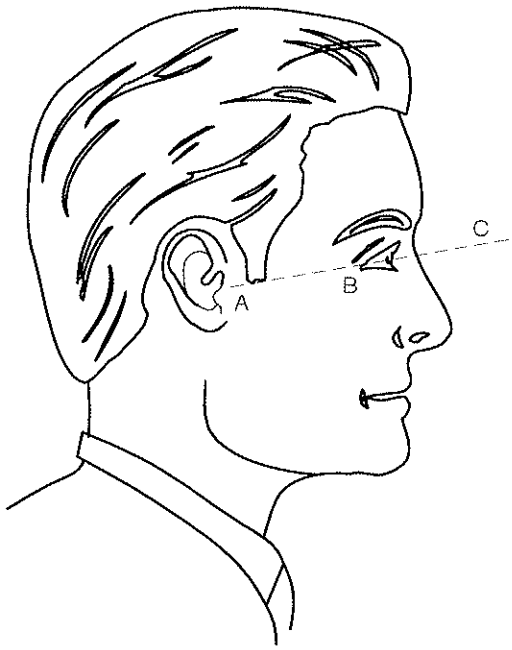
Stubble growth, depending on its length and stiffness may interfere with proper sealing of a facepiece and it is necessary that male wearers of respirators shave daily.

When the hair is worn long, particular care should be taken to ensure that none is trapped beneath the sealing surface.

B6 OTHER FACTORS

All forms of jewellery that may interfere with the facial seal should not be worn while using respirators.

Facial make-up and creams applied to the face, should not be worn because they may migrate during the period of wear and interfere with the face seal.



LEGEND:

A = Notch in the cartilage of the ear
B = Canthus of the eye
C = Line below which the sideburns should not exceed

FIGURE B1 LENGTH OF SIDEBURNS

APPENDIX C

PROCEDURES FOR CLEANING AND DISINFECTING RPE

(Informative)

C1 SCOPE

This Appendix provides a guide for cleaning and disinfecting RPE.

C2 METHOD

To clean and disinfect RPE:

(a) Remove filters from facepiece where applicable

(b) Disassemble facepieces according to manufacturer's instructions.

(c) Replace or repair any defective parts.

(d) Wash components in warm (40°C maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.

(e) Rinse components thoroughly in clean, warm (40°C maximum), preferably running, water. Drain and allow to air dry.

(f) When the cleaner used does not contain a disinfecting agent, and disinfection is required, respirator components should be immersed for about two minutes in one of the following:

  (i) Hypochlorite solution (50 p.p.m. of chlorine) made by adding approximately 2 mL of laundry bleach to one litre of water at a temperature not greater than 40°C.

  (ii) Aqueous solution of iodine (50 p.p.m. iodine) made by adding approximately 0.8 mL of tincture of iodine (6–8 grams ammonium and/or potassium iodide/100 mL of 40% alcohol (v/v) to one litre of water at a temperature not greater than 40°C.

  (iii) Other commercially available cleansers of equivalent disinfectant quality when used as directed, if their use is recommended or approved by the respirator manufacturer. Resuscitators and medical masks should be cleaned by other methods. Check for most up-to-date information.

(g) After disinfection, rinse components thoroughly in clean water, drain and allow to air dry.

(h) Reassemble the facepiece in accordance with the manufacturer's instructions.

APPENDIX D

CHECKPOINTS FOR RESPIRATORY PROTECTION PROGRAM— ADMINISTRATION AND OPERATION

(Informative)

D1 PROGRAM OPERATION

D1.1 Employer responsibility

When control of exposure to an occupational hazard requires the use of respiratory protection it is the responsibility of management to ensure a respiratory protection program is implemented and maintained as an integral part of a risk control strategy. The scale and complexity of the program would depend on various circumstances but should contain the key elements outlined below. The result of the program should be that appropriate RPE is used in accordance with manufacturer's instructions and worn at all times.

D1.2 Documented policies and procedures

(a) Management responsibility.

(b) Designation and role of the administrator.

(c) RPE selection process.

(d) Medical screening of RPE users.

(e) Training in proper selection, usage, storage, inspection and maintenance.

(f) Issue of equipment.

(g) Fitting of equipment.

(h) Respiratory testing.

(i) Cleaning and disinfection.

(j) Inspection, maintenance and repair.

(k) Storage.

(l) Record keeping.

(m) Program auditing/evaluation and implementation of any corrective action.

D1.3 Appointment of administrator

(a) Suitably qualified/experienced program administrator appointed.

(b) Administrator role defined.

D1.4 RPE selection process

(a) Selections are made by knowledgeable and experienced individuals.

(b) Compliance with AS/NZS 1716 (where appropriate category exists).

(c) Limitations of RPE taken into account.

(d) Work area conditions and employees exposures assessed.

(e) Respirators selected on basis of contaminant (type, level of exposure) task and operator.

(f) Medical screening/evaluation of the prospective users has been made to determine their physical and psychological suitability to wear respiratory protective equipment.

(g) Users involved in selection process to ensure fit and comfort.

D1.5 RPE training

(a) Supervisors trained in their responsibilities.

(b) Employees trained in the proper usage, storage, inspection, demonstrated competency of use, maintenance and limitations of the respiratory equipment.

(c) Refresher training frequency established.

(d) Training provided by competent provider.

D1.6 Issue of equipment

(a) Exclusive use of respirators where practicable.

(b) Respirators issued in clean state.

D1.7 RPE testing

(a) The RPE is appropriately fit tested at appropriate intervals.

(b) Users who required correction lenses are properly fitted.

(c) Wearers check RPE fit before use.

D1.8 Cleaning and disinfection

(a) System of regular cleaning, disinfection, inspection and maintenance established.

(b) RPE is cleaned and disinfected after each use when different people use the same device, e.g. SCBA or as frequently as necessary for devices issued to individual users.

(c) Proper methods of cleaning and disinfecting are utilized.

D1.9 Storage

(a) Respirators stored to protect them from dust, sunlight, heat, excessive cold or moisture, or damaging substances.

(b) Respirators stored properly to prevent deformation.

(c) Gas and vapour filters are stored in containers/bags with airtight seals.

(d) RPE stored close to where they will be used.

D1.10 Inspection, maintenance and repair

(a) RPE inspected before and after each use and during cleaning in accordance with the manufacturer's instructions.

(b) RPE inspected, maintained and repaired by trained or knowledgeable individuals.

(c) SCBA designated for 'emergency use' is inspected at least monthly (as well as after each use).

(d) Replacement parts used in repair are those of the manufacturers of the respirator.

(e) Repairs of SCBA are made only by authorized personnel in accordance of manufacturer's instructions.

D1.11 Record keeping

(a) Maintenance and inspection records (dates, findings etc) particular of 'emergency use' respirator protective equipment.

(b) Filter use (where applicable/appropriate).

(c) Filters marked with date first fitted.

(d) Battery use (where applicable).

(e) Respirators issued for personal use are marked to identify user.

(f) Date of issue, whom to and period of usage.

(g) Employee and supervisor training records.

(h) Dates of specific testing.

(i) Training records (who, what, when).

(j) Audit records.

D1.12 Audit program

(a) Regular audits undertaken.

(b) Auditing undertaken by trained or knowledgeable persons.

(c) Audit criteria/checklist used.

(d) Correction measures implemented in timely manner.

APPENDIX E

RESPIRATOR SELECTION EXAMPLES

(Informative)

E1 EXAMPLE 1

TASK: Tunnelling in rock containing quartz for 8–10 hours per day.

PARTICULATE MEASUREMENTS

Tunnelling machine operator	1.5 mg/m^3 respirable quartz (TWA)*
Other workers in vicinity of operator	0.3–0.5 mg/m^3 (TWA)*
Exposure standard—respirable quartz	0.1 mg/m^3 (TWA)*

RESPIRATOR SELECTION:	**Tunnelling machine operator**	**Other workers**
Required protection factor (see Clause 5.2.2.2)	15	3
Examples of other PPE but not limited to:	Occupational protective helmet, hearing protection, miner's lamp, faceshield and eye protection	Safety helmet, hearing protection, miner's lamp and eye protection
General choice (Table 4.2)	—PAPR P2 —P2 filter in a full facepiece —Half facepiece air-line RPE	—P1 half facepiece
Final selection	—Helmet type PAPR fitted with lamp bracket and earmuffs	—P1 disposable
Reasons for choice	Air-line unsuitable due to lack of mobility. Full facepiece unsuitable for extended usage	Personal choice—light-weight, no maintenance required

* TWA = time-weighted average.

E2 EXAMPLE 2

TASK: Manufacturing operation requiring addition of volatile solvents to a batching tank. Engineering controls not yet operational. Operation performed once per day for half an hour.

GAS/VAPOUR MEASUREMENT

During addition of solvent	540 p.p.m. methyl ethyl ketone (MEK)
Exposure standard, MEK	150 p.p.m.
Required minimum protection factor	4
Comments	In this case it is more appropriate that the protection factor determination is based on the excursion limits for the following reasons: • the 8 hour exposure standard of 150 ppm is not exceeded in this example • the STEL for MEK is 300 ppm and has been exceeded • the general excursion limit of 3 has been exceeded The protection factor determination is more conservative based on the excursion limit than the STEL
General choice (Table 4.4)	—Type A AUS for Type A1 gas filter with half facepiece —PAPR A1 with half facepiece —Air-line with half facepiece
Final selection	—Type A AUS or Type A1 gas filter with half facepiece
Reason for choice	The task is too short to merit selection of a powered respirator or supplied-air equipment
Replacement	The filter should be stored according to the manufacturer's instructions and replaced every week or sooner if the odour of MEK is apparent. Determine the filter schedule in consultation with information from suppliers

APPENDIX F

SOURCES OF AIR FOR AIR-LINE RPE

(Informative)

F1 SCOPE

This Appendix provides information for the user or purchaser of respirable compressed air supply systems. It gives guidance on features of air supply systems designed to deliver respirable air to the user of air-line rpe.

These systems are either—

(a) compressed air from a low pressure compressor (less than 15 bar) that is filtered to comply with the specifications for respirable air (Appendix A); or

(b) compressed air supplied from high pressure cylinder/s. These cylinder/s are generally either 200 bar (20 MPa) or 300 bar (30 MPa) and the air from the cylinder/s is regulated to a pressure required to deliver the required amount of air. (These are generally called air-line trolleys).

NOTE: Operations involving refilling of SCBA or any high pressure cylinders used in air-line trolleys should be carried out following the guidance given in AS 3848.2.

F2 LOW PRESURE AIR SUPPLY SYSTEMS

F2.1 General

Plant air supply systems are not suitable for air-line respirators unless specific precautions are taken to eliminate scale, rust, water, oil mist, irritating ingredients and odours that can occur in this type of air supply system.

Where the air supply is used in both the manufacturing process as well as for the supply of respirable air, all respirable air should be delivered to the RPE through a pressure regulated and filtered system so that any backpressures from the operating plant do not affect the flow of air to the RPE. Cross contamination of non-filtered and filtered respirable air supplied to the RPE shall be eliminated by the design of the systems.

Compressors shall be maintained and serviced in accordance with the manufacturer's recommendations and records kept of this maintenance and servicing. The compressor shall not be allowed to run hot, as harmful substances may be produced by the decomposition of any lubricating oils and internal components of the compressor. Consideration should also be given to the use of oil-free compressors.

Use of the respirable air regulator/filter system should be at a location as close as practical to the user of the RPE. Provision should be made to ensure that the RPE receive an adequate supply of air under all plant operating conditions.

F2.2 Location of the compressor

The compressor should be located in a building or structure that provides ample space on all sides to ensure good ventilation, maintenance accessibility and in an area where the ambient temperature is as cool as possible. Geographical location of the compressor should also be taken in account when specifying the filtration system. As an example; areas that are subject to high humidity will require a larger filtration system because the high humidity will give a higher water content of the compressed air.

The air intake for the compressor should be located in open air, away from the source of atmospheric contamination. The use of filters on an air intake should be of secondary importance to this requirement. Intake filters, where fitted should be replaced at regular intervals in accordance with the manufacturer's instructions.

The possibility of contamination of the compressor intake air by discharge from pressure relieving devices on other plant in the vicinity should be considered as well as the effects of changes in wind direction. Contamination may occur when the compressor is driven by an internal combustion engine or is located close to motor vehicles. Particular care should be taken to ensure that a clean sir supply is available if a portable air compressor is being used to supply the breathing air.

F2.3 Design of the air supply system

F2.3.1 *General design*

Design of the air supply systems should avoid the pocketing of stale air in the pipelines. The use of ring circuits is suggested. The design of the ring circuit should include the installation of water traps located at the lowest point in each section of the ring circuit. These water traps will drain away water from the pipeline. Water traps should be drained prior to using the equipment and at regular intervals dependant on the ambient conditions.

F2.3.2 *Couplings*

All couplings on the respirable air system should be of the 'safety type', i.e. requiring at least two deliberate actions to separate the connector or coupling and should be incompatible with those used for other compressed gas and air services.

NOTE: The contents of all piping, conduits ducts and other services should be identified and suitably marked to prevent incorrect connection of air-lines. Attention is drawn to AS 1345 regarding the identification of services.

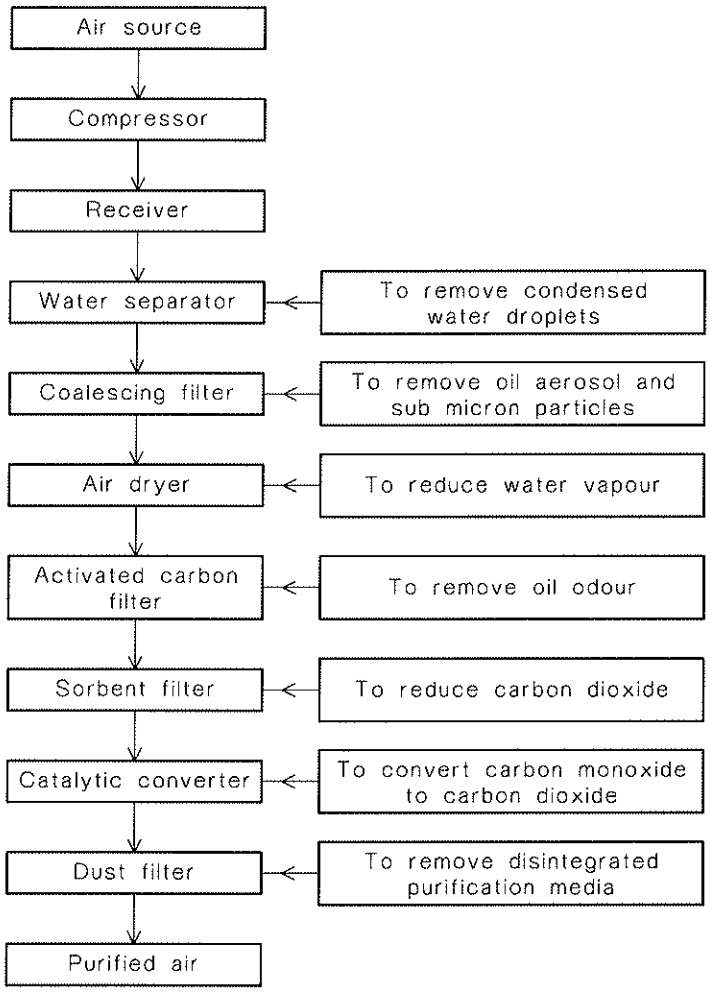
F2.4 Filtration system components for respirable air

When writing specifications for a compressed air purification filtration package, the user should state that, when installed in the user's premises, the filtration system should produce air which meets the air quality requirements of Appendix A of this Standard for a specified period of time at a specified air flow rate.

A generalized description of a compressed air supply filtration system for respirable air is given below. Not all of these components are always necessary, depending on specific air supply equipment and requirements. Expert input is needed to determine the elements needed for a specific location and application.

There are two systems that may be either a dedicated filtration system that is fixed to the compressor or a portable filtration system. Both systems use similar components except that the portable air filtration systems. Both systems use similar components except that the portable air filtration systems that are connected into a works air supply system are usually smaller than a fixed dedicated respirable breathing filtration system. The portable filtration system should be located as close to the RPF user as practicable.

The effectiveness of the filtration system requires that the various components comprising the system be placed in the correct sequence (see Figure F1).



NOTE: Not all purification elements may be required

FIGURE F1 SEQUENCE OF A TYPICAL BREATHING AIR-LINE PURIFICATION TRAIN

The first element shown in the filtration system is a mechanical device to remove liquid water. The air, after leaving the mechanical water separator, passes into a coalescing filter or equivalent where oil, aerosol and submicron particles are removed.

An air dryer or sorbent filter then reduces the water vapour content of the compressed air to prevent moisture contamination of the next stage.

The air after leaving the air dryer or sorbent filter the air passes through an activated carbon filter designed to remove oil, odours and some organic and hydrocarbon vapours.

If the carbon dioxide content of the compressed air needs to be reduced, an additional sorbent filter may be required.

The next step in the filtration system may be the catalytic conversion of carbon monoxide to carbon dioxide. In some instances, where the carbon monoxide concentration is high, it may be necessary to reverse the sequence of these last two stages.

The final component of the filtration system is a dust filter required to protect the air delivery system from the disintegrated purification media.

NOTES:

1 Some purifiers are designed to remove a number of contaminants in one vessel.

2 A pressure regulator may be required in the above system for each RPE user to ensure the correct flow rate and pressure supply to each RPE device.

3 This system will comprise a number of pressure vessels that should be designed in accordance with AS 1210.

F2.5 Testing of air quality

As part of the RPE program for a compressed air supply system, the quality of the air shall be checked regularly. The time interval depends on—

(a) the volume of the airflow through the filtration system; and

(b) the amount of contaminants that the filtration system has to remove.

Annual checking (see Appendix A) may not be sufficient to show air quality deterioration in all cases.

Results of air quality tests should then be used to ensure the quality of the air remains in accordance with Appendix A.

The frequency of testing is to be reviewed dependant on the usage and results of the testing.

F3 AIR-LINE TROLLEYS

Air-line trolleys are made up of a group of high pressure cylinders filled with respirable air and connected to a control panel.

The control panel should have—

(a) a regulator;

(b) gauges to show the pressure both in the high pressure cylinders and delivery pressure to the RPE; and

(c) connections to air-line/s.

It may also have—

(i) individual control valves for each air-line connected to the control panel; and

(ii) safety valves.

Trolleys are usually transportable but this depends on the size of the high pressure cylinders, e.g. 6, 9 or 50 litre, and the quantity of cylinders in the group.

Care should be taken when using an airline trolley to monitor the quantity of air remaining in the cylinders. A suitably trained or experienced person should undertake this monitoring to warn the RPE user to vacate the contaminated area to safe area. A warning device that warns the wearer or the attendant when the pressure falls below a predetermined level.

To fill cylinders for an airline trolley system, a high pressure compressor (>100 bar) is used.

Users of high pressure compressors for filling high pressure cylinders should seek advice and expert guidance from equipment installers, suppliers and designers. They are outside the scope of this Appendix.

NOTE: Operations involving refilling of SCBA or any high pressure cylinders should be carried out following the guidance in AS 3848.2.

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