

Chemical Safety Guidance

February 2020

Respiratory Protective Equipment (RPE) *aka 'Face Masks'* **Selection, Use and Maintenance**

Occupational Health and Safety Service
HSD009C (rev 4)



**UNIVERSITY OF
CAMBRIDGE**

Contents

Section A: Technical Information

- 1 Introduction**
- 2 Technical Terms Associated with RPE**
 - 2.1 Dusts
 - 2.2 Mists
 - 2.3 Fume
 - 2.4 Vapours and Gases
 - 2.5 Assigned Protection Factor, APF
 - 2.6 Nominal Protection Factor, NPF
 - 2.7 Respirable Dust
 - 2.8 Inhalable Dust
- 3 Occupational Exposure Limits**
 - 3.1 Workplace Exposure Limits
- 4 Typical Applications for RPE**
- 5 Training of Users**
- 6 Fit Testing**
- 7 Maintenance, Examination and Testing of RPE**
- 8 Record Keeping**

Section B: Apparatus

- 1 Types of RPE Available**
- 2 Filtering RPE**
 - 2.1 Filter Performance Specification
 - 2.2 Choosing RPE
 - 2.3 Fitting and Testing Filtering RPE
 - 2.4 Maintaining the Equipment
- 3 Respirators Supplying Breathable Air from an Independent Source**
 - 3.1 Factors Affecting the Decision to Use BA
 - 3.2 Types of BA
 - 3.3 Selection and Training of Users of BA
 - 3.4 Storage, Maintenance and Testing
 - 3.5 Air-line Apparatus
 - 3.5.1 Compressed air-line breathing apparatus
 - 3.5.2 Fresh-air hose equipment
 - 3.6 Self-contained Breathing Apparatus
 - 3.6.1 Generic types available
 - 3.6.2 Self-contained breathing apparatus designed for escape or self-rescue
 - 3.6.3 Self-contained breathing apparatus for other purposes

Section C: Further Reading

Section D: Appendices

- Appendix 1 Worked Example of Risk Assessment and Selection of Filtering RPE
- Appendix 2 Report Sheet for a Fit Test
- Appendix 3 Checking, Maintenance and Record Keeping

Respiratory Protective Equipment (RPE)

Section A: Technical Information

1 Introduction

Respiratory protective equipment (RPE) is a term applied to a variety of devices that when used correctly can protect persons working in hazardous atmospheres. Hazardous atmospheres include areas where the air contains a contaminant in the form of gas, vapour or particulate matter. The contaminant may be intrinsically harmful to health, but there are also circumstances where an otherwise 'harmless' dust, if present in excessive amounts, could become a hazard to health. These issues should be addressed in the Risk Assessment and wherever possible controlled by engineering means rather than resorting to RPE. As with any form of personal protective equipment it must always be remembered that **RPE will ONLY protect the person wearing it !**

NB: Hazardous atmospheres also include areas where there may be too little oxygen to support life. NO 'filtration' mask or equipment is suitable for a reduced oxygen atmosphere: this is a very special case and would require NOTHING LESS THAN AIR FED BREATHING APPARATUS, see point 3 in Section 2 on p14 below),

An atmosphere containing gases, vapours or particulate matter (including fungal spores) may arise from an incident or directly as a result of the work being done, which could include such diverse activities as cleaning, moving dusty items, mixing, weighing, boiling, solvent cleaning, sweeping, grinding, welding or sawing. Reduced oxygen atmospheres could arise as a result of evaporation of a cryogen such as liquid nitrogen, liquid helium or dry ice/solid carbon dioxide or by the escape of any gas (except oxygen or air) from a leaking rig, pipeline or cylinder.

The hierarchy of control measures defined in the Control of Substances Hazardous to Health (COSHH) Regulations¹ requires that removal of the hazard altogether is the first priority. This would mean that:

- The use of a highly toxic material should be avoided wherever possible, by substituting a non-toxic or less toxic material.

Engineering control measures are the next best approach, and may mean that:

- Forced ventilation may be required. In certain circumstances the decision may be made for this to be triggered automatically by a gas sensor in an emergency
- Evaporating cryogenic gases such as nitrogen, helium or carbon dioxide should be routed away from any enclosed work space wherever possible
- Certain work may be carried out entirely within an enclosed area, such as a glove box, so that contaminants can never enter the breathing zones of workers
- Processes may be carried out inside a fume cupboard or similar device
- An air extraction device could be used – for example, an air extraction device fitted to the end of a soldering iron, an integral dust extraction unit fitted to a woodworking machine or 'extraction arms which can be fixed or flexible/movable.

Respiratory Protective Equipment is at the bottom of the COSHH hierarchy of control measures because it only protects the person wearing it !

However, there are occasions when it is required as an additional protection measure, or where engineering control measure are not reasonably practicable

NB: The use of ANY Respiratory Protective Equipment identified in a risk assessment as a control measure must be subject to a 'Face-Fit Test' prior to use in compliance with the COSHH Regulations; see point 6 below.

This document describes the main types of RPE available, giving sufficient information to ensure that the correct type is obtained and that it is used and maintained correctly.

2 Technical Terms Associated with RPE

2.1 Dusts

Dusts are very small particles of solid material that are generated by the breakdown of larger pieces of solid material. They remain suspended in the air for a time that is determined by their buoyancy and the air conditions. Dusts are generated by processes such as sweeping, grinding and sawing. Dusts and other airborne particles can be divided between those that are inhalable and those that are respirable, see 2.7 /2.8 below.

Ultrafine dusts, or nanoparticles as they are also known, can represent a specific hazard since their small size, < 100 nm (0.1 µm), makes them amenable to breaching many of the body's natural defences; see the Nano-safety guidance on the Safety Office website.

2.2 Mists

Mists are airborne droplets of liquid, produced by the atomisation of a liquid or the boiling and condensation of a liquid. Mists can be created by spraying and mixing and can come from pump exhausts. **NB:** 'Standard dust masks' are not usually suitable for liquid mists.

Note; technically an 'aerosol' can refer to both to airborne liquids and airborne solids (dusts) but in everyday parlance has been taken to mean airborne droplets of a liquid.

2.3 Fume

Fume is very fine particulate matter formed by the vaporisation of a solid and its condensation in the air. It is generally produced by such activities as welding polymers, pouring molten metal, or welding metals (which also produces metal oxides, silicates and fluorides). Particle sizes of metal fume extend from large 1 mm diameter particles, right down to nanoparticles of approximately 10nm (0.01 µm) or less. They therefore span both inhalable and respirable fractions. When choosing respiratory protection the word FUME only has this meaning. It does NOT mean exhaust fumes, or the fumes from acids etc.

2.4 Vapours and Gases

Vapours and gases arise from solvents, gas supplies etc. which could also be flammable.

2.5 Assigned Protection Factor (APF)

The APF is the performance of the RPE, expressed as the ratio of the concentration of the contaminant outside the RPE to the concentration inside as a factor of the WEL. This is only achieved if the mask is used correctly by those who have been trained to wear it.

2.6 Nominal Protection Factor (NPF)

The NPF is the level of protection the equipment has to demonstrate under laboratory conditions to gain approval to the appropriate class of the performance standard.

2.7 Respirable Dust

Respirable dust is particulate matter that is inhaled, and is small enough to reach right down into the gas exchange zone of the lungs (the alveoli).

Note: Occupational hygiene use a definition of '*respirable dust*' based on a particles size distribution of 'less than 10 µm diameter with a median diameter of 4.3 µm'.

[**NB:** This is distinct from the environmental fractions which are based on particle distributions with median diameters of 10 µm (PM10) and 2.5µm (PM2.5)].

2.8 Inhalable Dust

Inhalable dust is the total particulate matter that is inhaled. It consists of a combination of respirable dust and dust that is airborne but is too large to reach the gas exchange zone of the lungs. Many larger particles are trapped by the hairs and mucous in the nasal and bronchial passages. From thence they are coughed or sneezed out, or are swallowed encapsulated in mucous and thereby may enter the digestive system !

2 Occupational Exposure Limits

Occupational Exposure Limits, aka Workplace Exposure Limits (WELs) in the UK, are legal limits set by the UK's Health and Safety Executive (HSE) to help protect the health of workers and should **never ever** be exceeded.

Manufacturers of chemicals will record these limits in their Safety Data Sheet (SDS) however, **always consult an up to date SDS**. The SDS may also quote other exposure limits, relating to different countries, especially the USA, i.e. OSHA Permissible Exposure Limits (PELs) or ACGIH Threshold Limit Values (TLVs), whilst these have no legal bearing in the UK, they should still be considered as valuable 'guides'.

3.1 UK Workplace Exposure Limits (WELs)

The revision of COSHH in 2005 introduced a single UK Occupational Exposure Limit, known as the Workplace Exposure Limit (WEL) for airborne substances. Should an SDS refer to the old 'pre-2005' OES (Occupational Exposure Standard) or MEL (Maximum Exposure Limit) values, **confirmation of the current WEL should be sought**.

The WEL is averaged over a specified period of time and is therefore a time-weighted average (TWA). Two time periods are used for WELs; the 8 hour long-term exposure limit (LTEL), effectively the daily average and the 15 minute short-term exposure limit.

The UK Workplace Exposure Limit is the maximum legally permitted airborne concentration of a hazardous substance that people can be allowed to breathe at work over the specified period, therefore it must NEVER be exceeded, it is however not necessarily a safe level of exposure for everyone!

For dusts where an individual WEL has NOT been set by the HSE, there are over-arching maximum limits to exposure of 10 mg/m³ of inhalable dust, or 4 mg/m³ of respirable dust, both averaged over an 8-hour time period¹.

It should be remembered that the absence of a substance from the list of WELs does NOT mean that it is safe. For these substances, exposure should be controlled to a level to which nearly all the working population could be exposed, day after day at work, without adverse effects on health" (HSE). This may require the setting of an internal exposure limit from first principles after careful study of the manufacturer's data, industry journals, occupational health sources and hygiene journals.

NB: Irrespective of the existence of a WEL, all potential exposures to substances hazardous to health should be reduced to as low as reasonably practicable in accordance with the COSHH Regulations and University policy.

4 Typical Applications for RPE

RPE may be appropriate in the following circumstances:

- Routine operations where exposures to airborne contaminants are expected to be below the occupational exposure limits, but the wearers will gain an improved quality of life by using RPE, e.g. by wearing a mask to filter out a 'bad smell'
- Where exposures exceed the appropriate occupational exposure limit and control measures are in the process of being installed. RPE may provide a temporary means for controlling the exposures
- Where maintenance work may require personnel to enter areas with high contaminant levels in order to service equipment, such as filters. An example is work with MMMFs (Machine or Man-made Mineral Fibres), where University Guidance recommends the use of a half-face mask with a FFP3 filter
- Where plant failure may lead to a need to escape in a contaminated atmosphere
- Where exposure is of short duration (e.g. connecting a cylinder of toxic gas) and the permanent provision of other means of control is not reasonably practicable
- For trained personnel to use in the event of an incident
- For protection against laboratory animal allergens
- For protection against moulds, fungi and spores.

5 Training of Users

Potential users of all types of RPE require training. The protection factors that the piece of equipment is capable of delivering can only be achieved if the equipment is correctly worn and where necessary maintained. Prospective users should be trained in the following:

- How to inspect the equipment before use
- How to wear and fit-check the equipment when putting it on
- How to clean and regularly maintain the equipment where appropriate
- How to store the equipment.

They should be told the limitations of the equipment, and what risks it is protecting them against. They should know how to report defects in the equipment and how to obtain replacements. The practical training should include:

- Inspection before use
- Practice in putting on, wearing and taking off the equipment
- Instruction in how to obtain a good facial fit, and how to check that it is effective
- Practice and instruction in how to replace any parts that are to be changed by the users (e.g. filters) where appropriate
- Practice and instruction in how to clean the equipment where appropriate
- How to store the equipment safely.

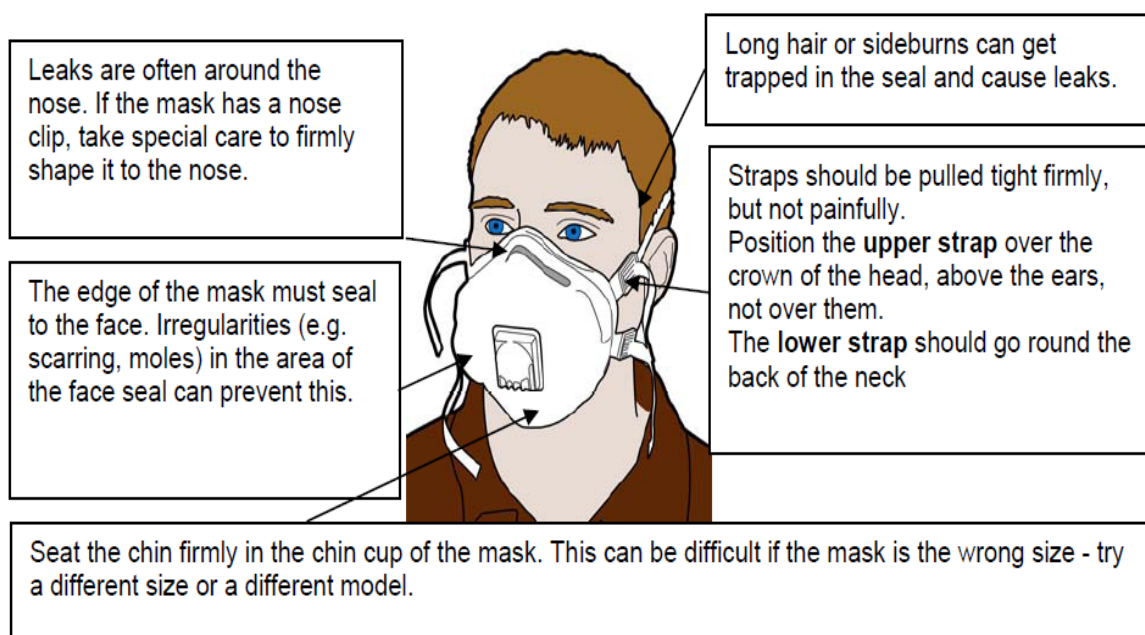
6 Fit Testing

RPE will only protect the wearer adequately if it fits properly, so 'face fit testing' is an essential part of the selection process and a legal obligation under COSHH wherever the Risk Assessment identifies RPE as a control measure.

Face fit testing is required for **all** close-fitting types of RPE, where the seal between the person's face and the RPE is critical, **including 'disposable face' masks**. Note: It is unlikely that one size or even a range of products from one manufacturer will fit everyone.

In addition to the 'face fit test', each time close fitting RPE is used (put on aka donned) it must be 'fit checked', see leaflet HSD119E on the Safety Office website for further guidance on how to 'put on' and 'fit check' disposable masks.

Some of the more frequent potential problems with achieving a good 'face fit test' or 'face fit check' and possible solutions are shown in the diagram below:



For all close-fitting filtering face masks the 'Face Fit Testing' should be carried out when making the initial selection of RPE i.e. before first use.

NB: A fit test is only valid for the named individual tested and the specific make and model of mask used during the test. The presence of a beard or even a day's growth of stubble will prevent an adequate seal of the mask to the face.

If a different mask is used for ANY reason (including the manufacturer changing the design of a replacement mask) it will require retesting on the individual. However if a new 'replacement mask' is the **same make and model** as the old one the test will still be valid.

Currently the COSHH does not specify a set interval for re-testing the face fit, however it would be prudent to retest every 3 to 5 years under normal laboratory conditions, or more frequently under more extreme conditions as determined by risk assessment. However COSHH does stipulate that it should be repeated if the wearer gains or loses a significant amount of weight, if he or she undergoes any substantial dental/facial work, or if there are any other significant changes to the face (e.g. scars, moles etc).

Fit testing must be carried out by a competent person, who can recognise the capabilities and limitations of the method, understand the purpose of the test exercises and give training on the use / limitations of the equipment.

Further information on fit testing, including information on competence to perform such tests, the exercises to be performed whilst testing and the types of equipment / methods needed to perform the tests, is contained in the HSE leaflet HSE 282/28. The result of a fit test should be recorded in a report similar to the example in Appendix 2.

There are two types of fit test – qualitative and quantitative:

Qualitative tests are pass / fail tests based on the use of an aerosol spray which is either sweet, bitter or odorous and the users subjective assessment of leakage. They are not suitable for full face masks. During the fit test, the wearer of the RPE will be invited to do several exercises which are designed to challenge the mask to face seal.

Quantitative tests are non-subjective and give a numerical value of the 'fit factor'. They are based on instrument measurements to determine the ratio of the number of airborne particles inside and outside the mask during the exercise routine. Quantitative face fit tests are available from the safety office and a number of commercial providers also offer this service.

Loose-Fitting Filtered Air Fed Hoods

The loose-fitting hood type RPE depends on an adequate supply of filtered air being pumped across the face to maintain protection and is less dependent on a tight fit to the wearer's face. Therefore it does not legally require fit testing. Nevertheless, a loose-fitting face piece requires the correct size to be chosen to ensure the wearer has adequate protection. Loose-fitting face pieces may be better suited to those wearing spectacles with side arms and people with facial hair in the region of the face seal of a tight fitting mask. In the vast majority of scenarios loose fitting alternatives to tight fitting masks are available and should be selected where necessary, taking into account the physical size and weight of the equipment and any need for intrinsically safe ('spark-proof') filter units (ATEX / EX rated) for use in potentially flammable atmospheres.

7 Maintenance, Examination and Testing of RPE

For RPE to continue to protect the individual it must be stored correctly and examined and tested to ensure that it is still in good condition (see appendix 3). Any defects must be rectified immediately and only spare parts from the original manufacturer should be used.

For all 'reusable' RPE that is not disposed of after a single use, a place needs to be designated for its storage. The equipment should be protected from damp, contamination and sunlight. For simple apparatus this need be no more sophisticated than a sealable plastic bag to protect it from dust and contamination whilst kept in a suitable location, such as a drawer or cupboard. The more complex equipment should be stored in a purpose made container from the supplier, a locker or a lockable cabinet.

RPE must be kept clean. It must be cleaned thoroughly (commercial wipes are available for this purpose) before it is put away, and/or in all cases where it is handed on to another person to wear. Rubber face pieces can usually be washed with mild soap and lukewarm water, and must then be rinsed thoroughly and dried thoroughly before storage. Only use cleaners that are recommended by the manufacturer of the RPE.

Reusable RPE should be maintained in accordance with the manufacturer's instructions. Examination should include checks that all parts are present, clean, correctly fitted and in working order. Particular attention should be paid to ensure that straps, face pieces, filters and valves are sound and in working order. **Examinations of reusable RPE should be done once a month**, or more frequently if the health risks or conditions of exposure are severe. Where RPE is used infrequently it is acceptable to make the examination before each use, but in any event intervals between examinations should not exceed three months (see page 52 of the Approved Code of Practice associated with the COSHH Regulations¹). All examinations should be recorded.

Some manufacturers make a 'reusable' RPE that is specifically intended to only be retained for a maximum of 28 to 30 days from first use, thereby removing the legal requirement for monthly maintenance. However if this type of mask is used it must still be cleaned after use and checked before use as with any other reusable RPE **and should** be disposed of after the specified life in accordance with manufacturer's instructions. Note: The 3M 4000 series '28 day masks' offer protection against dust (P2 or P3) and a limited protection against some chemicals, see the manufacturer's specifications.

For powered and power-assisted respirators the tests should in addition include the condition of the battery pack, and a check that the respirator delivers the recommended minimum volume flow rate, the manufacturer should provide a means of doing this. In addition the quality of the air supplied should be tested at least once every three months.

NB: If powered and power-assisted respirators are being used / kept for 'emergency only' situations such as spillage/releases then it is VERY important that they are regularly maintained, charged and always in a 'ready to use' condition for trained operators to use.

Similar conditions apply to any RPE (or PPE) that has been supplied for 'emergency only' use (face fit testing requirements still apply).

During monthly maintenance of 'reusable' RPE particular attention must be paid to the status of the pre-filter and the main filter medium / cartridge, replacing it before it becomes exhausted through clogging / fouling or reduction of absorption capacity. Chemical absorption respirators / cartridges will be designed and manufactured to be effective against a particular concentration of a specified chemical for a specified time and must be replaced well within this specification (see manufacturer's data).

For example a welding fume respirator **may** be specified to give ozone protection up to 10x the WEL. Other cartridge types may be specified as suitable for 10x the WEL or 1000 ppm whichever is the lower etc (see manufacturer's data).

Before use **always** check the respirator and ensure the filtration medium / respirator is appropriate for its intended use and is still functional – if in doubt replace / replenish it. Also check the 'pre-filter' and replace it if it is contaminated/dirty, this will not only allow an adequate supply of air, but also protect the main filter from premature blockage.

For RPE that incorporates compressed air cylinders (Breathing Apparatus, aka BA), the tests should include the condition and efficiency of all parts, the pressure in the cylinder and the volume flow rate, if in doubt then seek professional advice.

Reusable RPE generally has a maximum life expectancy of 5 years at which time it should be replaced (if **not** by the same make and model then a further face fit test will be required on the new make / model). To facilitate the management of RPE and its replacement, all RPE will have a manufacturer's date mark.

For further information on the maintenance of reusable RPE see Appendix 3.

8 Record Keeping

Records of the examination of RPE should be kept for at least five years (a legal requirement). These records should contain:

- The name and address of the employer
- The particulars of the equipment examined sufficient to identify it uniquely
- The name of the maker
- The date of the examination
- The name and signature of the person doing the examination
- The condition of the equipment and details of any defects found.

For self-contained breathing apparatus (BA) the pressure of the air in the supply cylinder, and for powered equipment the volume flow rate should be recorded.

Face fit test records should also be retained for their period of validity, but a minimum of at least five years. They must be available for inspection on request and a copy should be given to the employee.

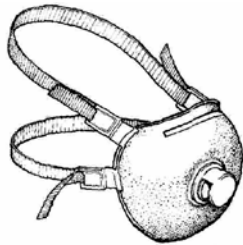
The risk assessment for the work, which will have assessed the hazards, the risks of exposure, considered the options for substitution and control, and justified the use of appropriate RPE should be retained until either the work is complete or until it is replaced or revised. Revision is appropriate if there is reason to suspect the assessment is no longer valid, there has been a significant change in the work or the results of any monitoring of exposure show that revision is necessary.

Departments must keep records of selection, maintenance, testing and training; see Appendix 2 and Appendix 3.

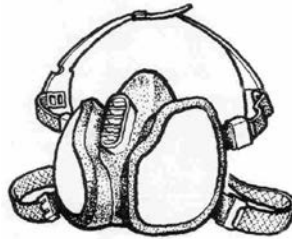
Section B: Apparatus

Figure 1. Respirators that filter the air that is breathed

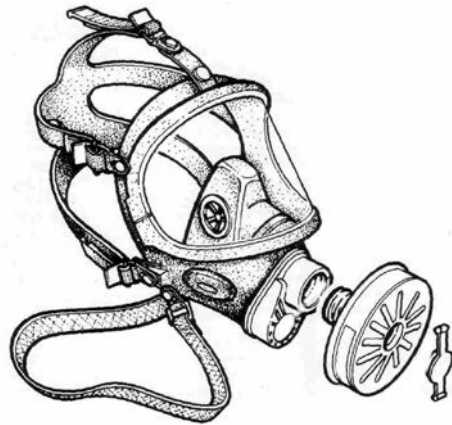
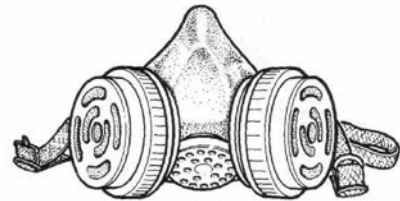
(a) Single-use
'paper' disposable
face masks,



(b) 'Rubber' face masks
which are disposable
after 28 or 30 days



(c) Re-useable
half-masks with
replaceable filters



(d) Full-face masks with
replaceable filters

(e) Powered respirators that provide
a stream of filtered air

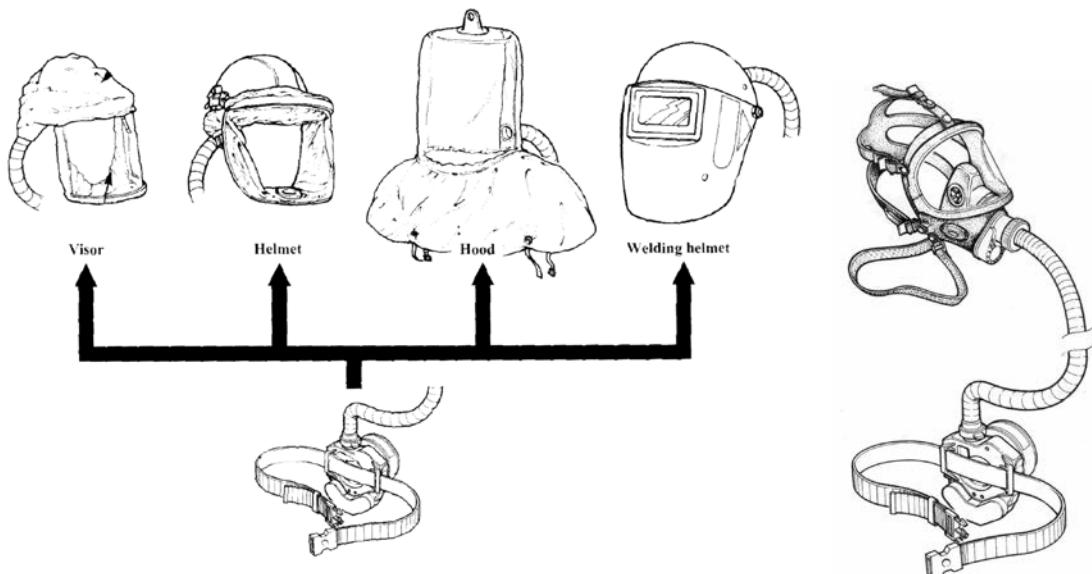
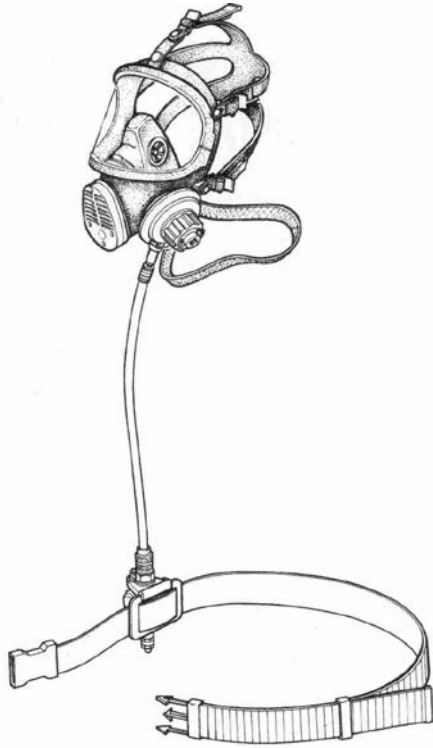
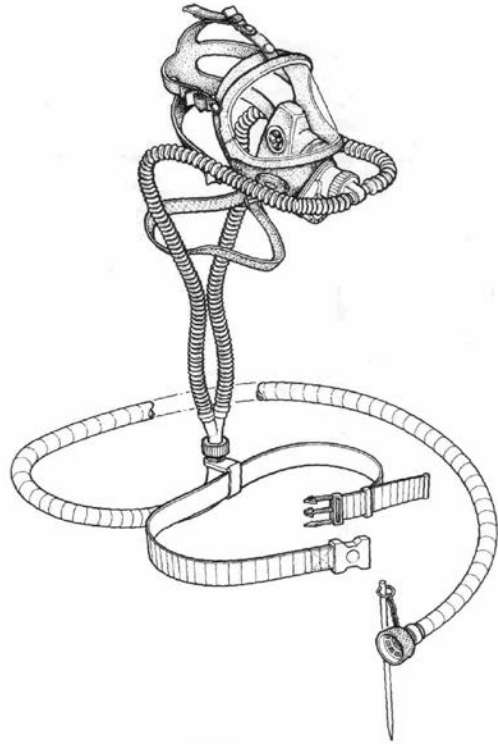


Figure 2. Respirators supplying breathable air from an independent source

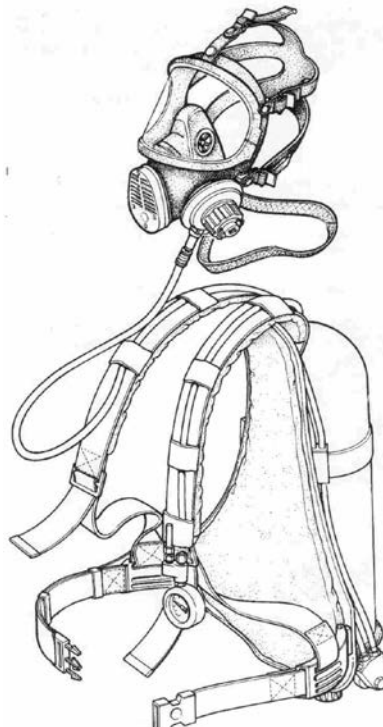
(a) Compressed air-line BA



(b) Fresh-air hose equipment



(c) Self Contained Breathing Apparatus (SCBA) with air tank



Note: Self-contained Breathing Apparatus for escape is not illustrated

1 Types of RPE Apparatus

It is important to understand the basic limitations of each type of RPE before specifying and purchasing equipment.

There are two broad families of RPE – one family of equipment filters the air that is in the room, so that contaminants are removed on inhalation. The second family of equipment supplies breathable air to the wearer from an independent source, which may involve remote filtering. The main types are illustrated in Figures 1 and 2 above.

2 Filtering RPE

Filtering RPE merely filters the air before the wearer breathes it in and is therefore totally dependent on the specification and condition of the filter.

It must therefore NOT be used in any of the following circumstances:

- **Where the atmosphere is deficient in oxygen**
- In an enclosed or confined space*
- In an atmosphere where there is an immediate danger to life or health if the RPE were to leak, fail or the filter medium saturate.
- Where you are not sure of the concentration of the contaminant or its identity
- Where the contaminant is not easily detected by smell, taste or irritation
- Where the concentration of the contaminant exceeds the ability of the respirator to filter it down below the exposure limit.
- In circumstances where others will be put at risk, even if the wearer is protected, unless **all** those at risk are similarly protected.

* A confined space is defined as any place, including an inadequately ventilated room, chamber, tank, vat, silo, pit, trench, pipe, sewer, service duct, well or other similar space in which there is a risk of serious injury arising from fire or explosion, or the loss of consciousness due to increase in body temperature, or the loss of consciousness or asphyxiation of any person arising from gas, fume, vapour or the lack of oxygen.

2.1 Filter Performance Specification

The performance of RPE is specified by two parameters - the type of filter medium and its efficiency. The filter media is formulated to absorb specific substances/chemicals, therefore the filter must be chosen for the specific application. For instance a mask designed only to absorb inorganic gases will not be effective against acidic gases. Table 1 below summarises the common filter designations. Each filter has three classes, Class 1, 2 or 3, so a filter combination such as B2P3 would define a filter that is Class 2 with respect to inorganic vapours and Class 3 with respect to particulates. It is possible to purchase filters that have more than one absorbent medium incorporated, or to combine filters to give protection against more than one type of contaminant, see table 1 below.

Note: Chemical absorption is the process by which the filter medium 'traps' an airborne chemical substance. **However** desorption is the process by which a previously absorbed chemical can, under certain circumstances, be released from the absorbent filter medium. Desorption can occur naturally during prolonged storage or by the presence of another more strongly absorbed chemical displacing the less strongly absorbed chemical. Generally the more volatile the chemical the LESS strongly absorbed it is. In addition the capacity of the filter medium to absorb volatile organic vapours is lower than for some other chemicals and therefore the 'reuse' of organic vapour filters should be avoided.

Absorbent filter cartridges should be changed between 'applications' i.e. if it is being used for a different chemical (especially if it is less volatile), after prolonged storage and as a minimum after the manufacturer's specified interval.

It is important to read all the manufacturers specifications with great care !

Filter Medium Cartridge Specifications for RPE:

Filter Type	Colour Code	Protection Against
A		Certain organic gases and vapours with a boiling point greater than 65°C, as specified by the manufacturer.
B		Certain inorganic gases and vapours as specified by the manufacturer
E		Acidic gases such as sulphur dioxide, as specified by the manufacturer.
K		Ammonia and organic ammonia derivatives, as specified by the manufacturer.
P	white	Particulates, which may include both solids and liquids
AX		Organic gases and vapours below 65°C
Hg		Mercury (maximum use time of 50 hours)
SL		Solid and liquid (oil based) particulates

Table 1 Filter Media.

For reusable half and full face masks in the University, the choice can sometimes be simplified to choosing either a **P3 particle/dust filter with no chemical absorption protection** or the larger, heavier ABEK (+Hg) with both particle and chemical protection (chemical protection being limited in line with the ABEK specification in the table above). However this obviously does not preclude the use of other filter types where appropriate.

NB: A 'standard' ABEK (+Hg) cartridge does not protect against carbon monoxide or nitrous gases, such as nitrogen monoxide, both of which require specialist filters which are designed for single use only and special guidelines apply !

Class of Protection:

The class of protection relates to the fraction of the material that the filter can remove. Protection factors are usually quoted as either the Nominal Protection Factor (NPF) or the Assigned Protection Factor (APF). The NPF is the maximum theoretical performance, whereas the APF is the actual performance that you might reasonably expect in practice if the mask is used correctly. It represents the protection achieved by 95% of those wearing the mask, who have been face fit tested, trained and are supervised. Be aware that in the worst case the NPF and the APF can differ by a factor of as much as 100, so it is essential to scrutinise the data given. Table 2 summarises the classes of protection.

Class of Protection	Typical Assigned Protection Factor (APF)
1	4
2	10
3	20, when fitted in a half-face mask, 40 when fitted in a full-face mask.

Table 2 Class of Protection Against Particles, BS EN 149

For a mask with an APF of 10, it follows that it can be used in atmospheres in which a contaminant is present up to a maximum factor of ten times the occupational exposure limit ie: 10x WEL.

Disposable 'Paper' Dust Mask Specifications:

FFP1 masks when fitted properly provide 80% protection against **dust*** (APF4)

FFP2 masks when fitted properly provide 94% protection against **dust** (APF10)

FFP3 masks when fitted properly provide 99% protection against **dust** (APF20)

* FFP1 disposable masks **NO NOT** provide adequate protection and should not be used with hazardous dusts in the University (1 in 5 particles could pass through the mask !).

There are a few specialised 'absorbent' disposable respirators on the market which are designed to **absorb 'nuisance levels'** of a specified substance, these are **only suitable for use below the WEL i.e. for 'nuisance smells'**, not as protection against potentially harmful gas or vapour exposure levels, since they have a very limited absorbent capacity. For protection against potentially harmful vapour or gas exposure levels a reusable mask with an appropriate cartridge is required, see table 1 above.

2.2 Choosing RPE

Once it is known what the contaminant is, and the degree of protection required, there remains the choice between the disposable or re-usable equipment.

The disposable equipment is cheap and lightweight, and cleaning and storage are not an issue. It is usually only available with filtering media that can protect against dusts, rated to BS EN 149. The minimum standard for protection for personnel working with animals has been the Class 2 (FFP2 for dusts), **however** a higher level of protection is afforded by a Class 3 (FFP3 for dusts) and the appropriate disposable dust masks are often suitable.

Reusable equipment is available in many variants. The simplest are quite similar to the disposable masks, with a single filter medium, rated to BS EN 149. However the family of re-usable equipment also includes half masks and full-face masks. The half mask covers only the nose and mouth and may be manufactured to BS EN 405, 1993, or BS EN 140, whereas the full-face mask protects the eyes as well and may be manufactured to BS EN 136.

Half masks may be disposable with fixed filters and intended to be discarded at the end of a prescribed time limit or when the filters become clogged, alternatively they may have replaceable filters. The former disposable type have a potential advantage in that if disposed of in under 30 days they do not require recorded maintenance and testing. The latter type is however more versatile, since a single mask can be used for a variety of uses with the correct filter cartridge. However, it will require recorded maintenance and testing and there is a danger that a mask might be picked up and used for a purpose for which the filter presently in it is not suited, so good management is essential.

Full-face masks incorporate replaceable filters and visors. Visors are available with impact resistance (up to BS EN 166 B, suitable for medium energy impact).

RPE that blows filtered air via a visor also have replaceable filters. This equipment has advantages where the working conditions are hot, since the forced ventilation over the face increases the comfort of the wearer. **However** if flammable vapours or gases are present consideration must be given to using 'intrinsically safe' - 'spark-proof' equipment.

2.3 Fitting and Checking Filtering RPE

RPE cannot give good performance if the wearer has a beard or other facial hair inhibiting the seal round the face, one day's stubble will prevent a correct face fit.

Unfortunately, even the daily growth of facial hair for some people may be sufficient to cause the seal between the mask and the face to fail by the end of a working day. If this is the case, other options, such as air fed hoods, should be considered.

In the case of full-face masks, wearers of spectacles may also experience difficulties, since the side arms of spectacles will interfere with the seal. For these people, other forms of RPE should be used. Spectacles can be worn inside hoods and blouses, but they can become dislodged and it is important to consider how the wearer might attempt to reposition his spectacles, and how this will affect performance of the RPE.

RPE is often available in a range of sizes, because people's faces are of differing sizes. The manufacturer's catalogue should be consulted for this information and it should be remembered that RPE from different manufacturers will suit different individuals.

Fitting Simple Disposable 'Paper' Masks:

Only use simple disposable face masks supplied with two elastic straps, **DO NOT** use 'single' strap masks as they will never form a good seal against the face! When fitting (donning) the mask, the top strap should go above the ears on the head and the bottom strap under the ears around the neck. Disposable masks with adjustable elastic straps allow adjustment to ensure the mask is held securely against the face. Masks with

adjustable elastic straps are therefore **much more likely to form an adequate seal against the face**, when used correctly, than those with simple non-adjustable straps. Having fitted the straps, use both hands to mould the metal nosepiece to fit comfortably to the shape of the wearer's nose, however do not use excessive force as this can distort the seal. If moving air can be felt against the eyes, this usually feels cool/cold, then the mask is leaking around the nose seal and it should be readjusted, if air flow is still detectable the face seal is inadequate and the mask unsuitable.

Note: Disposable masks with, two adjustable straps, a broad flexible foam rubber face seal and an exhalation valve are more likely to form a good face seal than those with no valve, non-adjustable straps and simple 'edge of paper' seals.

Reusable Masks:

Full face masks have several straps, and the wearer should be shown how to don the mask and adjust the straps correctly i.e. *'tightly and evenly'*.

To 'check' the seal after donning before each use, the front of the respirator should be covered with both hands, taking care not to disturb the fit, and the wearer should inhale sharply. A negative pressure should be felt inside the respirator. In the case of a full-face mask, the wearer should hold their breath after inhaling, to see whether there is leakage. Some face masks are supplied with a blanking plate to fit over the filter cartridge thereby sealing the mask and facilitating this method of leak testing (in such cases the sealing plate must be removed before use!). If the mask appears to be leaking, the position of the respirator and the head straps should be adjusted and the test repeated.

If moving air can be felt against the eyes, this usually feels cool/cold, then the mask is leaking around the nose seal and should be readjusted, if air flow is still detectable the face seal is inadequate and the mask must not be used.

2.4 Maintaining the Equipment

Many respirators used in the University are disposable throwaway items, and should be discarded after a single use.

Maintenance-free '28/30 day' RPE should be discarded if the filters become clogged or saturated or after 28/30 days.

Respirators that are designed for reuse should be cleaned with a soft cloth cleaner or specialist wipe, allowed to dry and stored correctly in a sealed dry container or bag to prevent contamination between uses (see Appendix 3). Reusable RPE will have the facility to change filters; this should be done whenever they become clogged or saturated. Care should be taken to ensure the filter is not contaminated during fitting and that it is fitted the correct way, often arrows on the filter indicate the direction of airflow.

Note: Breathing through any filter can cause the fibre medium to become 'damp' and if not allowed to dry this can impair efficiency and potentially result in bacterial or mould growth.

3 Respirators Supplying Breathable Air from an Independent Source (i.e. Breathing Apparatus aka BA)

It would be most unusual for BA to be specified as a control measure for any routine chemical exposure in a 'chemical laboratory' and should not be so specified without first consulting the Safety Office.

3.1 Factors Affecting the Decision to Use Breathing Apparatus

This type of RPE is commonly known as breathing apparatus (BA), because it supplies breathable air to the wearer from an independent source. It can potentially be employed in more hazardous areas than a filtering respirator. Nevertheless, it is essential to first observe the hierarchy of control measures, and to select the correct type of BA for an application, since not all equipment offers the same degree of protection.

BA can give protection against 'lack of oxygen' and 'toxic atmospheres', and is the only kind of protection suitable where the atmosphere is immediately life-threatening. It may also be suitable for a limited number of high risk operations, such as 'changing' cylinders of extremely toxic gas. It may also be suitable in certain emergency situations, such as the clearing up a spillage of a carcinogen, but only if the situation has been risk assessed, a safe system of work devised and there are at least two trained BA wearers/operators.

BA is NOT suitable for the use by University personnel to tackle fires or carry out any rescues, aside from the obvious risks, you would not be insured !

Successful rescue depends on a constant supervision of the persons at risk by professional personnel who are trained in rescue i.e. the emergency services.

Rather than planning to use BA the emphasis **must** always be to limit the probability of an issue occurring and to reduce the likelihood of someone being harmed as a result, e.g. by routing exhaust gases directly to fresh air or to return lines, by limiting the amount of gas or cryogen stored and used in the room, by designing the layout of the room so that people can always leave quickly if needed, and by provision of oxygen level meters to monitor the atmosphere and raise an alarm in good time.

Using BA for entry into a 'confined space' would require additional measures in line with the HSE Approved Code of Practice. This includes, an action plan for safe working, a risk assessment, a permit to work system, arrangements for communication, testing and monitoring of the atmosphere and emergency procedures. A laboratory in which the atmosphere becomes asphyxiating due to the release of a gas would fall within the 'legal definition' of a confined space.

3.2 Types of BA

This equipment includes two major types:

- Air-line breathing apparatus, fed from compressed air or fresh air, and
- Self-contained breathing apparatus (see below).

3.3 Selection and Training of Users of BA

While BA offers the greatest protection, it is also the most demanding to the wearer. Persons who will be required to use such apparatus must:

- Be physically fit and not seriously overweight
- Not suffer from claustrophobia or vertigo
- Have good eyesight
- Not be receiving regular medication or suffer from long term illness
- Be free from respiratory symptoms, such as asthma
- Preferably not have a beard, which may interfere with the seal of the face-mask.

Managers and supervisors must be aware of why the equipment is being used, and how it should be worn properly. Refresher training is also required, particularly for those who do not wear the equipment very often.

3.4 Storage, Maintenance and Testing

The safe system of work that has been documented in the risk assessment should include suitable storage arrangements for the BA. It is advised that breathing apparatus is stored in a secure area under lock and key to prevent persons who have not received adequate training and authorised from using it.

While people may challenge these security measures, it must be made clear that the apparatus is not for rescue purposes but only for planned operations involving certain hazardous materials.

BA should be cleaned and disinfected after each use. Rubber items may be washed with soap and lukewarm water, always following the manufacturer's instructions. It should then be thoroughly rinsed and dried before putting away.

BA should be examined and tested. Where it is in regular use, it should be thoroughly examined at least once a month, in accordance with the Recommendations of the Approved Code of Practice accompanying the COSHH Regulations¹. Examinations should include checking for signs of wear or damage to straps, face-pieces and valves.

BA which incorporates gas cylinders (which are pressure vessels) should be on a formal inspection and maintenance programme employing a competent person. There should be a log of such maintenance and inspection, and this should be available for scrutiny at all times. Records of examination, testing, and repairs of BA must be kept for 5 years¹.

3.5 Air-line Apparatus

In this type of apparatus the air is fed to the wearer via a hose. This can make the apparatus difficult and awkward to use, due to the need to reposition the hose if the wearer is moving about. The length of hose limits the distance that the wearer can move. It can be worn for extended periods of time, but it would not normally be used for atmospheres where there is an immediate danger to life. Some typical assigned protection factors are given – your attention is drawn to how modest some of these are. It is essential to check these with the supplier before making a final choice of equipment.

3.5.1 Compressed air-line breathing apparatus

If a compressed air source is used the air supplied must be of breathable quality, to BS 529: 2005, and this may require a filter to be fitted to the supply line. COSHH Regulations require the air to be tested for purity monthly and records of such tests to be kept for five years. The main types of apparatus are summarised below in Table 3.

Type	Assigned Protection Factor	Comments
Air line with hood	Up to 200	Can have up to 30 m hose. Should have low-flow warning device
Light duty air line with hood LDH1 LDH2 LDH3	10 20 40	Maximum hose length 10 m. A class of equipment that is commonly used for spraying applications.
Heavy duty air line with Half mask Full face mask, constant flow Full face mask, positive pressure demand	20 100 2000	The highest specification option is suitable for work in 'confined spaces'.

Table 3 Compressed air-line breathing apparatus

3.5.2 Fresh-air hose equipment

This equipment relies on the supply of uncontaminated air from outside the area to be fed by hose to the wearer. Where the apparatus is not power assisted, it relies on the wearer creating suction to draw fresh air into the hose. Thus any split or leak could result in contaminated air being drawn into the hose. The power-assisted equipment has a continuous flow of positive pressure air down the hose.

3.6 Self-contained Breathing Apparatus

This apparatus supplies air or oxygen to the wearer, generally from cylinders that are an integral part of the apparatus. The period of protection is determined by the capacity of the cylinders and the work rate of the wearer. This type of apparatus potentially provides the highest degree of protection to the wearer.

3.6.1 Typical generic types available

Open circuit types may be of the demand or demand with positive pressure type. Air is supplied on demand to the wearer from high-pressure cylinders via a pressure reducer and demand valve connected to a full-face piece. Exhaled air is passed through a non-return valve to atmosphere.

Closed circuit types re-circulate the exhaled air, filtering it to remove carbon dioxide, and topping it up with fresh supplies from the bottle.

The air supplied may be negative pressure demand, in which the suction generated in the facemask on inhalation opens a demand valve and allows air into the mask – with this equipment the pressure in the mask is lower than the surroundings, and there is a danger of ingress of contaminants if present.

In positive pressure apparatus, the equipment is designed to maintain a slight positive pressure above the surroundings, even when the user is inhaling. This ensures that normally any leakage is in the outward direction. However, maintaining a positive pressure may not always be successful if the wearer is working at a high physical work rate.

3.6.2 Self-contained breathing apparatus for escape or self-rescue

It is not envisaged that there are any applications for this equipment within Chemical Laboratories in the University of Cambridge, however if so, please consult the Safety Office.

3.6.3 Self-contained breathing apparatus for other purposes

The highest standard of protection is gained by using self contained breathing apparatus. However, it can only offer protection for a very short period of time, of order 15 minutes, due to the limited capacity of the gas bottles, and the seal of the mask is dependant on the wearer donning it correctly.

Section C: Further Reading

1. Control of Substances Hazardous to Health, COSHH ACOP and guidance, 2002 (6th edition; as amended 2013), L5, HSE
2. Occupational Exposure Limits, EH40, published by the HSE ie: EH40/2005 as amended.
3. Working with Man Made Mineral Fibres, HSE
4. Fit testing of respiratory protective equipment facepieces, HSE Information Document 282/28, HSE
5. Safe Work in Confined Spaces Regulations, 1997, Approved Code of Practice, Regulations and Guidance for the Confined Spaces Regulations, L101, 2014 HSE
6. Respiratory Protective *Equipment at Work, A Practical Guide*; 2013 HSG53 HSE

Section D: Appendices

Appendix 1: Worked Example of Risk Assessment and Selection of Filtering RPE

Description of the work Varnishing several doors in an indoor workshop, using polyurethane varnish. Operation done once in the year.	
Hazards The varnish contains a solvent, quoted in the safety data sheet as 'Mineral Spirits' (synonym for white spirit). This is a mixture known to cause irritation of eyes, nose, throat, dizziness and dermatitis. It is reported to act as a narcotic in high concentrations. EH40 gives a mixture calculation for white spirit giving a Workplace Exposure Limit of 550 mg m ⁻³ . The acute toxicity from inhalation of the vapour is low in normal use, however it can have chronic effects and as reported in the SDS 'may be fatal if swallowed and enters airways'. The solvent is flammable. It is a threat to the environment.	The risks The person is liable to be exposed to white spirit vapours as a result of their evaporation from the drying surface. Concentrations could be high. Toxicity is low, for single exposures. There is a risk of fire.
Who is liable to be affected Any person in the room, but particularly the person carrying out the varnishing.	The likely outcome The person may display symptoms as listed in the hazards. The building/person could be set alight if the solvent comes into contact with flame.
Control measures Avoid having naked flames, electric heaters, etc in the room. The worker should avoid getting the varnish on the clothing due to its flammability. Rags, etc that are used to wipe brushes, etc, should be disposed of carefully since they are potentially flammable. Thinners used to wash brushes must not be allowed to enter the drains, it is a hazardous waste. The room should be well ventilated by a trough draft (open all windows). The worker should wear a respirator rated for organic vapours (see Table 1) if the ventilation is inadequate (few or no windows or lack of adequate trough draft) to avoid symptoms of exposure appearing . Great care must be taken to avoid accidental ingestion by the users or others, all containers must be suitable, sealed when not in use and clearly labelled.	

Notes: The justification for using RPE in this instance is that the operation is a one-off for the person concerned and the acute toxicity of the solvent is low. This risk assessment arose from a real incident, where a carpenter presented himself to the Departmental Safety Officer of the Department concerned, complaining of numb lips and nose, and reporting that the smell was very strong. He had been wearing a dust mask, which did nothing to reduce exposure. After having been given a vapour filtering mask he reported that his symptoms rapidly subsided and he could no longer smell the spirits.

Appendix 2: Example Report Sheet aka 'certificate' for a 'Face Fit Test'

Report of Face Fit Testing of RPE	
Department of	
Name of person tested	
Research group/affiliation	
About the Facepiece Make of facepiece Model of facepiece Material of facepiece	Size of facepiece Serial number of facepiece Was this facepiece the subject's own, or a test facepiece?
About the Test Exercises performed: Normal breathing ☐ Deep breathing ☐ Turning head from side to side ☐ Moving head up and down ☐	Bending forward ☐ Talking out loud ☐ Normal breathing again ☐ Other ☐
Results Measured fit factor Pass/Fail	
Date of test	
Person performing test	
Notes Condition of test subject's own facepiece Did the test subject require help in donning and fitting the facepiece? How many repeat tests were needed to obtain a pass? Reasons for repeat tests	

Whilst formats may vary, a face fit certificate should as an *absolute minimum* include: the type of test, the name of the individual, the type, make and model of the mask, the test date, a clear statement of pass or fail and hand written the signature of the tester.

Appendix 3: RPE - Checking, Use and Maintenance Guidance Checklist

This document was written for use with the Sundström SR range of respirators (half masks), which are used by the Safety Office, however it could be easily adapted for use with the many other equally suitable respirators available in the UK, see manufacturer's instructions, for example 3M:

1. Before each use:

- Check that the mask is the correct size.
- Check that the mask is complete, correctly assembled and thoroughly cleaned.
- Check the mask body, valve membranes, membrane seats and harness for wear, cuts, cracks, missing parts, and other defects.
- Check that the appropriate filter is intact and installed properly.

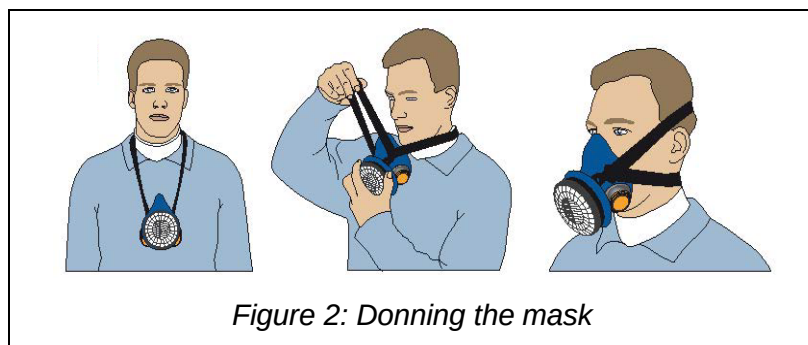
2. Fitting the filter:

- Check that you have selected the right filter and that the use-by date has not been passed.
 - A simple P3 particle filter is ONLY suitable for dust.
 - Gas/vapour filters are designed to remove gases or vapours. They do not necessarily protect against particles unless specifically specified to do so.
 - The A1BE2K1-Hg-P3 combined filter offers a broader range of protection against dusts, some chemicals (not all) and mercury vapour (see manufacturers specification).
- Fit the filter/combined filter in the mask so that the arrows on the filter point towards the user's face, the arrows point in the direction the air will flow. Carefully check that the edge of the filter is in the internal groove of the filter mounting all around.
- Fit the white pre-filter (coarse dust) in the pre-filter holder and press it into place on the filter.

3. Donning / Doffing (putting on / taking off)

3.1 Putting the mask on – aka 'Donning' (see Fig. 2 below)

- Remove any hood, glasses or ear protection from head.
- Holding the mask in one hand, grab the strap buckle and pull on the head strap until the pad is tight against the mask.
- Take out any twists or tangles.
- Holding the strap buckle, pull the strap over your head and put it around your neck.
- Let the mask hang on your chest.
- Grab the pad with one hand and the filter with the other.
- Hold the mask against your face.
- Pull the pad over your head and place it on the crown of the head.



3.2 Adjusting the harness

- Reach behind your neck and grab the free end of the harness strap.
- Pull the free end away from the neck until buckle pops open.
- Pull on the free end of the strap until the respirator seats comfortably on your face.
- Use your thumb and forefinger to squeeze the buckle shut.
- Wiggle the respirator until it seats comfortably.

3.3 Fit check

Use the airtight test disc SR 322 supplied to check whether the mask is tight.

- Place the dark grey test disc in the pre-filter holder and fit the holder to the filter.
- Put the mask on.
- Take a deep breath and hold your breath for about 10 seconds.

If the mask is tight, it will be pressed against your face. N.B. The test disc is intended for use only for facial fit testing under test conditions, **REMOVE AFTER THE TEST, BEFORE USE !**

3.4 Taking the mask off – aka ‘Doffing’

Do not take off the mask until clear of the hazardous area.

- Grasp the filter with one hand and the head pad with the other.
- Pull it forward over your head.
- Pull down the respirator until it rests on your chest.
- Reach behind your neck, grab the strap buckle and pull the head harness forward over your head and remove the mask.
- Clean and store the dry mask in an appropriate container.

4. Usage, Maintenance and Examination

4.1 Usage

It is essential that a record of the fit check be made each time the mask is used. If you cannot achieve a proper fit, do not enter the contaminated area.

It is good practice to record the duration of time the mask is worn. This can be done on the Fit Check / Usage Record sheet below.

4.2 Cleaning after each use

The filter should be removed and both the interior and exterior surfaces of the face piece wiped carefully with cleaning tissues, or other proprietary hard surface disinfectant wipes. When dry, the mask should be reassembled and stored in a suitable container, such as a purpose made storage box (available from Sundström).

Keep your mask away from direct sunlight (UV) or sources of heat.

If the mask is heavily soiled, use a warm (up to +40 °C), mild soap solution and a soft brush, followed by rinsing with clean water and drying in air at room temperature.

Proceed as follows:

- Remove the filter, the covers for the exhalation valves and the membranes, the inhalation membrane and the head harness.
- Clean as described above. Critical areas are the exhalation membranes and the membrane seats, which must have clean and undamaged contact surfaces.
- Inspect all parts and replace with new parts as necessary.
- Leave the mask to dry, and then assemble it.

N.B. Never use solvents or abrasive/corrosive chemicals for cleaning.

4.3 Examination

Examinations should be carried out regularly, monthly when in regular use or if only used occasionally, before use and in any event, at least every three months. The examination can be recorded on the Filter/Mask Inspection Record sheet below. The sheets must be kept for the life of the respirator, which should not exceed five years.

Items requiring Examination	Notes
1. Head Harness	Are the head straps intact and do they have good elasticity (still stretchy and not puckered)?
	Is the strap adjustment catch working and free from damage?
2. Face piece / Mask body	Is the face piece free from cracks, tears, distortion and dirt?
	Is the face piece material pliable?
3. Valves /Membranes [§]	Is the inhalation valve / membrane free from cracks, tearing and dirt? *
	Are the exhalation valves / membranes free from cracks, tearing and dirt? * In order to visually examine the exhalation valves, it is first necessary to carefully unclip the plastic valve cover using the projecting tab.
	Is the plastic valve cover free of signs of cracking or fatigue?
4. Filters	Is the white pre-filter clean and unclogged?
4a. P3 Dust Filters	Is the main filter within its expiry date?
	Is the main filter unclogged (i.e. can you draw air through the filter when breathing without undue / unusual effort)?
4b. A1BE2K1-Hg-P3 Filter	In addition to 4. and 4a. above, the filter should be changed at regular intervals, if there is reason to believe that the chemical absorbent has become saturated, and in any case not exceeding 50 hours of use.

[§] Sundström recommend that the valve membranes are changed annually. Therefore, once a year the mask and its inspection record should be returned to the Departmental Safety Officer for 'servicing' and auditing.

* The valve membrane (the thin orange rubber disc) is potentially vulnerable to damage and therefore must be handled with great care. If damaged the mask must be withdrawn from service pending valve replacement.

History

2016 reviewed with minor modification 2020

HSD009C (rev4)

© University of Cambridge
Occupational Health and Safety Service
Greenwich House
Maddingley Road
Cambridge
CB3 0TX
Tel: 01223 333301
Fax: 01223 330256

e-mail: safety@admin.cam.ac.uk
www.safety.admin.cam.ac.uk/

This guidance note contains illustrations that have been scanned from HSG53, "The selection, use and maintenance of respiratory protective equipment"

© Crown copyright material is reproduced with the permission of the Controller of HMSO and Queen's Printer for Scotland.