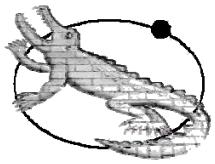
A Code of Practice for the Selection and Use of Personal Protective Equipment in the Department of Physics



Scope

This document outlines the conditions under which personal protective equipment (PPE) should be used, the selection process, the training in its use, and the care and maintenance of the equipment. It includes footwear, gloves, eyewear, head protection, respiratory protection and hearing protection.

Contents

1 Introduction and Definition of Personal Protective Equipment (PPE)

Personal protective equipment is clothing that protects the wearer from hazards – for instance welding goggles protect welders from eye damage. In the process for managing risk, personal protective equipment (PPE) is always taken as the last resort, since it only protects one person – the person who is wearing it.

> Hazards, and the risks that arise from them, should always be avoided by engineering control measures where reasonably practicable, leaving the use of PPE as the final layer of control.

However, there are certain situations where PPE is essential, and an example would be when pouring acid from one container to another. Similarly, for a specialised application, such as the occasional need to change over from a spent gas cylinder of toxic gas to a fresh one, extensive PPE would be justified.

All items of PPE manufactured after 1995 must carry the CE mark to denote compliance with European Directives. If you have equipment that is not so marked it may either be so old that its protection value is questionable, or it is not manufactured to any standard and is likewise questionable. There was a short period in which CE marked equipment also carried the date of manufacture – this may be useful in determining whether an item may be beyond its useful life.

Personal protective equipment must be compatible with

- The wearer
- The work to be done
- Any other PPE that is to be worn, such as helmets, shoes, etc.

This can present quite a challenge!

2 Footwear

2.1 Situations where footwear might be specified

Safety shoes or boots are generally specified for people who are exposed to the following types of risk:

- Working in environments where heavy or sharp objects may get dropped on their feet – this would include those working in workshops, metal stores, and other staff who move heavy apparatus or materials on a routine basis.
- Places where molten metal might splash onto the feet – this would principally be during welding operations.
- Places where there is a potentially serious slip hazard, which remains despite efforts to remove it at source (this might include kitchens),
- Places where there is a risk of a sharp object piercing the soles (e.g. on a building site, in a metal workshop),
- Places where there is a need to avoid build up of static charge, where there is a risk of fire and explosion.

There are instances of the first four situations in the Department, the last one is less likely.

2.2 Types of footwear available

Safety shoes to protect against impact are specified by the protection in Joules. Generally there are two grades of protection – 100 Joules and 200 Joules. The protection offered by

200 Joules is equivalent to protection against a 20 kg weight being dropped from a height of 1 metre. It is recommended that nothing less than 200 Joules protection, BS EN 345, is chosen for any workshop activity.

Soles of safety footwear usually have excellent slip resistance, but there are various enhanced designs to choose from. Additional features, if required, are shoes or boots that are heat resistant, antistatic or oil resistant.

For the fashion conscious, the range of safety footwear goes from trainers to boots, and includes types specifically styled for women.

3 Gloves

3.1 Typical situations where gloves are specified

Gloves should be used in the following cases:

- To protect against accidental contact with chemical substances or biological hazards,
- To protect against abrasions and general mechanical hazards, e.g. when moving bricks and rubble, or when handling gas cylinders. **NB Gloves should NOT be worn when using machinery – they can catch in moving parts. USE GUARDS.**
- To protect against extreme cold, for example when decanting liquid nitrogen via un-insulated pipework.
- To protect against heat – e.g. when welding or cutting, or when taking things out of an oven or furnace
- To give a good grip
- To protect against electricity, or to have anti-static properties

For each case, the glove specification is different. The requirements for the first five are outlined below.

3.2 Selection of appropriate gloves

Protection against chemical substances and micro-organisms

Gloves and gauntlets designed to protect the wearer against chemical hazards and micro-organisms are classified under BS EN 374.

Gloves to protect the wearer against chemical substances will fail in one of three ways:

- Permeation – in which the chemical agent migrates through the glove at a molecular level
- Penetration – where the chemical agent flows through closures, porosity, seams or other imperfections in the glove
- Degradation – where a damaging change in the physical properties of the glove results in exposure to the agent.

Thus the selection process should take into account the agent(s) to be protected against, and the expected performance of the glove material. Proper selection must also take into account the needs of the wearer. There should be adequate facilities for disposal of contaminated gloves. They are normally ‘black bag’ waste, unless they are extremely heavily contaminated, whereupon they may become ‘hazardous chemical waste’. Users need to be trained in the correct way to put the gloves on, and to take them off. Gloves may increase the risk to health if this is not done because contaminant may get inside the glove to reside permanently against the skin and cause greater exposure than would be experienced without the glove. Wearing the glove may lead to excessive sweating of the hand, which is irritating. Finally natural rubber (latex) can cause allergic reactions in some individuals.

The table below gives recommendations for the most suitable glove for a given application (source HSE guidance note INDG330)

Chemical family	Glove type					
	Natural rubber (latex)	Nitrile	Neoprene	PVC	Butyl	Viton
Substances that are miscible with water, weak acids and alkalis	✓	✓	✓	✓		
Oils		✓				
Chlorinated solvents						✓
Aromatic solvents						✓
Aliphatic solvents		✓				✓
Strong acids					✓	
Strong alkalis			✓			
PCBs						✓

These are only very general recommendations. A detailed analysis of breakthrough times under conditions of total immersion can be obtained from the Oklahoma State University Chemical Guide. http://www.pp.okstate.edu/ehs/hazmat/Perm1.htm . Contact the supplier of the gloves to check their performance before buying.

Latex is a material that can cause allergies and, as such, it is itself a substance hazardous to health. Using latex gloves requires written justification. Since the risk is increased with powdered gloves, only POWDER-FREE gloves may be used. Health surveillance is required in order to detect any allergic reactions to the gloves.

Gloves to protect against micro-organisms are also classified under BS EN 374.

Protection against mechanical hazards

Gloves classified under BS EN 420 offer protection against superficial cuts, abrasions and mild detergents. They are suitable for general handling and **light** site work, packing, gardening and kitchen work.

Mechanical protection for intermediate risks is classified under BS EN 388, with four rated categories:

Abrasion	Performance index 1-4 (1 is the lowest performance rating)
Blade cut	Performance index 1-5
Tear	Performance index 1-4
Puncture	Performance index 1-4

A glove classified under this system could therefore have four performance indices associated with it. An X would indicate that a particular test was not appropriate (e.g. puncture in a knitted glove). These gloves are suitable for heavier handling tasks such as sheet metal handling, glass handling and refuse collection.

Protection against cold

The British Standard for these gloves is BS EN 511. If cold liquids are being handled, it is important to choose gloves that cannot soak up the liquid, and it is desirable to have gloves that will not allow liquid to dribble down inside and become trapped next to the skin.

Protection against heat

Gloves and gauntlets for use when welding and thermal cutting should be approved to BS EN 407. These have no external seams to burn.

For less demanding applications, such as protecting the hand when withdrawing items from furnaces, or for kitchen wear, or for more specialised requirements, consult a supplier's catalogue.

4 Eyewear and Facewear

4.1 Situations where eyewear or facewear should be specified

The eyes and face are very vulnerable to damage, and eyesight is precious. Although the risk of injury should be controlled for preference by engineering controls, there will always be occasions where protective eyewear and/or facewear is advised. These include:

- Pouring a liquid that could damage the eyes, either due to its chemical nature (corrosive, harmful, irritant or toxic) or to its temperature, e.g. liquid nitrogen, acids, alkalis, carcinogens, solvents.
- Working with power tools that produce dust and debris, or where the break-up of a tool is foreseeable, e.g. electric drills, grinding machines.
- Working with chemicals that produce irritant vapour, e.g. ammonia.
- Working with sources of radiation – heat or light, e.g. glassblowing, welding, some laser activities.
- Working with molten metals
- While performing chemical reactions
- While using an air hose.
- When working with a gas or liquid under pressure
- Any other situation where the risk assessment identifies a risk to the eyes or face that cannot be engineered out.

4.2 Selection of appropriate eyewear

Flying debris and liquids

When choosing spectacles or goggles for protection against flying debris, the table below (markings from BS EN 166) give some advice on what is available.

	Frame	**Lens**
Mechanical strength		
Increased general robustness, tested by 22 mm ball at 5.1 m s^{-1}		S
Low-energy impact resistance, tested by 6 mm ball at 45 ms^{-1}	F	F
Medium energy impact resistance, tested by 6 mm ball at 120 ms^{-1}	B	B
High energy impact resistance, tested by 6 mm ball at 190 ms^{-1}	A	A
Field of use		
Liquid chemicals	3	
Large dust particles (> 5μm)	4	
Gas and fine dust particles	5	
Short circuit electric arc	8	
Molten metals and hot solids	9	9
Resistance to misting		N
Resistance to surface damage (scratches)		K
Optical class		
Refractive tolerance + 0.06 dio.		1
Refractive tolerance + 0.12 dio.		2
Refractive tolerance +0.12/-0.25 dio.		3

For an operation such as grinding, you should choose medium impact resistance as the minimum. You would also choose a face shield to that standard rather than simple goggles, because of the added protection you would obtain.

When handling liquids, goggles are preferred to spectacles, due to the protection that they give around the lenses. All too often, accident reports show that liquids and debris enter the eye from around spectacles. However, the disadvantage of goggles is that they can mist up, and become difficult to wear. A face-shield can sometimes overcome both these problems.

Protection against radiation (arc and heat)

Welding eye protection is described in BS EN 169, and there is a selection chart for shade numbers. An abbreviated version is given below:

Process	Current range (A)	Shade number
MMA	< 40	9
	40 – 80	10
	80 – 175	11
	175 – 300	12
	300 – 500	13
	> 500	14
MIG, heavy metals	< 100	10
	100 – 175	11
	175 – 300	12
	300 – 500	13
TIG	< 20	9
	20 – 40	10
	40 – 100	11
	100 – 175	12
	175 – 250	13
Oxyacetylene welding	Less than 70 litres acetylene per hour	4
	Between 70 and 200 litres per hour	5
	Between 200 and 800 litres per hour	6
	Over 800 litres per hour	7

For applications not in this table, ask the Safety Officer.

Laser eyewear

There are two British Standards relating to Laser eyewear: BS EN 207 and BS EN 208. Any laser eyewear that does not meet these standards is likely to be unsuitable, and should not be used without the express approval of the Health and Safety Executive. Note that laser eyewear **DOES NOT** allow you to safely view the beam – it is only protection against accidental exposure.

BS EN 207 deals with filters used for personal eye protection against laser radiation in the range 180 nm to 1 mm. It deals both with the transmission characteristics of the eyewear and the performance of the frames. The eyewear is marked with a code to indicate :

The wavelength or wavelength range against which protection is afforded
The scale number or lowest scale number
The manufacturers ID
The test mark of the inspection body.

Filters manufactured to BS EN 207 have been tested for stability against radiation for 10 seconds for continuous wave devices, and 100 pulses for pulsed devices.

Markings for laser eyewear

Symbol	Laser type	Pulse duration /s	No. of pulses
D	CW	10	1
I	Pulsed	10^{-4} to 10^{-1}	100
R	Giant pulsed	10^{-9} to 10^{-7}	100
M	Mode coupled pulsed	$< 10^{-9}$	100

Example:
Goggles marked D 652 L7 CE95 ZZ

D indicates that they are intended for a CW laser
652 indicates that they are for 652 nm only
L7 indicates an optical density of 7. They have a spectral transmittance at 652 nm of 10^{-7}
CE95 is the European test mark
ZZ is the mark of the Approved Inspection Body.

BS EN 208 deals with eyewear for laser adjustment work.

Further advice on the choice of eyewear is in the Department Code of Practice for lasers, and the Department Laser Supervisor or Safety Officer should be consulted.

4.3 Care of eyewear

Eyewear is easily damaged. Some lens materials are susceptible to attack by solvents, so care should always be taken not to spill these on the eyewear. All eyewear is damaged by abrasion. Always follow the instructions for cleaning, to minimise the damage that is done to the eyewear. Never leave eyewear lying about on benches, etc, where they may get dust on them, or get scratched. Put them away in a container, or at least hang them up out of harm's way.

Eyewear should be examined before use, and any that has been damaged must be replaced.

5 Respiratory protection

5.1 Situations where respiratory protection should be specified

In common with all other PPE, respiratory protection is the last resort, and is only to be used after other means of controlling exposure have been considered. Such circumstances might include where:

- Exposures exceed the occupational exposure limit, and control measures are in the process of being installed.
- Maintenance work is being carried out, and staff need to enter areas with high contamination levels to service equipment.
- Employees need RPE for escape in the event of plant failures.
- Exposures are of short duration (e.g. connection of gas cylinders) and the permanent installation of other protective measures is not reasonably practicable.

There are two major classes of RPE:

1. Equipment such as face masks, with filters, also powered respirators with filters, which take in contaminated air from the workroom and filter it before supplying it to the wearer. These devices are all known as respirators; and
2. Air-fed apparatus, which takes uncontaminated air from an independent source and supplies it to the wearer. These include air-line breathing apparatus, and self contained breathing apparatus.

Dusts are generated when solid materials are broken down into fine particles. These will float about in the air and settle due to gravity. Processes such as grinding and sawing will produce dusts.

Mists are airborne droplets, produced by the atomisation of a liquid or the boiling and condensation of a liquid. Mists can be created by spraying, mixing, pump exhausts.

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 metals or polymers, or pouring of molten metal. When choosing respiratory protection, the word FUME has only this meaning, it does NOT mean exhaust fumes, or the fumes from acids, etc.

Vapours and gases come from solvents, gas supply cylinders, etc.

It is important to realise that a mask intended for particulates will not be effective against vapours and gases, and vice versa. Some types will fulfil both functions, but READ THE ACCOMPANYING LITERATURE.

Before selecting respiratory protection, you must have been able to answer the following questions:

1. Is the atmosphere fit to breathe (i.e. is there sufficient oxygen)?
2. Is the contaminant a dust, fume, gas or vapour?
3. What is the relevant occupational exposure limit?
4. What is the concentration of the contaminant in the atmosphere?

Before using respiratory protective equipment, users should be trained in the correct way to put it on and obtain an air-tight seal. Without this skill, the equipment will be ineffective, and the wearer will be exposed to the contaminant.

5.2 Selection of appropriate respiratory protection for dusts and fume

Protection factors

Respirators are classified in BS EN 149 according to the degree of protection that they give. A respirator that does not bear a CE marking can only be expected to filter out large particulates, and should generally not be used. CE marked filters will be marked P1, P2 or P3, and the meaning is as follows.

Designation	Theoretical protection factor (multiple of the Occupational exposure standard)	Assigned protection factor (what is likely to be attained in practice)
P1	4	4
P2	12	10
P3	50	20

Categories of disposable respirators have been simplified from 2001, so that all disposable respirators have to meet the oil mist test. The designations for these will change according to the table below.

Old EN149	Category	New EN 149	Category	Assigned protection factor
EN 149	FFFP1	EN 149:2001	FFFP1	4
EN 149	FFFP2S FFFP2SL	EN 149: 2001	FFFP2	10
EN 149	FFFP3S FFFP3SL	EN 149: 2001	FFFP3	20

The designation ‘S’ referred to the mask’s ability to filter solids only, and ‘SL’ its ability to filter solids and liquids. From 2001 all masks have to be able to meet both criteria.

In use, contaminated air is drawn in through the filter medium by the wearer’s own effort. Except in the most simple type of dust mask, exhaled air goes back to atmosphere via a non-return valve in the mask. The lifetime of the filter mask is dependent on the concentration of contaminant that it has to deal with, and resistance to breathing increases as the dust mask becomes clogged.

The possibility of leakage around the seal to the face is reduced by using a mask that uses an electric fan to draw in air through the filter and feed it to the breathing zone of the wearer.

Worked example: a dust, which has an Occupational Exposure Limit of 5 mg m^{-3} may be present in concentrations up to 60 mg m^{-3}. Which filter should be used?

The filter will need to reduce the concentration by a minimum of a factor of 12. Even though a P2 would nominally be suitable, this assumes peak performance. A P3 should be chosen.

5.3 Selection of appropriate respiratory protection for gases and vapours

These filters have carbon in them. They have their limitations – if the vapour is from a liquid with boiling point less than 65^{o}C, the contaminant may not be captured by the filter. Some manufacturers offer special filters for low-boiling point liquids. Dusts will also generally pass straight through this type of filter. Where both dusts and vapours or gases are present it may be necessary to wear two filters, and respirators designed for this are available.

Filters are often designated 'ABEK', due to the codes:

A Organic vapours
B Inorganic vapours
E acid gases
K ammonia

A filter respirator MUST NOT BE USED for:

1. oxygen deficient atmospheres
2. in enclosed or confined spaces
3. in atmospheres immediately dangerous to life or health
4. in atmospheres where the concentrations and identity of the hazard are unknown
5. for protecting against gas or vapour with poor warning properties, e.g. taste, odour or irritation.
6. in concentrations greater than those for which the filter is rated or the Regulations permit.

5.4 Equipment supplying breathable air to the user

The source of the air for this apparatus may be a compressed air line, via a hose to fresh air, or complete self-contained breathing apparatus. The air or oxygen supply may be demand, assisted, constant flow or with positive pressure. The apparatus comes with a choice of masks – some with full-face, others with hoods, helmets, visors or a full suit.

Compressed air supplied equipment is suitable for protection against exposure to sensitising agents such as isocyanates. If the equipment has a visor, as opposed to a hood, it is not suited to use where there is a danger or being overcome, due to the leakage around the visor. The quality of the compressed air must meet the standard BS4275.

Fresh air hose equipment: hoses for this equipment need to be sufficiently strong to withstand rough usage. Standards for this equipment are BS EN 138, 139, 269, 270.

The highest degree of protection is offered by self contained breathing apparatus, where the equipment comes with its own air or oxygen supply. Persons who will be required to use such apparatus must:

- Be physically fit
- Not suffer from claustrophobia or vertigo
- Not be seriously overweight
- 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.

Such apparatus may be appropriate in the following circumstances:

- Changing a gas cylinder, where the contents are very toxic
- Entering a contaminated area in order to shut down apparatus or make the situation safer
- Entry into a confined space under a permit-to-work system.

It is recommended that these activities are not carried out without a second trained person with a complete set of breathing apparatus being in attendance.

Breathing apparatus is **not suitable for rescue**, with the sole exception of a properly planned and rehearsed scheme, perhaps associated with entry into a confined space. In order to be effective as rescue, someone should always be in readiness, monitoring the situation. In any situation where the atmosphere is immediately dangerous to life or health, there should be continuous supervision from a safe area with rescue equipment always available.

Breathing apparatus requires a high standard of training and maintenance. Wearers must be trained to use the equipment, how to wear it, and what its limitations are. Managers and supervisors must also be aware of why the equipment is being worn, and how it should be worn properly. Refresher training is also required, particularly for those who do not wear the equipment very often.

5.5 Care of equipment.

Estimates of the cartridge life of the RPE should be made when undertaking risk assessment. Dust and particulate filters will become clogged when heavily contaminated, and breathing will become more difficult. Filters for vapours, when spent, will allow the contaminant to pass right through. At this stage it is important that the wearer leaves the contaminated are and obtains a new filter.

Filters should not be left lying about in dust laden atmospheres, where dust may then settle on the inside of the mask. They should be put away in a clean place.

RPE should be examined before use, with particular attention paid to the harnesses, rubber parts that ensure a good seal. Manufacturer's maintenance schedules and instructions should be adhered to in respect of cleaning, disinfection, examination, repair, testing and record keeping.

6 Hearing Protection

6.1 Situations where hearing protection should be specified

Reference: The Control of Noise at Work Regulations, 2005

Like all other hazards, the priority is to reduce the noise at source. Improvements over the long term may be made through the buying policy – seeking out machinery with quieter operation. Sometimes it is possible to reduce exposure to noise by enclosing a machine, or mounting it differently. It is possible to isolate people from noise by giving them sound-proofed refuges.

Ultimately, if the environment is still too noisy, then hearing protection may be necessary. The action levels for noise are as follows:

- Between 80 dB(A) and 85 dB(A) daily or weekly personal noise exposure and a peak sound pressure of 135 dB (C weighted) is the lower exposure action level.

- Above 85 dB(A) daily or weekly personal noise exposure and a peak sound pressure of 137 dB(C) is the upper exposure action level
- A daily or weekly personal noise exposure of 87 dB(A) and a peak sound pressure of 140 dB(C) is the exposure limit.

If all reasonably practicable measures have been taken to attempt to reduce the noise exposures to below the lower exposure action level have been taken, but these levels are still exceeded then hearing protection shall be used as follows:

- If the personal noise exposure exceeds the lower exposure action level but does not exceed the upper exposure action level then hearing protection must be provided on request to any employee so exposed,
- If the upper exposure action level is exceeded, hearing protection is mandatory. That is, it must be provided and it must be worn.

In order to discover whether these limits are reached, you need a noise assessment. You will know that you need a noise assessment if there is anywhere, where people work, where you have to shout to make yourself heard by someone standing a metre away from you.

6.2 Selection and use of appropriate hearing protection.

The aim is to bring the exposure of the wearer down as far as reasonably practicable, but at least below 80 dB(A). Noise is rarely 'white' so it is appropriate to do an octave band assessment of the noise source, and to choose hearing protection with optimum performance in the frequency ranges concerned. Reputable manufacturers give performance graphs, obtained by a test method in accordance with BS EN 352, to show the expected attenuation as a function of frequency.

It is a common misconception that wearing hearing protection makes it difficult to communicate by speech with others, but research has shown that while the overall noise level is reduced, the contrast is the same between the speech and the background. Hearing protection improves communications in noisy areas.

There are two types of hearing protector:

Muffs , whose performance depends on the airtight seal to the head, all round the ear.
Plugs, which go straight into the ear canal.

When choosing hearing protection, you should bear the following in mind:

- Directional sound, particularly if incident from above or below the ear is attenuated much less than the manufacturers' performance figures would suggest, due to the poorer seal round muffs above and below the ear.
- The plastic seals on the muffs will deteriorate over time, and the head band is liable to degrade, reducing the performance
- Safety glasses/goggles reduce the effectiveness of muffs by up to 5 dB.
- Ear plugs are reduced in effectiveness by as much as 22 dB if they are fitted incorrectly.
- Taking the protectors off for even a short time, can dramatically reduce the protection achieved. For example, a 30 dB protector, which is removed for only 5 minutes out of an eight-hour day, is reduced in effectiveness to only 20 dB.

In view of the warnings above, choose hearing protection with as high a factor of safety as possible.

6.3 Care of equipment

Muffs should be kept clean, and the seals replaced if they degrade. Some makes have replaceable ear cushions and foam cup inserts. If the head band becomes ineffective, they need to be replaced. Do NOT drill holes in the cups for ventilation!

In the use of ear plugs, hygiene is paramount, otherwise they can be the source of irritation and infection. Many types are throw-away items, and others are washable. Ear plugs must be fitted correctly, and this requires some instruction.

7 Other Clothing

7.1 Head protection

The Standard to look for in the selection of head protection is EN397. Protection may be quoted to molten metal, electricity, and suitable temperature range for use.

It is important to choose head protection with a view to compatibility with any other personal protective equipment that is required. Some hard hats come with a range of clip-on accessories, including hearing protection and face protection or various designs.

Hard hats have a limited life. It is strongly recommended that they are replaced every five years, and if they have been subjected to excessive wear and tear they will need replacement more often.

Bump caps, as opposed to helmets, protect only against minor bumps and scrapes and are marked under BS EN 812. These can be disguised as baseball caps, making them more acceptable to the wearers.

7.2 Overalls and Lab Coats

Most lab coats and overalls are not true personal protective equipment, but are to protect your normal clothing from damage. Choosing the style and thickness is generally a matter of personal preference.

Outer clothing is available to protect against chemical hazards, flame and static properties, for specialised uses. For welding, it is appropriate to select clothing manufactured to EN470, since this will not only have been fabricated of a suitable material, but the design will have ensured that, for instance, spatter cannot get into the pockets.

7.3 Jackets and trousers for improved visibility.

Jackets and trousers which are yellow or orange, with reflective strips, enable the wearer to be seen more readily. For situations where high visibility is important, such as working in poor light or adverse weather conditions on site (e.g. field work), you should choose clothing classified under BS EN 471, which specifies the background and reflective material. Class 1 is adequate for uses other than on the roads (the higher classes are for higher risk operations, including work on the highways).