GUIDELINES NO. AERB/SG/IS-3

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GOVERNMENT OF INDIA

AERB SAFETY GUIDELINES

PERSONAL PROTECTIVE EQUIPMENT

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDELINES NO. AERB/SG/IS-3

PERSONAL PROTECTIVE EQUIPMENT

Atomic Energy Regulatory Board
Mumbai - 400 094
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Orders for this guidelines should be addressed to:

The Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai - 400 094
India

FOREWORD

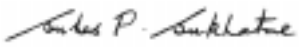
The Atomic Energy Regulatory Board (AERB) constituted by the Government of India vide Statutory Order No. 4772 dated November 15, 1983 was entrusted with the responsibility of enforcing safety and regulatory functions envisaged under the Atomic Energy Act, 1962. AERB is responsible for enforcing safety in all atomic energy related activities within India as well as for enforcing the provisions of the Factories Act, 1948 in all units of the Department of Atomic Energy (DAE). In discharging these responsibilities, AERB has been drawing up codes, guides, standards and manuals to facilitate the concerned organisations in implementing the necessary safety regulations.

The Guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods. It combines the following eight information booklets of AERB issued in 1992 and gives updated and comprehensive information regarding personal protective equipment in a single document.

No.	Title
PPE-1	Helmets.
PPE-2	Safety Footwear.
PPE-3	Respiratory Protective Equipment.
PPE-4	Arm and Hand Protection.
PPE-5	Eye and Face Protection.
PPE-6	Protective Clothing and Coverall.
PPE-7	Ear Protection.
PPE-8	Safety Belts and Harnesses.

The relevant standards of Bureau of Indian Standards (BIS) have been extensively used in preparation of the document. It also takes into account the statutory requirements as laid down in the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

This document has been prepared initially by Dr. R.K. Kapoor, Former Head, Industrial Safety Group, Nuclear Power Corporation of India Limited. Subsequently it was reviewed by the staff of Industrial Plants Safety Division of AERB, by Shri K. S. Somayaji, Former Head, Industrial Hygiene and Safety Section, Health Physics Division, Bhabha Atomic Research Centre and by other professionals. AERB thanks all individuals who helped in its drafting and finalisation.



(Suhas P. Sukhatme)
Chairman AERB

DEFINITIONS

Ageing

General process in which characteristics of structures, systems or component gradually change with time or use (although the term 'ageing' is defined in a neutral sense - the changes involved in ageing may have no effect on protection or safety, or could even have a beneficial effect - it is commonly used with a connotation of changes that are (or could be) detrimental to protection or safety, i.e. as a synonym of 'ageing degradation')

Competent Authority

Any official or authority appointed, approved or recognised by the Government of India for the purpose of the rules promulgated under the Atomic Energy Act, 1962.

Contamination

The presence of radioactive substances in or on a material/the human body or other places in excess of quantities specified by the competent authority.

Inspection

Quality control actions, which by means of examination, observation or measurement determine the conformance of materials, parts, components, systems, structures as well as processes and procedures with predetermined quality requirements.

Luminous Transmittance

The ratio of the transmitted luminous flux to that of the incident luminous flux.

Quality

The totality of features and characteristics of an item or service that have the ability to satisfy stated or implied needs.

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1. INTRODUCTION

1.1 General

The primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workmen through use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, automation, etc. In situations where it is not possible to introduce any effective engineering methods for controlling hazards, the workman shall use appropriate types of PPE. For example, in construction work there is the possibility of a hand tool, a bolt, or some loose material to fall from an elevated level and strike the head of workman below. It is therefore necessary that the construction worker wears a safety helmet. It is for such situations, both the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996 have provisions for use of appropriate type of PPE.

Use of PPE is an important and necessary consideration in the development of a safety programme. Once the safety professional decides that PPE is to be used by workmen, it becomes essential to select the right type of PPE and the management should ensure that the workman not only uses it but maintains it correctly.

1.2 Quality of PPE

PPE must meet the following criteria with regard to its quality:

(i) provide absolute and full protection against possible hazard; and

(ii) it be so designed and manufactured out of such material that it can withstand the hazard against which it is intended to be used.

1.3 Selection of PPE

Selection of the right type of PPE requires consideration of the following factors:

- nature and severity of the hazard,

- type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air,

- expected activity of workman and duration of work,
- comfort of workman when using PPE,
- operating characteristics and limitations of PPE,
- ease of maintenance and cleaning, and
- conformity to Indian/International standards and availability of test certificate.

1.4 Proper Use of PPE

Having selected the proper type of PPE, it is essential that the workman wears it. Often the workman avoids using PPE. The following factors influence the solution to this problem:

- the extent to which the workman understands the necessity of using PPE,
- the ease and comfort with which PPE can be worn with least interference in normal work procedures, and
- the available economic, social and disciplinary sanctions which can be used to influence the attitude of the workman.

The best solution to this problem is to make 'wearing of PPE' mandatory for every employee. At other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time, clear and reasonable instructions shall be given to them as to why PPE must be worn.

Another way to overcome the reluctance of the workman to use PPE is to allow him to choose a particular style of PPE from a group of different styles pre-selected to meet the job requirements. This would require the concerned company to maintain a stock of different styles of PPE at plant premises.

In organisations where risky jobs are carried out by contract workmen, it is generally noticed that the PPE is provided by the contractor. Sometimes the contractor may not provide it at all or if he does provide, it may be of substandard quality. This needs to be strictly controlled by management of the organisation.

As an added incentive to wearing PPE, some organisations sponsor 'recognition awards' for those protected from injury on account of wearing PPE. 'Behaviour Analysis' of workmen can be carried out to encourage them to wear PPE. An example of such an analysis is given in Annexure-I.

1.5 Categories of PPE

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories:

(i) non-respiratory: those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts, and

(ii) respiratory: those used for protection from harm due to inhalation of contaminated air.

The applicable BIS (Bureau of Indian Standards) standards for different types of PPE are given in bibligraphy.

2. HEAD PROTECTION

2.1 General

Workmen exposed to hazardous situations where there is a possibility of objects falling or their bumping into suspended or projected fixtures, as in construction work, tree trimming, mining, overhead line construction or maintenance, metal or chemical plants, etc., must be provided head protection. Broadly this protection consists of safety helmets, caps, hairnets, turbans, etc. Hairnets, turbans etc. are used to protect women and men with long hair to prevent their hair from getting entangled in moving parts.

2.2 Types of Safety Helmets

Safety helmets are hard hats or headgear of varying materials designed to protect the workman's head, not only from impact but from flying particles and electric shock or any combination of the three. These also protect the scalp, face and neck from overhead spills of acid, other chemicals, hot liquid and also, shield their hair from entanglement in machinery, or exposure to irritating dust. Some of the hard hats are even provided with welding mask or face screen.

Helmets are classified into the following two types:

- full brimmed type helmet.
- brimless with peak.

Brimmed types of helmets provide an added protection to the neck, face and head. In situations where the worker has to operate in crowded space, the brim may be considered as a nuisance. In such situations a satisfactory compromise is achieved by providing a peak to brimless type of hard hats.

The above referred types of helmets have been further broken down into four classes:

Class A	-	Limited voltage resistance for general services.
Class B	-	High voltage resistance.
Class C	-	No voltage protection (metallic helmets).
Class D	-	Limited protection for fire fighting.

The materials used in head protection PPE for protection against different types of hazards are given in Annexure-II. Materials used in the construction of Class A and Class B helmet shells should be water resistant and slow burning, while in Class D helmets they shall be fire resistant and non-conductor of electricity.

The worker working on electricity or with electrical equipment should use Class B type of helmet, which should neither have holes in the shell nor parts made of metal. It should be tested upto 20 kV for 3 minutes with leakage currents not exceeding 9 mA. Class A should stand this test upto 2.2 kV.

The thinnest section of Class A and B helmet shells should not burn at a rate greater than 7.5 cm per minute.

After a 24-hour immersion test, water absorption of the shell should not be more than 5 per cent for class A and D and 0.5 per cent for class B.

2.3 Care of Helmets

Before every use, helmets should be inspected for cracks, dents or any rough treatment. Once damaged, the helmet should be discarded. Particular attention should be paid to the condition of the suspension because of the important part it plays in absorbing the shock of a blow. Look for loose or torn cradle straps, broken sewing lines, loose rivets, defective lugs and other defects. The sweatband and cradle inside the hat should be easily detachable to allow for cleansing and replacement. Cleansing should be done at least once a month by washing in warm soapy water or any other detergent and then rinsing it thoroughly.

Helmets should not be carried on the rear window of a vehicle, as it may become a hazardous missile in case of an accident or an emergency halt.

Some organisations issue helmets of different colours for identification of different working crews, e.g. safety staff may be issued green colour helmets.

2.4 Specifications for Helmets

2.4.1 Crash Helmets (IS: 4151-1993):

Specifications and other details for helmets used for scooter and motorcycle riding (crash helmets) are drawn from IS: 4151-1993. Some of the salient features are given below:

(i) Material:

Shell: non-metallic.

(ii) Size:

Circumferences inside headbands are 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640 mm.

(iii) Type:

- V-type or ventilating type: having provision for cradle for ventilation.
- NV type or Non-ventilating type: direct contact with head and protective padding.

(iv) Essential parts:

- Shell.
- Protective padding, 10 mm thick.
- Headband.
- Chin strap, 19 mm wide with no chin cup.
- Anti-concussion tapes.
- Cradle for ventilating types.

(v) Marking:

The following should be marked on the helmet:

- trade mark of manufacturer,
- size,
- type,
- year of manufacture, and
- ISI marking.

(vi) Mass:

800 g (maximum)

(vii) Test and Performance requirements:

- shock absorption without damage when a 10 kg wooden block is dropped from a height of 0.5 m.
- penetration resistance against a 3 kg pointed mass (60°) falling from a height of 1 m.

2.4.2 Industrial Safety Helmets (IS: 2925-1984):

The role of industrial safety helmet is to provide protection to the wearer against falling objects and other hazards which may be encountered in mining, tunnelling, quarrying, ship building, construction projects and similar other industrial occupations.

(i) Material:

Shell: non-metallic.

(ii) Size:

Circumference inside headband:

Small	-	500 - 540 mm.
Medium	-	540 - 590 mm.
Large	-	590 - 640 mm.

(iii) Essential Parts:

- Shell, peak, ventilation holes.
- Harness consisting of headband.
- Anti-concussion tapes.
- Chin strap.

(iv) Marking:

The following should be marked on the helmet:

- trade mark of manufacturer,
- size,
- ISI marking, and
- year of manufacture.

(v) Mass:

400 g (maximum)

(vi) Test and Performance Requirements:

- Shock absorption resistance against a wooden block of 3 kg dropped from a height of 1.5 m.,
- Penetration resistance against a plumb of 500 g with conical steel point falling from a height of 3 m.,
- Electrical resistance against 2000 V, 50 Hz for one minute.,
- < 5% water absorption when immersed in water for 24 hours at a temperature of 25°C.
- Heat resistance in an oven at 93° ± 50°C for 15 min.,
- No visible damage when a flame from a barthel burner (IS: 4355-1977) is applied on the shell for 10 seconds,
- Sterilisation and corrosion resistance tests.

2.4.3 Firemen's Helmets (IS: 2745-1983):

The main objective of firemen's helmets is to provide protection against falling objects during fire fighting, rescue operations and to some extent, against heat or electric shock. The details of various performance tests for this type of helmets are given in the standard IS: 2745-1983.

(i) Material:

Fibreglass

(ii) Size:

Circumference inside headbands are 530, 540, 550, 560, 570, 580, 590, 610, 620 mm.

(iii) Essential Parts:

Headband, not less than 30 mm in width.

Chin strap, 20 mm wide with no chin cup.

(iv) Marking:

- Trade mark of manufacturer
- Size
- ISI marking

(v) Mass:

800 g without visor

(vi) Performance Requirements:

- Shock absorption resistance against a wooden block of 5 kg dropped from a height of 2.5 m.
- Penetration resistance against a steel striker (plumb) weighing 3 ± 0.05 kg, with the conical steel point falling from a height of one metre.
- Electrical resistance against AC voltage of 2000 V at 50 Hz for one minute.
- < 5% water absorption when immersed in water for 24 hours at temperature of 27°C.
- No flaming or visible evidence of flame penetration into the inside of the helmet when a flame is applied to the outer surface of the helmet, whilst it is rotated steadily through one complete revolution at a speed of two revolutions/minute.

3. EYE AND FACE PROTECTION

3.1 General

In some operations it is necessary to choose PPE that will cover the entire face to protect against mechanical injury, chemicals, rays etc. A comprehensive list of operations, which require eye and face protection, is given in Annexure-III. Various types of PPE used for eye and face protection are given in Annexure-IV. Eyes can be injured from dust, flying particles, harmful radiation, accidental splashes of chemicals, etc. Face-shields are required particularly while handling chemicals, but are not recommended as basic eye protection against impact. Face-shields must be used in combination with basic eye protection to guard against impact.

Welding and cutting, foundry work, glass furnace works expose the eyes to harmful radiation. Welder's helmets guard against splashing of molten metals and from radiation produced by welding operation. These helmets are made of materials that provide insulation against heat and electricity and do not readily burn. The shield of these helmets should cover the face sufficiently far on each side so that the ears are also protected. Generally, the helmet's window, for seeing through, is designed to accommodate correct filter. It is advisable to use a disposable cover glass in front of the filter lens to protect it from pitting and other damage. This cover glass should be replaced whenever its surface gets scratch marks as they hinder the view. Hand-held face-shields are also used for welding operations or for observing welding process.

Wire mesh screen guard consists of woven metal gauge support in front of the face and incorporates a transparent lens in front of the eyes. These are designed to provide protection to the face against flying particles and spray of hazardous liquids. The wire screen provides much better ventilation in hot and humid operations, thus reducing the possibility of fogging.

Hoods also protect the face and eyes and are used in operations involving handling of highly caustic chemicals or exposure to excessive heat, such as in fire fighting operations. Hoods are made of material impervious to chemicals and a window in front of the hood allows the wearer to see through.

3.2 Types of Eye and Face Protection Equipment

For protection of face and eyes from heavy flying particles, face-shield of plastic can be used. Plastic should be non-flammable with the surface resistant to scratches during normal usage. It should not give distorted vision and

should be heavy enough to resist warping due to impact, daily wear and temperature and moisture conditions. Face-shields are generally suspended from a headband and may be hinged so that they can be raised or lowered when desired.

Eye protection equipment, like optical instruments, should be carefully selected, fitted and used. Protection of eyes is required from liquid splashes, harmful radiation and flying particles encountered in such jobs as chipping and grinding.

The following types of PPE provide eye protection:

- safety goggles,
- safety spectacles, and
- safety clip-ons.

The following types of PPE provide protection to both eyes and face:

- eye shield,
- face-shield, and
- wire mesh screen guard.

Contact lenses should never be considered a replacement for safe PPE for the eye. In fact, contact lenses have resulted in blindness/permanent impairment of workers because of corrosive chemicals or small particles penetrating the space between their contact lens and eyes. Such incidents prompted the American Society for the Prevention of Blindness to issue a statement that contact lenses have no place in the industrial environment.

Hardened glass lenses for eyes are no substitute for safety lens as they are only 2 mm thick, instead of being 3 mm for safety lenses. If corrective lenses are required, it is preferable to incorporate the correction in the goggle lenses. Alternatively, goggles, which cover ordinary spectacles, may be worn, but the cups of goggles should be wide enough to cover the complete spectacle.

3.3 Eye Protection for Welding

Welding helmets provide head and face protection during welding operation. Eyes need additional protection against the radiation emitted during welding. Radiation is emitted in all the three spectral bands [viz. ultraviolet (UV), visible

(V), infrared (IR)]. Depending upon the flux used and the size and temperature of the pool of melted metal, the welding process emits visible and infrared radiation. Ultraviolet radiation is emitted along with V and IR radiation during heavy gas welding and cutting operations and in arc cutting and welding exceeding 30 amperes.

For protection against this radiation, one has to use filter lenses of appropriate shade. These lenses are available in 16 different shades. Transmittance characteristics of these shades in the three spectral bands are given in Annexure-V. This Indian Standard helps to select the right type of shade for different types of welding operations.

The protective lens can be installed in a hand-held shield or in welder's helmet for protection against radiation emitted during welding operations.

To protect against pitting, the protective lens should be worn with a replaceable plastic or cover plate.

It is advantageous to combine the shade of the plate in welders helmet with that of the shade of the goggle worn underneath to produce the desired total shade. This procedure has an added advantage of protecting the eyes from other welding operations or from an accidental arc when the helmet is raised.

3.4 Eye Protection Equipment for Laser

Both spectacles and goggles are available for protection against nearly all the known lasers. Because the eye wear has maximum attenuation at specific laser wavelength, with protection decreasing rapidly at other wavelengths, one has to use the right type of eye wear for specific laser wavelength. That is why the laser protective spectacles should specify the wavelength to which it provides protection. Optical density should be shown on filter and the frames of spectacles should be distinctively coloured for identification of wavelength to which it provides protection.

A worker using lasers need to be extra careful as no single type of glass offers protection from all laser wavelengths. Laser goggles, hence, might give a false sense of security, tempting the wearer to expose himself to unnecessary hazards. In fact, most firms do not depend upon safety glasses to protect their employee's eyes from laser burns. There should be the assurance that laser goggles designed for protection from specific laser wavelength are not mistakenly used with different wavelengths of laser radiation.

The laser safety glasses should be evaluated periodically to make sure that adequate optical density is maintained at desired wavelength. This is particularly important as laser safety glasses exposed to very intense energy or power levels may lose effectiveness; these should be discarded promptly.

3.5 Selection of Eye and Face Protection Equipment

The following criteria could be adopted to select the brand for eye and face protection equipment:

- type of protection required,
- conformity to relevant publications of BIS,
- availability of test certificate,
- comfortable to wear, lightweight material of excellent clarity and convenient fit,
- a non-penetrable protective seal around the forehead, temple, nose and cheek areas, in case of chemical goggles,
- soft, flexible frame that adjusts perfectly to irregular facial contours of individual wearers,
- uninterrupted peripheral vision with unobstructed lines of sight in both horizontal and vertical planes,
- free from refractive distortion,
- no hindrance while using helmet, dust filters and corrective spectacles,
- secure lens retention even in adverse condition,
- ease of keeping them in good repair, and
- ease of maintenance.

3.6 Care of Eye and Face Protection Equipment

- Goggles should be kept clean. Lenses should be wiped with a clean and soft cloth.
- Goggles should be sterilised frequently.

- Goggles should not be borrowed or lent unless they have been cleaned and sterilised.
- Goggles should be kept in a clean case, and not carried loose in the pocket.
- Goggles should be kept in proper condition. Pitted lenses should be replaced before they cause eye strain.
- Elastic or fabric headband of goggles should not be stretched. Avoid hanging of goggles on a nail as it will result in stretching of headband.
- Oil, grease, acids, or solvents should be removed from eyecups, leather, rubber or metal parts of goggles. Oil and grease deteriorate rubber parts and reduce life of headbands. Headbands should be occasionally washed with warm soap solution followed by thorough rinsing.
- Goggles should not be dried by exposing to excessive heat.

Before sterilising goggles, disassemble them and scrub them thoroughly with soap water to remove accumulation of dirt or other foreign material. After being thoroughly cleaned, sterilise them by one of the following methods:

a) immerse for 10 minutes in 2 per cent cresol solution or 3 per cent carbolic acid solution or 70 per cent denatured alcohol solution,

b) immerse for 10 minutes in a solution of formalin made by mixing one part of 40 per cent formaldehyde solution with 9 parts of water, and

c) place in a moist atmosphere saturated with antiseptic vapours, preferably formaldehyde for 10 minutes at room temperature.

3.7 Specifications for Eye Protection Equipment

Eye protection equipment shall be of appropriate material free from visual defects and able to meet relevant performance requirements. They should be durable, strong non-irritant and corrosion-resistant. Except for spectacles, all materials which are likely to be exposed to thermal radiation during use and which come in contact with the operator shall have a thermal conductivity of less than 0.2 $W.m^{-1}k^{-1}$.

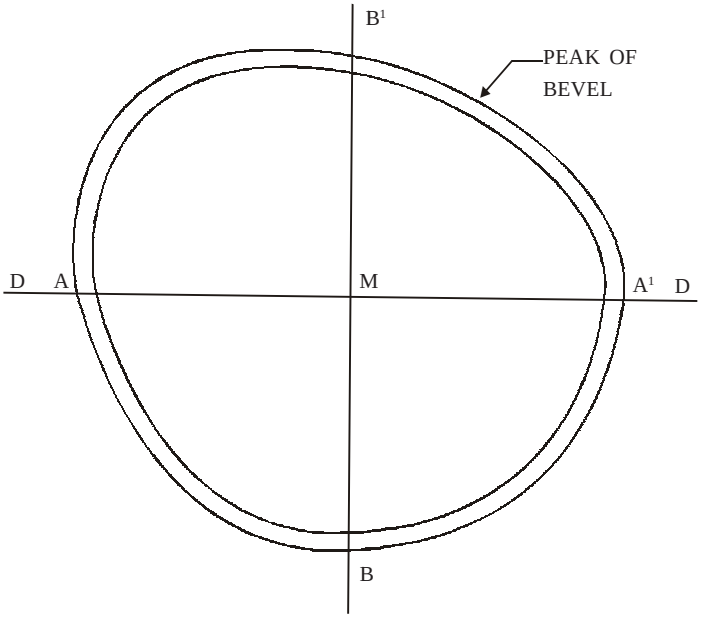
The headband of these devices shall be of good quality, durable and not less than 10 mm in width. Other parts or components incorporated in eye protectors shall be easily adjustable and replaceable.

3.7.1 Oculars

(a) Dimensions:

- Each ocular (Figure 1) of eye-cup goggles shall have a datum length of not less than 50 mm.
- Each ocular of safety spectacles and/or safety clip-ons should have a datum length of not less than 42 mm and a mid-datum depth of not less than 32 mm.
- Transparent visor of eye-shield should have a depth of not less than 100 mm.
- Oculars of single-frame coverall goggles fitted in pair should have a datum length of not less than 50 mm.

FIGURE 1: DIMENSIONS OF OCULARS



DD - Datum Line
AA^1 - Datum Length of Lens
M - Datum Center (Mid-Point of AA')
BB^1 - Mid-Datum Depth of Lens (Measured through M)

(b) Optical Requirements:

In order to affect vision as little as possible, the prismatic and spherical effects and astigmatism shall be as small as possible. The permissible tolerance for spherical effect, astigmatism and prismatic effect for oculars are given in Table 3.1.

(c) Diffusion of Light:

The contrast may be reduced and visual performances adversely affected if the ocular diffuses light appreciably. The limiting value of light diffusion is 1.0 cd/(m^2 lx) for welding filters and 0.5 cd/(m^2 lx) for all other filters.

(d) Quality of Material and Surface:

Except for a margin 5 mm wide, oculars for eye-protectors shall be free from any significant defects likely to impair vision when in use, such as bubbles, scratches, inclusions, dull spots, holes, mould marks, scoring or other defects originating from the manufacturing process.

(e) Robustness of Construction:

Oculars for protection against hazards other than mechanical are exempted from robustness tests. Oculars used for protection against radiation, dust and chemicals do not require this test unless the ocular is a combined filter and mechanical safety ocular. This test is for protection against high mass, low-velocity flying objects. The ocular shall be designed to withstand the impact of a 22mm diameter steel ball of about 44 g mass, dropped from a height of 1.27 to 1.30 metres. In this test there should not be any ocular fracture.

Mounted oculars should not have any deformation. Mounted ocular housing or frame should not fail [Ref.: IS: 7524 (Part 1)-1980].

(f) Transmittance:

Transmittance variation is measured by scanning with a light beam of 5 mm diameter over the entire area of an ocular. Luminous transmittance should be within the limits of shade No. 1.2 for oculars without filtering action and used solely to protect the eyes against mechanical and chemical hazards. Compliance with transmsittance requirement and appropriate chromaticity limits as prescribed in Table 3.1 is required when oculars with filtering action are used to protect the eyes against

harmful radiation, i.e. welding filters, ultraviolet filters, infrared filters or daylight filters

(g) It should have stability in presence of ultraviolet radiation.

3.7.2 Eye Protector Assembly

- Eye protectors shall ensure a sufficiently wide field of vision. The minimum temporal and downward field of vision shall be 50° and 60° respectively for eyecup type protection and 60° and 67° respectively for wide vision protectors.
- The assembled eye protectors should be stable without apparent deformation at elevated temperature of 55 ± 2°C.
- Be resistant to corrosion.
- Be suitable for disinfection.
- Oculars and frames should not be made of flammable material, such as cellulose nitrate.
- Eye protector assembly should withstand the impact of a 6 mm dia. steel ball striking the ocular at a known selected speed of 190-195 m/s when tested in accordance with the method prescribed in IS:7524 (Part-1)-1980. The oculars should have no fracture, deformation and frame failure.
- All parts are treated to prevent the adherence of molten metal and shall be resistant to penetration of hot solids.
- Protection against chemical splashes and gas vapour shall be ensured in the area enclosed by the eye protector in accordance with test prescribed in IS:7524 (Part 1)-1980.
- It shall be considered satisfactory for protection against dust if the reflectance of the ocular after the test is not less than 80 per cent of its value before testing.

3.7.3 Tests

Oculars of eye protectors shall be subjected to tests as given in Table 3.2.

TABLE 3.1: OPTICAL TESTS REQUIRED FOR OCULARS

PERMISSIBLE TOLERANCES FOR SPHERICAL EFFECT, ASTIGMATISM AND PRISMATIC EFFECT FOR OCULARS

Ocular	Type	Spherical effect (m^{-1})	Astigmatism (m^{-1})	Prismatic effect (cm/m)		
Unmounted	a	± 0.06	0.06			
	b	± 0.12	0.12			
		(power in meridian of maximum error)		Horizontal		Vertical
				Base out	Base in	
Mounted	a	± 0.06	0.06	1.00	0.25	0.25
	b	± 0.12	0.12	1.00	0.25	0.25
	c	+ 0.12 – 0.25	0.25*	1.00	0.25	0.25

* Axes must be parallel.

TABLE 3.2: TESTS FOR EYE PROTECTORS

Use of Eye Protector	Optical	Robustness	Heat Stability	Corrosion	Disinfection	Transmittance		Flame Resistance	High Velocity Impact	Molten Metal and Solid	Chemical Splashes	Dust	Gas and Vapour
						(a)	(b)						
General purpose	X	X	X	X	X	X	_	X	_	_	_	_	_
High velocity impact	X	_	X	X	X	X	_	X	X	_	_	_	_
Molten metal and hot solids	X	0	X	X	X	X	X	X	_	X	_	_	_
Splashes	X	0	X	X	X	X	_	X	_	_	X	_	_
Dust	X	X	X	X	X	X	_	X	_	_	_	X	_
Gases and vapours	X	0	X	X	X	X	_	X	_	_	_	_	_
Filtering action	X	0	X	X	X	_	X	X	0	0	_	_	_
Combination as above	X	0	X	X	X	X	0	X	0	0	0	0	0

X - Mandatory
O - Optional

4. HAND AND ARM PROTECTION

4.1 General

About one-third of the injuries that occur involve hand and arms. Such injuries occur when the workman has to handle materials with sharp ends, hot metals, chemicals, corrosive substances, electrical works, etc. Because of apparent vulnerability of the fingers, hands and arms, the use of PPE for protection of hand and arm becomes necessary for workers. The portion of hand and arm exposed to the hazard is to be fully covered with suitable material that provides adequate protection against the hazard. The hand and arm type of PPE (see Annexure-VI) could be gloves, wrist gloves, mittens, hand pads, thumb and finger and sleeve guards, etc. Materials used for hand and arm protection against different types of hazards are given in Annexure-VII.

4.2 Gloves

It should be remembered that gloves should not be used while working on moving machinery such as drills, saws, grinders or other rotating and moving equipment that might catch the glove and pull it along with the worker's hand into the machinery.

In situations where gloves are used to protect workers' hands from chemical solutions, the gloves should be long enough to extend well above the wrist, but so designed that there is no flaring cuff which might trap any splashes and introduce the liquid into the glove. It should fit tightly around the forearm. It is advisable for the sleeves to be worn outside the glove cuff.

Electric line repairers working around energised high voltage should use specially made and tested rubber gloves. This glove may be worn under a heavy leather outer glove to safeguard from cuts, abrasions and wire punctures. Regular testing and inspection of the gloves is absolutely essential and gloves failing to meet the original specifications should be discarded promptly. Gloves, hand pads and mittens which are reinforced with metal staples should not be used in and around operations involving electrical apparatus. Rubber gloves should not be used for handling derivatives of petroleum as they have a deteriorating effect on natural rubber. For such works, gloves made of synthetic rubber, such as neoprene, can be used.

Where a complete glove is not necessary, finger stalls may be used. These are available in combination of one or more fingers. The construction of the stall depends upon the degree or type of hazard to be confronted. The finger stalls are useful in operations involving edge tools. Finger stalls can be made of asbestos, rubber, leather, metal mesh, etc.

Where finger dexterity is not required, some workers prefer to use mittens instead of gloves. Modifications of mittens are also available, for example, one finger mittens permit use of thumb and index finger with a combined covering for other three fingers. It offers finger dexterity similar to gloves while possessing the characteristics of the mittens. Mittens are manufactured of the same materials as gloves and are generally used in the same type of operations too.

4.3 Hand Pads and Arm Protection Equipment

For protection against heat or extremely abrasive or splintery material, hand pads give better protection than gloves, since they can be made heavier and less flexible without discomfort. Hand pads should have a surface large enough to cover the entire palm of the hand. They should not be used while working on moving machinery. The pads should at all times be sufficiently loose to release the hands and fingers, if caught on a rough edge or nail.

Hand and arm protectors are required to be used when engaged in operations involving exposure to heat. These should be made of asbestos cloth or wool.

4.4 Selection of Hand and Arm Protection Equipment

The following criteria could be adopted to select the brand of arm and hand protection equipment:

- conformity to relevant publications of Bureau of Indian Standards,
- suitability of the material in view of the hazards,
- selection of appropriate length and thickness to suit the application,
- suitability of the lining,
- selection of proper grip,
- selection of appropriate cuff style, and
- availability of test certificate.

4.5 Specifications for Hand and Arm Protection Equipment

4.5.1 Specifications for Rubber Gloves for Electrical Purposes (IS: 4770-1991):

Rubber gloves for electrical purposes offer protection against electric shock while working on energized conductors and equipment. However, it does not

imply that rubber gloves shall be the only means of protection for working on live circuits or components. The specifications deal with four types of gloves suitable for maximum working potential of 650, 1100, 3300 and 4000 V_{rms}.

There are four types of gloves called type 1, 2, 3, 4 based on wall thickness, maximum working potential, leakage current, and breakdown voltage as given in Table 4.1.

(i) Material and Manufacture:

Arm and hand protective equipment for electrical purposes shall be made from rubber (natural or synthetic) either by dipping process or from calendered sheets and the compounds, when vulcanised, shall satisfy the BIS specification. It is desirable to use different colours for inner and outer layer. In gloves built from calendered rubber sheets, all joints shall be made by butting or skiving the edges closely together, with the joints being strengthened inside or outside or on both sides with a rubber strip or tape of quality similar to that used in gloves.

The gloves shall have a smooth surface and be free on both the inner and outer surfaces from visual defects like patches, blisters, porosity, embedded foreign material, or other physical defects, which can be detected at the time of inspection or testing.

(ii) Shape:

Gloves shall be of wrist or gauntlet type, with the cuff edges being finished with a roll or rubber reinforcing strip.

(iii) Electrical Properties:

Each glove in the consignment, when tested, shall withstand alternating test potentials specified in Table 4.2 for one minute without breakdown. The leakage current shall not be more than the appropriate values given in Table 4.2. The leakage current at the normal working voltage of the glove when tested shall not exceed 0.3 milli amperes.

TABLE 4.1: THICKNESS OF GLOVES

Gloves	Maximum Working Voltage (rms)	Minimum Thickness at		Maximum Thickness +	
		Crotch Area* (mm)	Other than Crotch Area (mm)	Area 'A' (mm)	Area 'B' (mm)
Type 1	650	0.60	0.65	1.05	1.05
Type 2	1100	0.75	0.90	1.25	1.65
Type 3	3300	1.00	1.15	1.50	2.05
Type 4	4000	1.25	1.55	2.05	2.55

* Crotch area is a circular area with 12.5 mm radius, whose centre is at intersection of the plane of the axis of the fingers (or thumb) and a line, at the crotch, midway between the base of the adjacent fingers (or thumb) and extending from palm to the back of the gloves.

\+ Area A and area B are defined in Fig. in IS:4770-1991.

TABLE 4.2: TEST POTENTIAL, LEAKAGE CURRENT AND BREAKDOWN VOLTAGE OF GLOVES

Gloves	Maximum Working Potential (rms) of Glove Volts	Test Potential (rms) Volts	Maximum Leakage Current (rms) at Test Potential mA	Minimum Breakdown Voltage (rms) Volts
Type 1	650	5000	4	17000
Type 2	1100	10000	8	20000
Type 3	3300	15000	12	25000
Type 4	4000	20000	14	30000

(iv) Physical Properties:

- Tensile strength : not less than 140 kgf/cm^2
- Elongation at break : not less than 600%.
- Tension set : The tension set of the representative samples tested, following an elongation of 300 per cent and a recovery of 10 minutes shall not exceed 20 per cent.
- Ageing properties : When subjected to ageing in an air-oven for 168 hours at 70°C, the tensile strength and the elongation at break shall not exceed the following limits of the corresponding values obtained before ageing.

Tensile strength	:	+ 10% - 15%
Elongation at break	:	+ 5% - 15%

(v) Marking:

The gloves shall be marked with the following information:

- Size and type of gloves.
- Maximum working potential.
- Manufacturer's name or registered trade mark.
- Month and year of manufacture.

The marking shall be at the back, legible, permanent and shall not impair the quality of the gloves.

4.5.2 Gloves for Protection against Chemicals:

Gloves for protection against chemicals are made of materials impervious to liquids for protection against irritating corrosive substances. No one type is

universally suitable against all possible hazards. The choice depends on the particular acid, solvent, caustic, oil, chemical, etc. involved. No Indian standard is available for chemical safety gloves. In the absence of BIS standards, general guidelines for selecting proper gloves are given below:

(i) Materials for Selecting Proper Gloves:

- Butyl : Synthetic rubber material offers thehighest penetration resistance to acid, gases and water vapours e.g. acetic acid, ammonium hydroxide, hydrochloric acid, hydrofluoric acid, sulphuric acid.

- Neoprene: Synthetic rubber material has excellent tensile strength, heat resistance, ability to withstand most acids, caustics and remains flexible at low temperature, e.g. ammonium hydroxide, hydrochloric acid, hydrofluoric acid, sodium hydroxide, and sulphuric acid.

- Nitrile : Synthetic rubber material offers superior chemical and abrasion resistance; suggested for use in oils, fats, acids, caustics and alcohol.

- PVC : Synthetic thermoplastic polymer provides excellent wet grip and abrasion resistance. It is chemically resistant to oil, grease, acids and solvents.

- Latex : Natural rubber material has outstanding tensile strength and temperature resistance. Thick latex gloves also provide resistance to acids and alkalis, e.g. surgical and post-mortem gloves.

- PVA : Water-soluble synthetic material cannot be used in water or water based solutions; it is highly impermeable to gases; it has excellent chemical resistance to aromatic and chlorinated solvents, e.g. benzene, trichloroethylene.

(ii) Length and Thickness:

Wrist length/elbow length/shoulder length thickness of glove material is very important. Thin gloves allow better dexterity and flexibility, while thick gloves provide better overall protection but are less flexible.

(iii) Lining:

- Unlined : Offer better sensitivity and dexterity than lined gloves.
- Flock lined : Shredded fibres (usually cotton) applied to the inside surface of the glove material, absorb perspiration and allow easy wear.
- Knit lined : Cotton or synthetic material bonded to the inside surfaces of the glove, absorbs perspiration, affords additional heat protection and is more durable
- Jersey lined : glove, absorbs perspiration, affords additional heat protection and is more durable.

(iv) Cuff style:

- Pinked : A finished appearance commonly found on knit-lined rubber gloves.
- Rolled : Serves as a barrier against chemicals which may run off the glove on to the skin. Also provides additional cuff strength.
- Knit wrist : Provides a snug fit and prevents material from entering the glove.
- Gauntlets : Extended length helps to protect the wrist area.

(v) Markings:

- Size
- Material
- Manufacturer's name
- Year of manufacture

Many gloves feature a textured finish that provides a better grip (smooth, crinkle, rough, embossed). Some gloves rely on the inherent qualities of the material to provide a good grip.

The level of protection provided by a chemical resistant glove depends on several conditions, such as chemical concentration, temperature and duration of use.

4.5.3 Specifications of Leather and Cotton Gloves [IS: 6994 (Part 1)-1973]:
It covers eleven types of industrial gloves made of leather and cotton.

(i) Material for leather gloves:

Chrome, tanned cow or young buffalo grain or split leather to conform to the following requirements:

- the leather and flesh split shall be of natural colour having thickness of 1.0 to 2.0 mm and 1.5 to 2.0 mm respectively,
- it shall be soft, pliable and free from flaws or loose fibres,
- it shall be treated in such a manner as not to obscure defects and shall not be stained with compounds of iron,
- the leather shall not contain any chromate extractable by water or dilute acids, and
- the leather shall be treated for mildew resistance.

(ii) Material for cotton drill gloves:

- Cotton drill : shall be unbleached 315g/m^2 with a tolerance of 19 g / sq.m.
- Knitted fabrics for cuffs : 2/20 all cotton.
- Thread : Cotton sewing thread as per IS: 1720-1969.
- Size, design and stitching : As per IS : 6994 (Part-1)-1973.

(iii) Markings:

The gloves shall be legibly stamped on the inside of the cuffs with the following information:

- type and nominal size of the gloves,
- where applicable, the words ‘light mass’, ‘medium mass’ or ‘heavy mass’,
- msanufacturer’s name or recognised trademark, and
- year of manufacture.

4.5.4 Specifications for Leather Gauntlets and Mittens (IS: 2573-1986):

Leather gauntlets are generally worn by welders for protection against heat and abrasion during welding and by workers while handling moderately hot materials or materials with sharp and rough edges. Leather mittens are also worn while handling moderately hot materials and materials with sharp and rough edges. Material specifications are same as those for leather gloves, given in 4.5.3.

(i) Size of leather gauntlets for welders:

Size	Length (mm)
Small	300 ± 5
Medium	350 ± 5
Large	450 ± 5

(ii) Thread:

Cotton, polyamide cotton, core spun or any other suitable thread.

(iii) Test:

Each of the gauntlets selected according to sampling procedures shall be examined for size, thickness of leather, dimension, workmanship, finish and manufacturing details without opening up of the gauntlets.

(iv) Markings:

- Size of the gloves.
- Manufacturer's name or recognised trademark.
- Year of manufacture.

4.5.5 Specifications for Asbestos Gloves:

The utility of asbestos gloves for protection from heat and fire hazards depends upon the quality of asbestos cloth used in their manufacture. The cloth for asbestos gloves of brand Firefly K.21 has the following properties:

No physical or chemical change of cloth of glove should occur upto temperature of 450°C and it should retain its fibrous nature upto temperature 1400°C. It should be fire resistant, rot proof, vermin proof.

(i)	Thickness (approximatly)	:	2mm
(ii)	Width (approximatly)	:	1000 to 1060 mm.
(iii)	Weight (approximatly)	:	1.35 kg/m^2 (50 to 55 kg/roll)
(iv)	Construction weave	:	Non metallic, plain, single ply. Warp plyends per 2.5 cm - 9. Weft ply pick per 2.5 cm - 17-1
(v)	Moisture content (1 hour at 105^0 C.)	:	2.5% maximum by weight.
(vi)	Loss on ignition (30 minutes at 800^0 C).	:	25% maximum by weight.
(vii)	Thermal conductivity	:	0.75 x 10^{-3} cal/s-cm-°C

5. FOOT AND LEG PROTECTION

5.1 General

Protection to foot and leg is required while handling material or corrosive and chemical liquids. Commonly used foot and leg PPE are safety shoes, foot guards, kneepads, leggings and leg guards.

Depending upon the nature of hazards against which protection is required, safety shoes are classified into following six principle types:

- safety-toe shoes,
- conductive shoes,
- foundry (molder) shoes,
- explosives-operations (non-sparking) shoes,
- electrical hazard shoes, and
- shoes suitable for mining operations.

The materials used for manufacture of foot and leg PPE and types of safety shoes for protection from different types of hazards are given in Annexure VIII and IX respectively.

5.2 Safety-Toe Shoes

The common foot protection employed in industry is the metal toe-box-safety shoe. This type of shoe is required when handling heavy materials, rolling objects like barrels, heavy pipes, rolls, truck wheels, to protect against kicking sharp sheet metal. In occupations where there is likelihood of heavier objects falling and striking the toe, then foot guards in addition to safety shoes should be worn. The foot guards are flanged, heavy-gauge metal and corrugated-sheet metal covers that protect the foot from toe to ankle. With the flanges resting on a firm floor, the foot guard should resist an impact of at least 45 m.kg. without damaging the shoes underneath or injuring the feet.

Metal toe-boxes may also be used for shoes which provide additional protection against different hazards, for example, conductive-spark resistant shoes, molder shoes, non-conductive shoes. Depending on the type of safety

shoe, protection against additional hazards like building of static electricity on person (conductive shoes), resistant against sparks (non-sparking shoes made without metallic parts), electric insulation from ground (non-conducting shoes) is provided to workers. For work under wet conditions, rubber boots/ shoes fitted with steel toe-box provide protection against impact.

5.3 Conductive Shoes

These are required by workers who work in dusty, chemical or explosives plants or where the atmosphere may contain a flammable mixture. The conductive shoes are in fact safety-toe-shoes with the added designed feature of discharging harmlessly to the ground static electricity charges, which may be built up on the body of the wearer as he/she moves around. They have conductive soles to drain off static charges and because of its non-ferrous construction to reduce the possibility of friction sparks in locations with fire or explosive hazard.

The conductive quality of the shoe is dependent on a good electrical contact between the sole of the foot of wearer and sole of the shoe. The wearer should not insulate his feet by using woollen stockings/silk/foot powder or allow the sole of the shoe to become oil-soaked, as these adversely affect the shoes' conductivity. Initial and subsequent periodic tests should be made on conductive shoes ensuring that the maximum allowable resistance of 4,50,000 ohms is not exceeded.

5.4 Foundry Shoes

These shoes are required by workers employed in operations where molten materials are used for preventing sparks and spattering of molten compounds from entering inside the shoe.

Foundry shoes are safety-toe-shoes, which are designed to fit snugly around the ankle and to completely enclose the foot. They slide over the foot and are held closely to it by means of an elastic expansion insert. The wearer should cover the tops of the foundry shoes by his trousers to keep out the molten metal.

5.5 Explosive - Operations (Non-sparking) Shoes

These shoes do not have conductive soles and have non-ferrous eyelets and nails. The metal-box toes are coated with non-ferrous material.

These shoes are required to be worn by workers in the following operations:

- in hazardous locations where the floors are non-conductive and grounded, such as in the manufacture of certain explosive compounds, and

- when cleaning tanks that contain gasoline or other volatile hydrocarbons.

5.6 Electrical Hazard Shoes

This safety-toe shoe is to be used in areas where potential for electrical shocks exists. No metal is used in preparation of this shoe, except for the base toe, which is insulated from the rest of the shoe. If these become damp (wet) or badly worn out, they cannot be depended for protection.

5.7 Other Types of Safety Shoes

Besides the types of safety shoes described earlier, there are a few special shoes, which provide protection against hazards posed in certain types of risky operations. These are described below:

(i) In construction sites where protruding nails exist and where possibility of coming in contact with energised electric equipment does not exist, shoes equipped with reinforced soles or soles of flexible metal should be used.

(ii) For working on hot surfaces like asphalting, wood soles provide good protection. Hot surfaces should not be very hot, as it will char the wood. This type of wood soles footwear is sometimes called 'pavers sandals' or 'paver shoes'.

(iii) Plastic shoe covers are required to be used for

- protecting a product from contamination, and
- preventing the spread of contamination to non-contaminated areas, e.g. working with radioactive materials.

5.8 Care of Foot and Leg Protection Equipment

- Leather shoes should be kept as dry as possible. If they get wet, they should be dried slowly.
- User of leather shoes should wash the feet and change socks daily as perspiration harms the leather and causes the lining of shoes to wear out and become rough.
- Shoes should be kept in good repair, as worn-out soles and rundown heels are dangerous.

- Conductive sole shoes, designed to prevent the accumulation of body static charges, as well as anti-spark and shock resistant, require special attention. Only repairmen thoroughly familiar with their construction and trained in approved methods of repairs should attempt this work. The advice of the manufacturer should be sought.
- Shoes should be cleaned frequently.
- For certain operations, when the workers on different shifts or jobs are required to wear same pair of rubber boots, it is necessary to disinfect boots after each shift or job.

The following washing procedure is recommended for rubber boots:

- Inside and outside of rubber boot should be washed with a hose under water pressure.
- Boots should be dipped into a tub containing a solution of 1 part sodium hypochlorite and 19 parts water.
- The boots should be rinsed with hose under water pressure and dried.

5.9 Specifications for Different Types of Safety Shoes

5.9.1 Leather Safety Boots and Shoes [IS: 1989 (Part-1 & 2)-1986]:

- Should be ankle high.
- Should have six eyelets (four eyelets or less in each of safety shoes.)
- Toe should be reinforced with steel toe cap.
- Tongue should be padded.
- Bottom be made of vegetable-tanned sole leather or moulded rubber sole and heel.
- Eyelets be made of aluminum or brass coated steel of size 10 mm.
- Mass - 1750 g/pair of size 8 (maximum) with hob nails,toe tips and heel tips. 1650 g/pair of size 8 (maximum) without hob nails, toe-tips and heel tips. The mass shall increase or decrease by 75 g per pair for each bigger or smaller size respectively.
- Steel - toe cap should be as per IS: 5852- 1996 and should withstand blows of 14.2 kgf.m.

5.9.2 Fireman's Leather Boots (IS: 4128-1980):

Wellington type of shoes as required by IS: 4128-1980 for fire fighting are not manufactured in India. As per the current practice, PVC or rubber gum boots are used by firemen during firefighting/rescue operations. Jodhpuri shoes in black are used by fire staff as a part of uniform and for fire officers shoes in brown colour are used.

5.9.3 Electrical Safety Shoes:

The BIS standards for electrical safety shoes are under preparation. However, IS: 4770-1968 lays down the standard for testing of rubber gloves/boots for electrical purposes.

As per this standard there are four types of gumboots for electrical purposes based on the maximum voltage recommended to work on. These are classified as type I,II,III, and IV for which the corresponding maximum working voltages are 650, 1100, 3300 and 4000 volts respectively.

5.9.4 Chemical Safety Shoes:

No BIS standard is available for chemical safety shoes. Shoes whose sole is made out of PVC or nitrile rubber are generally acceptable for use in chemical plant areas. A number of suppliers are manufacturing shoes with sole resistant to acid, alkali and oil. IS:5557-1969 gives specifications for rubber knee boots for use on floors, which are covered with oil, grease, etc.

5.9.5 Electrical-cum-Chemical Gum Boots:

PVC full gums boots with stockinet lining inside and conforming to IS:12254-1988 can be used both for chemical and electrical purposes, and shall have the following specifications:

- Height - in different sizes 10", 12", 14".
- Electrical - 5 kV electrical shock proof.
- Material - PVC - virgin material.
- Inside lining - Stockinet.
- Sole design - With serrations in opposite directions.

5.9.6 Shoes Suitable for Mining Operations:

The types of protective footwear required for miners must be approved by Director General of Mine Sefty (DGMS) who does the necessary testing. Types of safety shoes for different types of mining operations are given below:

- Safety leather boots : for underground coal mines and mica mines.
- Safety leather boots with
  - Leather sole : for underground non-coal mines like gold, copper, manganese, etc.
  - Rubber sole : for coal mines especially for workers like trammers, shortfirers, etc.
- Safety leather shoes with
  - Leather sole : for most surface mines of coal, limestone, iron ore, etc.
  - Rubber sole : (Note: The underground workers should not, as a rule, use shoes.)
- Rubber knee boots : for use in extremely wet conditions where workers have to stand and work in ankle-deep water or even more. This type of footwear is suitable for wet sinking shafts, in wet mines with more or less flat gradients, and for workers in China clay mines engaged in washing operations.

6. BODY PROTECTION

6.1 General

Certain jobs require protection for the whole body, like in the case of exposure to fire, extreme heat, molten metal, corrosive chemicals, cold temperature, body impact, cuts from materials which are handled. Other specialised hazards are often part of what is known as 'job exposure' (e.g. nuclear radiation exposure). Protection to body against such exposures can be provided by wearing aprons, overalls, jackets, complete head-to-toe protective suits, etc. Selection of type of body PPE depends on the nature of hazard, severity of hazard and nature of activities of concerned user. Wherever complete body protection is not needed, it is advisable to avoid unnecessary safety clothing, as it may hamper the efficiency of user. If a user needs complete coverage, he should be provided the same. For example, in pressurised heavy water nuclear reactors, complete coverage to the body of worker is provided through plastic suit to prevent entry of Tritium into the body through the skin.

Materials used in the manufacture of body protection PPE against different types of hazards are given in Annexure-X.

Body protection may be required against the following main types of hazards:

- heat and hot metal,
- impact and cuts,
- exposure to toxic materials, and
- special hazardous situation involving women workers, e.g. long hair, loose clothing, etc.

These are described in detail in the following subsections.

6.2 Protection Against Heat and Hot Metal

The following types of materials can be used for body protection PPE against hazards arising out of operations involving heat and hot metals:

(i) Leather Clothing:

It provides protection against heat, splashes of hot metal, limited impact forces, infrared and ultraviolet radiations.

(ii) Asbestos and Wool Clothing:

In case intensity of heat is somewhat more than that represented by welding operations, asbestos and wool, as well as leather clothing is used. Specially treated asbestos clothing has been developed which is impervious to metal splash upto 1600°C. Metal fastenings of such clothing should be covered with flaps to keep them from becoming dangerously hot. Fibreboard can be used particularly in the front part of asbestos legging to provide protection against impact. This type of body PPE is required by foundrymen working with molten metal. There is no proven evidence that wearing asbestos clothing poses a health hazard.

(iii) Aluminised Clothing:

For operations involving temperature upto 1100°C, use of aluminised clothing is essential, as seen in furnaces and ovens, coking, slagging, fire fighting and rescue work. The aluminised coating reflects much of the radiant heat and the underlying material of such clothing insulates against the remainder. This type of body protection falls under two classes:

- emergency suits are constructed of aluminised asbestos or glass fibre with layers of quilted glass fibres and a wool lining on the inside. These may be used where the temperature exceeds 550°C, as in a kiln or furnace or where men need to move through burning areas for fire fighting or rescue operations.
- fire proximity suits depend primarily on the reflective ability of aluminised coating on a base cloth of asbestos, glass fibre or synthetic yarn. These suits are used in the proximity of high temperature, such as in slagging, coking, and furnace repair work with hot ingots and in fire fighting operations.

(iv) Flame-Retardant Clothing:

For protection against flame or small sparks, one can use ordinary clothing made flame-proof by application of suitable flame-proofing compounds. Durable, flame-retardant work clothes are available. Such clothing should be distinctively marked so that untreated garments are not used by mistake by those need fire-retardant clothing.

6.3 Protection against Impact and Cuts

It is necessary to protect the body from cuts, bruises and abrasions on most jobs where heavy, sharp or rough material is handled. Different types of protectors are available for almost all parts of body:

(i) Protection of shoulders and back:

Padded duck should be used by workers who carry heavy loads or objects with rough edges.

(ii) Protection of abdomen against blows:

Aprons of padded leather, plastic, hard fibre or metal should be used.

(iii) Protection of knees:

Kneepads should be worn by mold loftsmen and others whose tasks require continuous kneeling.

6.4 Protection against Exposure to Toxic Materials

Clothing made of impervious materials should be used by workers for protection against dust, moisture (e.g. Tritium exposure in heavy water nuclear reactors) and corrosive liquids. Materials used for this type of protection include natural rubber, synthetic rubber, neoprene, vinyl, polypropylene, polyethylene films and fabrics coated with them. Such impervious clothing can be used to make different types of body wears, ranging from aprons and bibs of plastic sheet, to garments which completely enclose the body from head to foot and contain their own air supply. For the complete enclosure of the body in protective clothing made of impervious material, the hose of the supplied air apparatus should be connected to the face-piece as well as to the suit to provide ventilation.

Natural rubber clothing should not be used in work areas where oils, grease and organic solvents and chemicals are used. Similarly, in operations where daily contact with acids and caustic solutions occur, the worker should not use cotton clothing coated with impervious synthetic materials as these chemicals will deteriorate regular cotton and impervious quality of clothing would be lost.

6.5 Care of Body Protection Equipment

- Asbestos suits should be dry cleaned to avoid shrinkage and these suits should be stored so that asbestos fibres are not torn or crushed in handling.

- After dry-cleaning, the flameproof garments should be tested for serviceability in respect of flame-resistant properties.

- The chemical-resistant garments should be protected from excessive heat and mechanical damage. These garments should be cleaned with warm soapy water before storing; unnecessary folding or creasing should be avoided.

- Rubber clothing should be protected from excessive heat and mechanical damage. These should be washed and dried thoroughly before storing. Warm air drying should be used when possible. While storing, care should be taken that these clothing do not get cut, torn, scratched or worn by abrasive action. Crushing or creasing should be avoided, as far as possible.

Cleaning of body protection equipment requires additional care. While cleansing the clothing the following precautions need to be taken:

- washing arrangements should be such that it does not deteriorate the fabric or adversely affect their properties, e.g. excessive water temperature during washing should be avoided,

- the pressure of compressed air used for dusting of clothing should not exceed 30 psig, and

- the vacuum system should be used as it prevents the spread of dust.

6.6 Specifications for Different Types of Body Protection Equipment

6.6.1 Flame/Heat Resistant Suits

Flame resistant suits of fire fighters can withstand radiant heat upto 5 minutes and flame lick upto one minute against complete flame immersion. Heat-resistant suits are primarily intended for industrial workers, who may be exposed to high temperature during the course of their work and are expected to be able to withstand radiant heat upto five minutes and occasional flame licks.

(i) Materials :

The materials used for making these suits shall be non-flammable, light weight and flexible with sufficient heat reflecting properties. The materials shall be durable and should not disintegrate when subjected to intense heat and/or flames. These suits are made up of three layers: (i) outer layer, (ii) middle layer and (iii) inner layer.

(ii) Outer Layer :

The outer layer of the clothing shall be of high reflectivity so that it shall reflect over 90 per cent of the radiant heat incident upon it. For this purpose, asbestos cloth laminated with aluminised polyester film or vacuum deposited aluminised asbestos cloth has been found most suitable.

(iii) Middle Layer :

Felt-wool is used for middle layer because it is very light, open-weave material and offers very good thermal resistance.

(iv) Inner Layer :

The inner layer (body) of the suit is made from natural, polished, white chrome leather. It is quite flexible light and has good strength. The material can be used repeatedly and easy to clean and maintain.

(v) Clothing Assembly:

Clothing assembly used for the manufacture of flame/heat-resistant suits shall have high thermal capacity as well as thermal resistance. It shall meet the following specifications:

- its thickness shall not be more than 15 m,
- the weight of the outer layer and middle layer shall not be less than 700 g/m^2 and 450 g/m^2 respectively,
- all the stitching thread shall be flame retardant,
- all the joints in the suits shall have sufficient overlap to prevent ingress of heat and sparks,
- fastener shall be secured in use, yet shall permit rapid removal of clothing in an emergency,
- metal fittings, like rivets, shall be sealed with insulating material, and
- the workmanship of the finished suit shall be of the highest quality. The design of the garment shall ensure adequate air gaps between the fabric and the body for ventilation. No external pockets shall be allowed.

(vi) Functional Requirements:

The material of the outer layer of clothing assembly (i.e. aluminised asbestos) shall comply with the requirements given below:

- no test specimen shall continue to flame for more than 8 seconds after the ignition flame has been removed,
- after-glow shall not spread beyond the area of the material damaged by flaming, and
- the average length of material, which chars or melts, shall not exceed 85 mm.

(vii) Thermal Protective Index:

The protective clothing shall give minimum thermal index value of 40 for flames (time in seconds before the temperature of the back surface of the protective clothing assembly rises by 25 ^{0}C, when exposed to a standard heat source of burning hexane) and 300 for thermal radiation (time in seconds before the temperature of the back surface of the protective clothing assembly rises by 25 ^{0}C, when exposed to a standard radiation source consisting of a radiant panel.)

(viii) Sizes and Weight of the Suits:

The suits shall generally be made in four sizes and the weight shall be kept as low as possible. The size and the maximum permissible weight are given below:

Sl.No.	**Size**	**Overall Length in mm. ± 20 mm**	**Maximum Weight in kg**
1.	Small	1480	7.0
2.	Medium	1520	8.0
3.	Large	1560	10.0
4.	Extra large	1600	12.0

This suit should be worn with properly designed boots, gauntlets and headgear complete with visor and curtain for face and neck protection against the flame and radiant heat. It is also advisable to use SCBA along with the suit. The design of the suit shall be such that the SCBA can be worn under the suit.

(ix) Performance Tests:

The finished suit complete with flame/heat-resistant boots and helmet with visor shall be worn by the operator who shall perform the functions given below:

(a) cycling for 5 minutes followed by running for two minutes,

(b) ascending and descending a 10.5 m extension ladder pitched to its fully extended length, ten times each way in succession, carrying down a human dummy each time he descends the ladder,

(c) standing or walking for three minutes within 600 mm of a fire in the open, the fire being equal in intensity to a fire in 5000 litre of aviation turbine fuel,

(d) the wearer shall run out a length of hose 30 m without difficulty. The wearer shall also be able to carry a person weighing 90 kg on his shoulder at least for 30 seconds without any undue exertion or fatigue, and

(e) a tank measuring 3 x 3 x 0.6 m containing 0.5 m depth of water with a layer of oil shall be ignited and the wearer shall handle a branch pipe in the following manner: A thermometer shall be inserted in the breast-pocket of the wearer. Its temperature before insertion shall be recorded. The wearer shall now approach a distance of 0.6 m from the flame for a maximum period of 45 seconds and then withdraw. The thermometer shall be taken out to note the requisite temperature recorded. It shall not register a rise of more than 7°C when originally placed.

(x) Instructions:

Manufacturer's instruction shall be provided with each suit of protective clothing. These shall give information on how the best results may be obtained in use and on limitation of the clothing.

(xi) Markings:

Each suit shall be legibly and indelibly marked with the following information:

- manufacturer's name or trade mark,
- size,
- type (flame or heat-resistant suit),
- year of manufacture,
- expansion time limit, and
- ISI mark, if applicable.

6.6.2 Suits for Radiation Protection

Protective plastic suits play an important role in reducing occupational exposure to radiation, particularly in locations contaminated with radioactive materials. Some radioactive materials, such as Tritium can be absorbed through the skin. These suits when ventilated properly act as a barrier against absorption. Various types of suits are employed in DAE units depending upon the nature and level of contamination in the working areas. Commonly used suits are of two types: two-piece suit and single piece (frog) suit.

Two piece suits consist of a coverall, made of suitable plastic material for covering the body and the feet and a hood with a transparent visor for covering the head, whereas in single-piece suit, hood is the integral part of the suit.

(i) Specifications:

Materials for making these suits should possess the following properties:

- the film used for the suit shall have a smooth, dull, non-embossed finish for proper decontamination,
- the film should remain flexible in the temperature range encountered,
- the film shall be of self-extinguishing type,
- the film should have minimum tear strength of 75 kg/cm in warp direction and 100 kg/cm in weft direction,
- the film should have minimum tensile strength of 200 kg/cm^2 in warp direction and 150 kg/cm^2 in weft direction,
- the ultimate elongation (%) of the film material should be a minimum of 150 per cent,

- the permeance of the film to water vapour should be a maximum of 20 x 10^{-6} cc/cm^2/s/mil thickness at 1 cm Hg pressure as determined by ASTM-E96-63T Method D. This value should not change after 168 hours storage at 70°C,

- the seam strength of the sealed films should be more than 3.64 kg/cm,

- the colour of the film should be yellow,

- these suits are made of laminated soft yellow coloured PVC film of 0.20 mm thickness. For visors of the PVC hoods, laminated crystal-clear transparent PVC films of thickness 0.30 mm to 0.50 mm are used. All the seams of the suit are electronically welded on a high frequency welding machine to provide better seal, and

- the suits should be well finished, free from dirt, scratches, cracks and pin holes, etc.

Taking into consideration the above specifications, weight, strength, flexibility, ease of fabrication, etc. it is found that virgin plasticised PVC films have widely been accepted to fabricate these suits, as these are able to withstand the stresses and the temperature encountered during field use.

6.6.3 Chemical Resistant Suits

These suits provide protection against exposure to corrosive chemicals, oxidising agents, solvents, etc. Total protection suits shall be of materials with high mechanical strength, be light in weight, allowing freedom of movement, self-ventilating and impermeable, and resistant to all corrosive agents against which protection is required. Gas-proof clothing may either be pressurised or non-pressurised. Pressurised suits are normally employed for those corrosive gases/liquids, which could be absorbed through the skin. Non-pressurised clothing comprise a hood, a suit and foot and hand protection. Pressurised suits consist of a one-piece suit with an integral hood supplied with air an airline or an air cylinder. Rubber and PVC aprons are also used to protect the workers in chemical laboratories and industrial establishments against acids and alkalis.

(i) Materials:

Protective suits used against corrosive chemicals are usually made from a fabric (treated cotton or artificial fibre) coated with synthetic

elastomers, like neoprene, styrene, butadiene rubber, acrynitrile rubber, butyl rubber or chlorosulphonated polyethylene. The woven cotton or rayon staple cloth coated with vinyl chloride or unsupported laminated PVC films are also used for making these suits. Suits made of mixed PVC-polyester fabrics can be used for both acids and alkalis.

(ii) Specifications for Suit Materials:

Materials selected for making these suits should possess the following properties:

- the weight of the finished material shall not exceed 680 g/m^2 as recommended in IS: 12257-1984,
- the minimum breaking strength in warp direction and weft directions shall be 12 kg/cm and 8 kg/cm respectively as recommended by IS: 3322-1965,
- the material shall not show any sign of cracking due to weathering effect or when exposed to corrosive chemicals,
- the coating shall be uniform, free from pinholes and devoid of unpleasant smell. It shall withstand continuous exposure to a temperature of 100°C for 24 hour without showing any sign of stickiness,
- the material shall be impermeable to water. The maximum rate of permeation shall not exceed 20 x 10^{-6} cc/cm^2/s/mil thickness at one cm Hg pressure,
- the material shall not show any appreciable change in mechanical properties, weight and dimensions after being kept in chemical reagents for 168 hours, and
- the plies shall not separate more than 10 mm under load of 3 kg as recommended by IS: 3322-1965.

6.6.4 Lead Rubber Aprons for X-rays

X-ray protective aprons are intended to be used during X-ray diagnostic examination with X-rays excited at voltage upto 150 kV peak.

Two types of aprons are employed depending upon the protection factor required.

- Type A:

  Have a minimum of 0.25 mm lead equivalent for X-rays generated at a voltage of 150 kV peak as per IS: 7352-1974.

- Type B:

  Have a minimum 0.5 mm lead equivalent for X-rays generated by a voltage of 150 kV peak as per IS:7352-1974.

  Three sizes of aprons, 'large', 'medium' and 'small' differing only in length are available. Sizes for aprons shall be so chosen that the aprons extend from the trunk and cover the gonads of the person.

(i) Material:

The protective material of the aprons shall be in the form of a uniform sheet made either from natural or synthetic rubber compound incorporating lead or a compound of lead. The rubber sheet containing lead shall be bonded on both sides with cotton sheeting and the finished material shall be flexible.

- The apron shall be provided with supporting fabric attached at the back, which shall consist of leather cloth.
- The apron shall have two pairs of tying tape made of 40 mm wide newar (cotton tape).
- The edges of the aprons shall be protected by means of cotton tape 20 mm wide newar.
- All the stitching shall be done by cotton thread conforming to a variety 28 (16 tex x 6) of IS: 1720-1978.
- The aprons shall be made from material as stated above which is free from joints and shall conforms to the design and dimensions as shown in Fig. 1 of IS: 1720-1978.
- The tensile strength and elongation at break of the rubber sheet containing lead shall not be less than 51kg/cm^2 and 200 per cent respectively.

- The tension set of the rubber sheet body material at 150 per cent elongation shall not exceed 30per cent. The period for which the test piece is kept in stretched condition and recovery shall be 10 minutes each.

- The adhesion strength should be such that the average load required to strip off longitudinally the covering fabric shall not be less than 1.5 kg by machine method with 5 cm/minute rate of traverse.

- The value of tensile strength and elongation at break and adhesion strength shall not show a change of more than the limits given below when kept in air-oven for 168 hours at 70°C.

Tensile strength	: +	20%
Elongation at break	: +	10%
		- 25%
Adhesion strength	: -	30%

- It shall also not show any apparent deterioration in body material, like stiffening. The apron shall be free from manufacturing defects such as patches, blisters, porosity, embedded foreign matter, cuts, pinholes etc. in the rubber sheet.

- The quality of the apron when worn by the X-ray operator should be such that he shall not get more than 0.2 mGy absorbed dose in one hour at a distance of 5 cm.

- Each apron shall be marked legibly and indelibly with the manufacturer's name or trade mark, year of manufacture, and size of apron.

7. SAFETY BELTS AND HARNESS

7.1 General

Safety belts and harness are required to be used by workers who have to work at heights, where a fall may result in serious injury or death. These can be of following types:

(i) Body Belt:

- To limit movement and positioning
- To restrict the worker to a safe area
- To help prevent a fall

This is used where freedom of movement is most important and where only limited fall hazards exist. This is not recommended where vertical free-fall hazards exist.

(ii) Body Harness:

This is used when the worker must move at dangerous heights. In a fall, the harness distributes impact force over a wider body area than does a belt, reducing the possibility of injury to the wearer.

(iii) Suspension Belt:

This is used at those work situations where it is not possible to work from a fixed surface and the worker must be totally supported by a suspension harness, as in the case of stack maintenance, tree trimming, shipboard painting, etc.

It is preferable if belt and harness are made of webbing rather than leather. Webbing has more strength and stretch; hence it has three to four times greater resistance to impact loading than leather of same size. Furthermore, the tongue of buckle on leather belt has comparatively less strength due to cut and pull through holes in the strap, while webbing belts use buckles which avoid loss of strength at buckle holes. Also, the leather belt requires special care and treatment to retain its strength, while the webbing does not. Webbing could be made of cotton or synthetic material such as nylon or dacron which have superior strength, and resistance to mildew and moisture. For

work areas using chemicals or oils, it is preferable if webbing is coated or impregnated with plastic or neoprene rubber materials. The weave of webbing should be of herringbone type instead of square (basket) weave. The former gives approximately twice the strength than basket weave.

Lifelines of safety belts and harness are usually nylon ropes of 12mm diameter or manila ropes of 19mm diameter. Nylon is more resistant to wear or abrasion than manila and is more resistant to some chemicals. The lifeline should be spliced into snaps and D-rings instead of being knotted. Splicing will retain approximately 90 per cent of the rated strength of the rope, while knots reduce the strength considerably, depending upon the type of knot or hitch used and the moisture content of the rope.

The anchorage for lifelines should be selected to permit as little slack as possible, thereby stopping a worker with minimum of free fall. Special notice must be taken of nearness of any beam or other obstruction which the workman might strike in case of a fall. The waist-belt should always be inserted through the D-rings or other devices for attaching the belt to the lifeline. It should never be riveted or fastened in such a way that the D-rings or lifeline get separated from the belt due to failure of rivets.

7.2 Care of Safety Belts and Harness

Each wearer of safety belt/harness should inspect this PPE daily before use. In case of fabric belts, if the considerable portion of outer fibres is noticed to be cut or worn, the belt should be rejected. Leather belts should especially be observed for cuts or deep scratches on the strap. Any deep cut of considerable length, in a direction across the width of the belt, calls for discarding of the belt. Within 30 to 90 days each belt should be thoroughly examined by a trained inspector. Belt hardware should be checked and the worn parts replaced. Each belt rivet should be examined to be certain that it is secure.

Safety belts in service should not be tested, as it may damage the belt, making it unsafe. Therefore, only sample belts or worn or doubtful belts should be tested for destruction to determine their safety. Belts subject to the maximum impact in an accidental fall should not be reused because the fittings might have been over stressed and weakened. The safety belt should be securely buckled and worn tight enough to prevent any possibility of the worker slipping out of it.

Cotton or linen webbing belts should be washed in soapy water, rinsed and dried by moderate heat. They are not damaged by temperature upto 100^0C.

Synthetic fibre belts should not be exposed to excessive heat as it might soften or melt the fibres or the chemical, subsequently affecting the composition of the fibre.

More care is to be taken of leather safety belts. Dirt adhering to this type of belt should be brushed off carefully so as not to scratch the leather. Leather belts should not be exposed to excessive heat, such as from a radiator, because a temperature as low as 65°C may permanently damage them. A leather belt which has been unused and not oiled for a year or two is much weaker than one which has been regularly used and adequately oiled over the same period, even when the unused belt will look newer and stronger. Leather belt should be oiled with neatsfoot, castor, soya bean or compound oil. Mineral oil should never be used for leather safety belts.

The materials used in the production of safety belts including webbing and rope shall pass the flammability resistance tests as given in Annexure-A of IS: 3521-1989.

The performance test should be carried on an articulated anthropometric dummy having a mass of 100 $\pm$ 5 kg and an overall height of 1.6 to 1.8 m with waist not more than 100 cm in circumference.

7.3 Specifications for Safety Belts and Harness

- The waistbelt, shoulder straps, hoisting straps, pole straps of all types of safety belts and harnesses shall be made of nylon/polyester webbing which shall not break under a minimum tensile load of 2000 kg. The width and thickness should be 44 $\pm$ 1mm and 3 $\pm$ 0.05 mm respectively.
- The threading for sewing load-bearing components shall have similar physical and chemical properties as the material being sewn.
- All rivets and washers used for joining the various sections shall be made from copper.
- Nylon, polyester or synthetic fibre shall be used for lifeline/safety line. It shall not break under a minimum tensile load of 2000 kg. The minimum diameter of the lifeline should be 10 mm.
- The metal components shall be solid or forged, the joints should not be visible and the jointed part of the metal should not impair the strength or quality.

- All fittings should be corrosion-resistant and chromium coated with ample thickness to last for a minimum period of three years of storage. All the metal parts mating with the webbing shall be smoothly finished, rounded and designed to prevent damage to the webbing.

- The hooks, clamps or other fastening and holding devices shall be of similar quality and properly treated or plated. The design of the hooks shall be self-closing type and care shall be taken to ensure that if pressure is exerted accidentally on the tongue or the latches, they shall not disengage. Aluminium, magnesium or titanium metals or alloys thereof shall not be used.

- If springs are used, they shall be so arranged and loaded that when the hooks are closed, the springs rest in position and are free from any movement until pressure is applied to release or to engage.

8. EAR PROTECTION

8.1 General

High noise levels are associated with a number of industrial operations and machines. Excessive exposure to high levels of noise can cause irreparable damage to hearing, in addition to some physiological and psychological harm. Occupational hearing loss is a notifiable disease under the Factories Act. In order to protect the hearing capacity of persons working in industries, the exposure to noise should be kept well within the specified permissible limits. Wherever the noise exceeds the permissible values, control measures should be adopted to reduce the exposures. Engineering control measures, such as institution of enclosures, process change and use of personal protective equipment for ears are employed as noise control measures.

Ear protectors fall into three main groups:

- plug or insert type,
- cup or muff type, and
- helmet type, which completely surrounds the head in which the attenuation of sound is achieved through the acoustical properties of the helmet.

These are classified into two subgroups:

- aural type, and
- superaural.

(i) Aural Type:

This is placed into the ear canal. It varies considerably both in design and material. Rubber and plastic types are preferable, as they are easy to clean, inexpensive and give good performance. It is important that ear-plugs be fitted individually by trained personnel. Plugs must fit properly and remain correctly seated. The slightest leakage in the fitting will lower the attenuation by even upto 16 dB in some frequencies. Hearing protectors made of silicone rubber, if properly molded and correctly used, prove more comfortable than prefabricated inserts. Soft

plastic plugs are more comfortable than hard plastic types and also hold their shape better than rubber types. Cotton inserted in the ear is a poor choice because of its low attenuating properties (2 to 12 dB depending on frequency). Wax protectors also have certain drawbacks-they tend to lose their effectiveness during the workday; they are objectionable from sanitary point of view; they are to be shaped by hand; and they can be used only once.

(ii) Superaural Type:

This seals the external edges of the ear canal in order to bring about sound reduction. These are made of soft rubber-like material and are held in place against the edges of the ear canal by a spring band or head suspension. Such ear protectors are also known as caps.

(iii) Muff Type:

This type of ear protector covers the external ear to provide acoustic barrier. The muffs (cups), which are cushions filled with liquid or grease, have better noise suppression than plastics or foam-rubber types, but may present leakage problems. Muffs are held over the ears by means of headbands.

8.2 Amount of Attenuation

The ear-plugs, if properly fitted, can attenuate noise by 25-30 dB in the high frequencies, which are considered to be the most harmful. Earmuffs of better quality may reduce noise by an additional 10-15 dB. Combination of ear-plugs and ear-muffs may reduce noise by an additional 3-5 dB. In no case, the total attenuation will be greater than 50 dB, because at this point bone conduction becomes significant.

8.3 Care of Ear Protectors

Regular cleaning of ear protectors is important for the sake of proper hygiene. Protectors that become contaminated or coated with hardened wax may cause discomfort and may lead to infection of middle ear.

8.4 Tests for Ear Protectors

The following tests described in IS: 9167-1979 should be carried out on 10 samples of a lot and no single failure is allowed:

- sound attenuation test as per IS: 6229-1980,
- damp heat test, accelerated,

- rapid change of temperature test,
- low temperature impact test,
- cleanability test, and
- headband extension test.

The ear protectors subjected to these tests should not crack or rupture or deteriorate. These tests are meant for ensuring basic climatic and mechanical durability of components.

8.5 Audiometric Testing

An audiometric testing programme should be maintained for workers who are exposed to noise levels in excess of 90 dB. Such a programme will help in determining whether hearing PPE worn by the workers are in fact protecting their hearing capability against noise damage. This will also facilitate the selection of workers more likely to be affected by the noise so that they may be transferred to another job.

8.6 Specifications for Ear Protection Equipment

The material used, which may come into contact with the body, should not cause irritation. It should be moisture-proof, heat-resistant and cold-proof. The ear-plugs should be elastic so that they can be easily inserted. The ear protectors should be so designed as not to easily fall off from the ear when being worn.

The material used should not get affected in any way when the temperature ranges between 25° to 55°C.

The sound attenuation requirements (IS: 9167-1979) of the ear protectors should be as given below:

Group	Frequency (Hz)	Group Sound Attenuation(minimum dB)	
		Ear-muffs	Ear-plugs
A	125 } 250 }	25	25
B	500 } 1000 } 2000 } 3000 } 4000 }	175	135
C	6000 } 8000 }	60	

Note : The minimum group attenuation is the sum of mean attenuation for each of the test frequencies contained in that group.

The acceptable minimum sound attenuation for each of the single test frequencies contained in Group B is as follows:

Test Frequency(Hz)	Sound Attenuation(minimum)	
	Muffs	Plugs
500	25	20
1000,2000,3000,4000	35	25

9. RESPIRATORY PROTECTION

9.1 General

Respiratory PPE are required by workers in work areas where there is lack of sufficient oxygen or where high levels of atmospheric contaminants are likely to be present. The contaminants may range from the relatively harmless substances to toxic dusts, fumes, smoke, mists, vapour and gases. This type of PPE shall be used in the following situations:

(i) Non-emergency Situations:

When workers are exposed to an atmosphere which does not have a rapid, dangerous effect upon life or health but will produce chronic illness, pronounced discomfort or permanent physical damage or even death after prolonged or repeated exposures. Such situations generally involve normal routine operations.

(ii) Emergency Situations:

At times workers are exposed to an atmosphere with high concentrations of contaminant which have a rapid, harmful effect on life or health even after comparatively short periods. Under such situations, respiratory PPE should provide complete respiratory protection to the worker with provision for safeguarding the wearer against even a momentary failure of PPE during exposure to the dangerous atmosphere.

9.2 Selection of Respiratory PPE

A wide variety of respiratory PPE are available from suppliers for persons working in different types of work situations. The following information is required for deciding on the type of respiratory PPE required:

a) the name of contaminant to be guarded against; its chemical, physical and toxicological properties,

b) type of work situation, viz. non-emergency or emergency, and

c) the period of time for which respiratory PPE is required to be used.

After considering the above information, refer to Figures 2 and 3 for selecting the type or types of respiratory PPE that would protect the worker. Besides the above selection procedure, the following general principles must be taken into account:

(i) Chemical cartridge respirators are suitable only in atmospheres that are not immediately dangerous to life and that contain a percentage of contaminants not exceeding 0.1 per cent by volume. These respirators should not be used for following types of contaminants:

- that are extremely poisonous in very small concentrations (e.g. hydrogen cyanide).
- that are not effectively absorbed chemically (e.g. carbon monoxide).
- that are not easily identified by odour (e.g. methyl chloride, hydrogen sulphide).
- that are irritating to eyes (e.g. sulphur dioxide).

(ii) Canister-type gas masks should be limited to use in atmospheres that are not deficient in oxygen or where the toxic contaminant does not exceed 2 per cent in concentration (3 per cent for ammonia) by volume.

The following criteria can be adopted to select the brand of respiratory protection equipment:

- conformity to the relevant publications of BIS,
- easy to don, use and take off,
- adequate protection against hazards,
- adequate protection factor,
- durable,
- comfortable and non-irritating,
- good field of vision,
- provision for communication and for use of spectacles,
- easy to clean and maintain,
- easy replacement of non-lasting parts,
- availability of test certificates, and
- availability of testing/servicing facility with the supplier.

FIGURE 2: CLASSIFICATION OF RESPIRATORY PROTECTIVE DEVICES

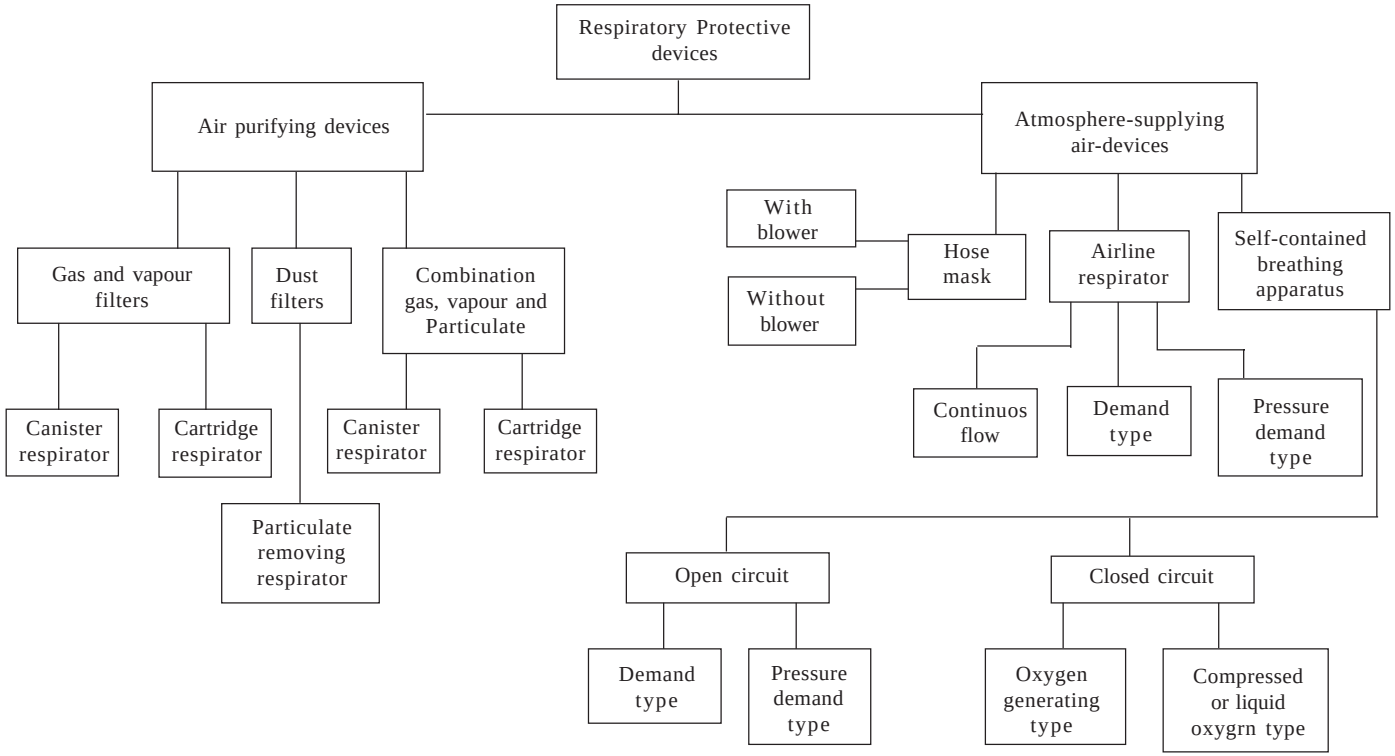
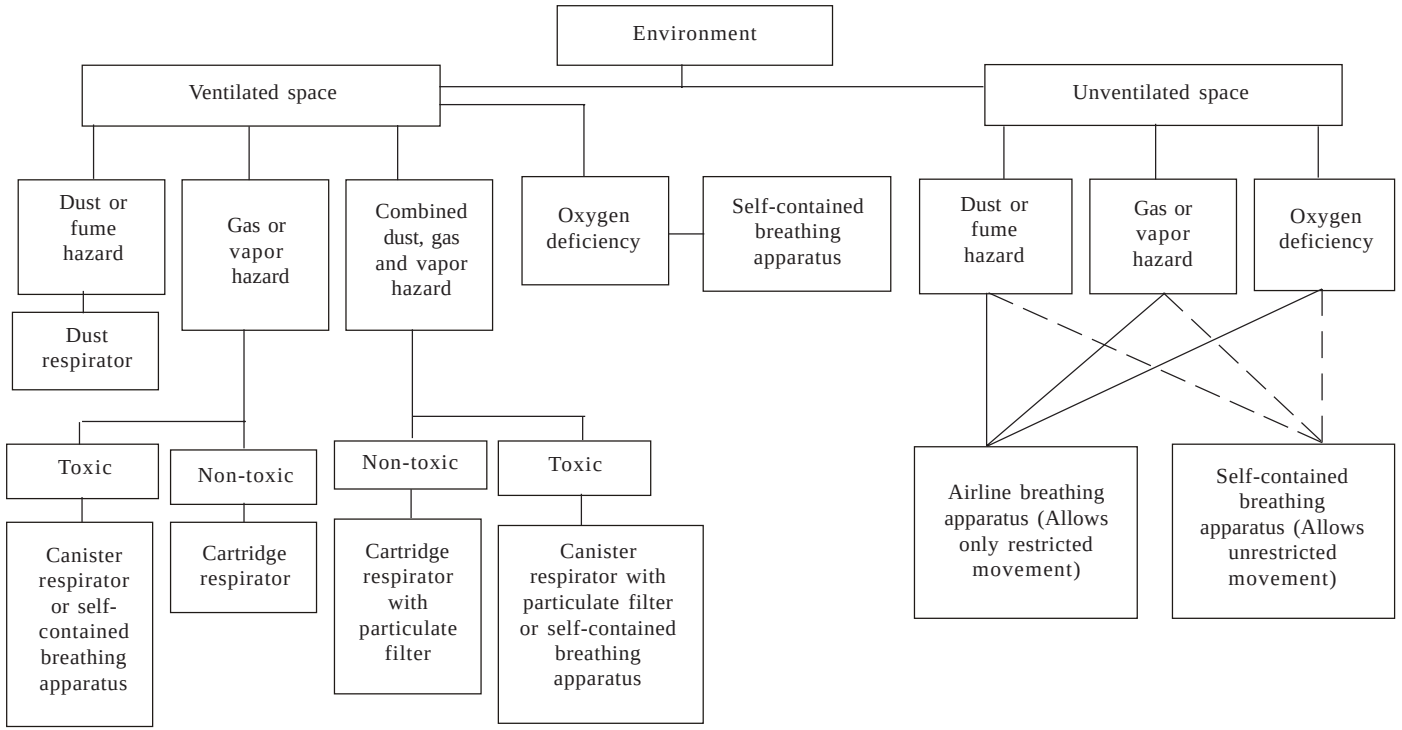


FIGURE 3: ENVIRONMENT CLASSIFICATION FOR SELECTION OF RESPIRATORY PROTECTION DEVICES



Normally in a ventilated space, oxygen deficiency would not occur, except, due to an accident situation

9.3 Care of Respiratory PPE

The following considerations should be kept in mind for maintaining the quality of respiratory PPE:

- Where practicable, the respirators should be assigned to individual workers for their exclusive use.
- It is advantageous to assign two respirators to each individual user. They last more than twice as long, and helps in carrying out proper servicing of respirators as the second respirator is used while the first is being serviced.
- Respirators must be cleaned regularly and disinfected.
- Respirators should be stored in a convenient, clean and sanitary location.
- Respirators used routinely should be inspected during cleaning. The deteriorated parts, if any, should be replaced. Respirators for emergency use, such as self-contained type (e.g. SCBA), are to be thoroughly inspected at least once a month and after each use.
- Respirators should not be thrown into tool boxes or left on work benches where they may get exposed to dust or damaged by oil or other harmful materials.
- Respirator should never be hung by the elastic headband or kept in a position, as to stretch the face-piece.
- Before storing, respirator should be carefully wiped with a damp cloth and dried. It should be stored without making sharp folds or creases on it. It should be sealed in clean, plastic bags.
- Users should wipe off oil, grease and other harmful substances from head-bands and other parts of the respirator as soon as they get dirty. Solvents should not be used to clean plastic or rubber parts.
- Supervisors should be made responsible for daily inspection of respiratory PPE, particularly of functional parts, such as exhalation valves and filter elements. They should see that the edges of the valves are not curled and that valve seats are smooth and clean. Inhalation and exhalation valves should be replaced periodically.

- In addition to daily check, trained persons should inspect the respirators. During weekly inspection, rubber parts should be stretched slightly for detection of fine cracks. The rubber should be worked occasionally to prevent setting (one of the causes of cracking), and the headband should be checked to ensure that the wearer has not stretched it in an attempt to secure a snug fit.

9.4 Training for Use of Respiratory PPE

For the following reasons, it is essential that the wearer of respiratory PPE undergoes special training before using it:

- Respiratory PPE may be used in emergencies (immediate dangerous to life), where there is strain and excitement.
- The operation of certain types of respiratory PPEs is fairly complex (e.g. self-contained breathing apparatus).
- Gas mask may not have been fitted properly on the face of the wearer.
- Wrong type or ineffective type of respiratory PPE may be used by the worker.

Hence, for safe use of any respirator, it is essential that the user is properly trained for its selection, use and maintenance. Training is to be given to the worker so that he gets skilled in the following:

- selection of proper respirator,
- proper fitting of face mask,
- proper handling of respirator,
- proper care of respirator, and
- effectiveness of respirator.

In training, the user wears the mask long enough to become accustomed to the breathing resistance.

The workers who use respirators need to be given training and periodic retraining, which include explanations and discussions, on the following:

- nature of the respiratory hazard and possible health effects if the respirator is not used properly,

- reason for selection of a particular type of respirator,
- how the respirator works and its limitations,
- how to put the respirator on and check that it is working and adjusts properly,
- how to maintain, inspect and store the respirator, and
- a respirator fit test for negative pressure respirators.

A guideline for using the right type of respiratory protection equipment for different types of hazards is given in Annexure-XI.

Colour code for canisters and cartridge-type of air-purifying respirators for different types of atmospheric contaminants is given in Annexure-XII.

Guidelines for marking on respiratory protection equipment based on BIS publications are given in Annexure-XIII.

9.5 Special Precautions for Respiratory PPE

- Right type of respiratory PPE should be used, as particulate filter respirators are of no use against solvent vapours, injurious gases or lack of oxygen.
- Chemical cartridge respirators should not be used where gas masks are required.
- Chemical filtering-type respirators should not be used where atmospheric supporting-type or self-contained units are required.
- From the standpoint of fire hazard, pure oxygen or air containing more than 21per cent oxygen should not be used in atmosphere-supplied respirators or in self-contained type of breathing apparatus.
- Canister gas masks should not be used in areas where oxygen content is less than 19.5 per cent by volume.
- Canister gas masks should not be used for fire fighting purpose. In fire fighting operations, wear self-contained breathing apparatus.
- Each person, who is required to wear the gas mask, should first undergo physical examination, especially of his heart and lungs. Anyone in questionable physical condition should be prevented from entering into a work environment posing respiratory hazards.

- The user of a gas mask should enter the contaminated area cautiously. If the mask leaks or the canister is exhausted, the user will usually know by the odour, taste or irritation of eye, nose or throat. The user should then immediately return to fresh air.
- If the canister of the gas mask is exhausted, it should not be left attached to the gas mask; but removed. A new canister should be selected and fastened in place.
- When a respirator is worn in a gas or vapour that has little or no warning properties like carbon monoxide, it is recommended that a fresh canister should be used each time a worker enters the toxic atmosphere.
- Filters of particulate filter respirators should be replaced whenever breathing becomes difficult due to plugging of filters by retained particulates inside.
- No one should wear self-contained breathing apparatus unless he is physically fit and well trained. Refresher training should be provided at least every six months.
- No one wearing self-contained breathing apparatus should work in an irrespirable atmosphere unless another person, similarly equipped, is in attendance, ready to give assistance.
- A canister or gas mask with broken seals should not be kept in service for more than one year, regardless of how little it has been used.
- In atmospheres with a high concentration of hydrogen cyanide or any other contaminant, which are absorbed through the skin, the user need to be protected by appropriate type of respirator and clothing.

9.6 Protection Factors for Respiratory PPE

The values of protection factors for different types of air respirators are given in Annexures-XIV and XV.

9.7 Specifications for Respiratory Protective Equipment

9.7.1 Canister Type Respirators (Gas Masks) (IS: 8523-1977)

There are three types of gas masks:

(i) front mounted or back mounted canister gas mask, with full face-piece,

(ii) chin type gas mask where the canister near the chin has full face mask, and

(iii) escape gas mask.

(i) Protection Limits:

Maximum volume concentrations of contaminants for which the canister should provide protection are as follows:

Sl. No.	Contaminant	Front or Back Mounted Gas Mask %	Chin-type Gas Mask %	Escape Gas Mask %
1.	Acid gases	2 (Notes 1 and 2)	0.5 (Notes 1 and 2)	0.1 (Notes 1 to 4)
2.	Ammonia	3 (Note 1)	0.5	0.5 (Note 3)
3.	Carbon monoxide	2 (Note 1)	Not recommended	1.0
4.	Organic vapours	2 (Notes 1 and 2)	0.5 (Notes 1 and 2)	0.5 (Notes 1 to 3)

Note 1 : Approval may be for acid gaspes or organic vapours as a class or for specific acid gases or organic vapours. Approval may also be granted for combinations of any or all of these materials.

Note 2 : Not for use against acid gases or organic vapours with poor warning properties or which generate high heats of reaction with sorbent material in canister.

Note 3 : Eye protection may be required in certain concentrations of acid gases, ammonia and organic vapours.

Note 4 : Suggested maximum use where concentrations are lower than those for some acid gases and organic vapours.

Inhalation and exhalation valves should be provided to protect the canisters. Dry exhalation valve and valve seat will be subjected to a suction of 25 mm of water gauge while in normal operating position. The leakage between valve seat and valve shall not exceed 30 ml per minute.

(ii) Face-piece Test:

The respirators shall be fitted to the face of three persons having varying facial shapes and sizes. Each person wearing the gas mask shall enter a chamber containing 1000 ppm concentration of isoamyl

acetate vapour and remain in the chamber for 8 minutes to perform certain activities:

- 2 minutes - nodding and turning head.
- 2 minutes - calisthenic arm movements.
- 2 minutes - running in place.
- 2 minutes - pumping air with air pump into 0.1 m^3 cylinder.

No person shall detect the odour of isoamyl acetate during the test period.

9.7.2 Chemical Cartridge Respirators(IS: 8522- 1977)

Chemical cartridge respirators (CCR) are designed for atmospheres not 'Immediately Dangerous to Life or Health' (IDLH). They are generally used only for evacuation purposes. The presence of some contaminants can be felt by human senses. In case the user of the respirator is able to feel the presence of such a contaminant, he should immediately evacuate from the area. The cartridge of the respirator should be replaced by a fresh one.

(i) Protection Limits:

Sr. No.	Type of CCR	Maximum Use Concentration
1.	Amines	100 ppm *
2.	Amine derivative	30 ppm *
3.	Ammonia	300 ppm
4.	Chlorine	10 ppm
5.	Hydrogen chloride	50 ppm
6.	Organic vapours	1000 ppm*
7.	Sulphur dioxide	50 ppm

* For amines, amine derivatives and organic vapours that produce IDLH conditions at concentrations lower than those given above, the suggested maximum use of concentrations shall be lower.

(ii) Breathing Resistance:

Resistance to air flow at the face-piece should be measured by using a test fixture with air flowing at 85 lpm. The resistance to air flow shall not exceed the following values:

Type of Cartridge	Inhalation Resistance (initial - final), mm of water	Exhalation Resistance, mm of water
Mask for gases,vapours and gases and vapours	35 - 45	20
Mask for gases, vapours, or gases and vapours, dust, fumes and mist	45 - 65	20

(iii) Face-piece Fit Tests:

The complete chemical cartridge respirator shall be fitted to the faces of three persons having varying facial shapes and sizes. Each person wearing a chemical-cartridge respirator shall enter a chamber containing 100 ppm isoamyl acetate vapour (1000 ppm for full face-piece respirator) and remain inside, doing light activities for 8 minutes. No person shall detect the odour of isoamyl acetate vapour during the test.

(iv) Face-piece Leakage Test:

Each of the three persons wearing two different respirators fitted to the face shall enter a chamber containing 100 ppm of dichloro difluro methane and remain inside for 15 minutes and to perform light activities. Air samples taken from inside the face-piece shall not exceed 5 per cent of the test concentration.

9.7.3 Filter Type Particulate Respirators. (IS: 9473-1980)

Filter type respirators are classified as follows:

- dust respirators,
- fume respirators,
- mist respirators,

- combined respirators (combination of mechanical filter and other type(s)), and
- radioactive dust respirator.

Hazardous materials shall not be used as a filtering medium. A durable container shall be provided for each respirator to protect it when not in use. Filter units shall also be protected similarly.

(i) Exhalation and Inhalation Valves:

Respirators for particulate matter having thresshold limit value less than 0.1 mg/m^3 shall be provided with exhalation and inhalation valves.

(ii) Tests for Face-piece:

Respirators shall be fitted to about 15 to 20 persons having a wide variety of facial shapes and sizes. The inhalation and exhalation valves shall be held closed and each subject shall exhale into the face-piece until a slight but definite positive pressure is built up in the face-piece. The absence of outward leakage of air between the face-piece and the subject's face is evidence of an acceptable fit.

The resistance to inhalation of a particulate respirator shall not exceed 30 mm of water column and resistance to exhalation shall not exceed 20 mm of water column at any time.

9.7.4 Compressed Airline Breathing Apparatus (IS:10245 (Part 3)-1982)

(i) Materials:

All materials used in the construction of airline respirator shall have adequate mechanical strength, durability and resistance to corrosion. These materials shall be anti-static and fire resistant as far as practicable. The exposed parts of the apparatus should not contain metals, which give frictional sparks, such as Mg, Ti, A1 or alloys of these metals. Materials of breathing apparatus that come in contact with skin shall not contain dermatitic substances.

(ii) Face-piece:

Since full face-piece for this type of respiratory protection is an important part, detailed requirements to be met by the face-piece are given below. These requirements may be applied to full face-pieces used for other types of respirators as well:

- The component parts, including breathing tubes shall withstand a test underwater at an air pressure of 1.7 kPa and shall be proved free of leakage.
- The half facemask shall cover the nose and mouth, and the full facemask should cover the eyes, nose, mouth and chin to provide adequate sealing to the face of the wearer.
- Face-pieces shall be light in mass and comfortable to wear for long periods.
- Face-pieces shall have preferably replaceable visors and shall be made of non-splinterable, clear and non-flammable materials.
- Face-pieces shall be secured to the face by means of adjustable and replaceable head harness.
- Device for speech transmission may be incorporated.
- Means to reduce misting of the visor shall be provided.
- Visor shall have a wide field of vision.
- The face-pieces shall have provision for attachment of prescription glasses.
- The dead space in face-piece shall be as low as possible.

(iii) Head Harness:

- The head harness shall hold the face-piece, half mask or mouthpiece firmly and comfortably in position. Fabrics used in the construction shall be resistant to shrinkage and shall not cause irritation to the wearer.
- The head harness shall be adjustable.
- The strap of the head harness shall be slip-proof and durable.

(iv) Harness or Belt:

Fresh airlines shall be provided with a belt to prevent a pull on the breathing tube, or on the face-piece. They shall be provided with buckles. The attachment connecting the hose to the harness shall withstand a pull of 1000N for 5 minutes without failure.

(v) Valves:

The design of the valve assemblies shall be such that valve discs or the assemblies can be readily replaced. It shall not be possible to fit an inhalation valve assembly in the expiratory circuit or an exhalation valve assembly in the inspiratory circuit.

(vi) Condition of Inhaled Air:

The carbon dioxide content in the inhaled air shall not exceed 1.5 per cent by volume when the apparatus is tested with a flow rate of less than 120 lpm of air.

(vii) Fresh Air Supply System:

The hose shall be fitted with a strainer at the free end to exclude debris. The hose should be resistant to collapse and kinking. The hose and couplings shall be tested for leak tightness by immersion in water with an internal air pressure of 7kPa. The hose shall be so flexible as to be wound on a drum 500 mm in diameter.

9.7.5 Self-contained Breathing Apparatus (SCBA) [Open circuit type. IS: 10245 (Part 2)- 1982]

A self-contained breathing apparatus (SCBA) enables a person to remain in irrespirable and poisonous atmosphere for a specified period of time, if required. It is also known as a rescue apparatus or gas mask. In this type of SCBA, compressed air carried in cylinders is fed through a demand valve and breathing tube to a full face-piece. Exhaled air is passed into the atmosphere through a non-return valve.

The apparatus must be simple, reliable and as compact as possible. It should not have any protruding parts or corners or edges on which the wearer of the unit can get caught in close quarters or can be injured. It must be possible to put on or take off the compressed air breathing apparatus without any interruption of the respiration. It must be capable of functioning in any position.

The supplier shall submit a test certificate for the cylinders and other parts at the time of supply.

(i) Materials:

The materials used in the construction of SCBA shall have adequate strength, durability and resistance to heat. They shall be anti-static and fire resistant as far as possible. Exposed parts of the apparatus shall be made of materials which do not give rise to frictional sparks.

(ii) Mass:

The mass of SCBA when fully charged shall not exceed 15.5 kg. The specifications for face-piece, head harness and valves are the same as specified in 9.7.4.

(iii) Warning Device:

The apparatus shall have an audible warning device. This shall operate when the cylinder pressure drops to a predetermined level. The warning device shall begin when there is a minimum of 10 minutes of effective duration of air in the apparatus.

(iv) Face Mask:

Gas cylinders and main valve shall comply with the provisions of the Gas Cylinder Rules, 1981. The cylinders shall be coloured as per IS: 3933-1966 (colour identification of gas cylinders and related equipment intended for medical use).

(v) Condition of Inhaled Air:

The carbon dioxide content in the inhaled air shall not exceed an average of 1.5 per cent by volume.

(vi) Special Requirements:

- The apparatus/set should operate with positive pressure automatically when the user starts breathing from the apparatus. The apparatus should not be used in the negative mode so as to prevent ingress of atmospheric contaminant or not cause discomfort to breathing.
- The effective duration of the set shall be for a minimum of 30 minutes.
- The air pressure in the cylinder should be reduced by a two-stage pressure reduction system.
- The reducing valve should be preferably of piston type.
- The apparatus shall be designed to include a radio communication set.
- As whistle warning unit shall be provided to warn the user when approximately 10 minutes of air remains in the cylinder.

- A robust waterproof pressure gauge shall be provided.
- The positive pressure demand valve shall be preferably of tilt-valve type with a spring loaded neoprene diaphragm to give long reliable service.
- The apparatus shall be provided with a quick coupling connection for providing a separate hose from a remote air supply source for extended work in toxic atmospheres.
- The cylinder valve shall have a self-locking function.
- The positive pressure of approximately 200 Pa (20 mm water column) shall be maintained in the facemask.

9.7.6 Specifications for Escape Breathing Apparatus[IS:10245 (Part 40)-1982]

Escape breathing apparatus is light in weight and suitable for short duration. This apparatus is designed for the sole purpose of enabling a person to escape from a work area contaminated with dangerous dusts, gases, fumes or vapours.

The requirements for the design, construction and performance of escape breathing apparatus are as given below:

(i) Duration:

The duration of an escape breathing apparatus should not be less than 10 minutes. Twin cylinder units are not recommended.

The specifications of the materials, design of face-piece, head harness, valves and gas cylinders shall be the same as given in 9.7.4 and 9.7.5.

(ii) Quality of Inhaled Air:

- oxygen content shall not fall below 21 per cent by volume.
- carbon dioxide content in the inhaled air shall not exceed 2.0 per cent by volume.

(iii) Mass:

The mass of the apparatus shall not exceed 4.5 kg.

ANNEXURE - I

USE OF BEHAVIOUR ANALYSIS TO ENCOURAGE WORKMEN TO WEAR PERSONAL PROTECTION EQUIPMENT

'Applied behaviour analysis' helps management to assess the factors that are capable of giving a quantum jump in improving its safety. Here this analysis is used to identify the causes that induce a worker not to use respiratory protection equipment and to use these findings to introduce measures to encourage workmen to wear appropriate types of PPE.

The basic tool of applied behaviour analysis is known as ABC analysis. 'A' stands for antecedent, which is an event that triggers the observable behaviour 'B'. 'C' stands for consequence, which is the event that follows from that behaviour. This analysis involves the following principles:

- both antecedents and consequences influence behaviour, but they do so very differently.
- antecedents influence behaviour indirectly, primarily serving to predict consequences.
- consequences influence behaviour powerfully and directly.

The following three features determine which consequences are stronger than others:

(i) Timing

A consequence that follows soon after a behaviour influences behaviour more effectively than a consequence that occurs later.

(ii) Consistency

A consequence that is certain to follow a behaviour influences behaviour more powerfully than an unpredictable or uncertain consequence.

(iii) Significance

A positive consequence influences behaviour more powerfully than a negative consequence.

A consequence which is soon, certain and positive influences behaviour most powerfully and the consequence which is late, uncertain and negative is the weakest. Table I.1 shows the range of consequences that result from eight possible combinations of soon-certain-positive.

TABLE I.1: THE RANGE OF CONSEQUENCES.

Strongest	Soon	Certain	Positive
Stronger	Not soon Soon Soon	Certain Not certain Certain	Positive Positive Not positive
Weaker	Not soon Soon Not soon	Not certain Not certain Certain	Positive Not certain Not positive
Weakest	Not soon	Not certain	Not positive

The ABC analysis, when carried to the problem of failure to wear respiratory protection equipment, gives the following antecedents:

- availability.
- peer pressure.
- rushing.
- time of day.
- modelling.
- lack of training.
- anticipation of mild consequences.

Similarly, consequences of this problem are saving of time, comfort, convenience, peer approval, etc. Using the classification for range of consequences as given in Table I.1, the different consequences for the problem fall into following classes:

- saves time strongest (soon - certain - positive)
- comfort strongest (soon - certain - positive)
- convenience strongest (soon - certain - positive)

•	peer approval	strongest	(soon - certain - positive)
•	injury or death	weakest	(late - uncertain - negative)
•	reprimand	weakest	(late - uncertain - negative)

It can be seen from this analysis that all these consequences are in favour of the worker adopting a risky behaviour, viz. failure to wear respiratory protection equipment. Challenge is then to introduce appropriate measures, which encourage workers to adopt safe behaviour. This can be done by replacing the earlier antecedents and consequences by those which promote safe behaviour.

For example to encourage workers to wear respiratory protective equipment, the following practices may be introduced:

(a) Training

Providing training to workers on the harmful effects of working environment and as to how wearing appropriate type of PPE protects them.

(b) Saving time, convenience and comfort

Provide hygienic, comfortable type of PPE to workers and locate the PPE within easy reach of workers.

(c) Peer Support

Introduce worker recognition schemes that encourage peers to support those workers who use PPE. Also introduce punitive measures to discourage those workers who do not use PPE. Wherever necessary, introduce use of PPE as a job requirement.

(d) Modelling

Supervisors and managers should act as role models by using PPE, even where they are involved in hazardous environment for a brief period.

(e) Rushing

Modify the work methods so that a worker has not to rush through jobs. He should have enough time to wear PPE before starting on hazardous jobs.

ANNEXURE - II

MATERIALS USED FOR HEAD PROTECTION EQUIPMENT AGAINST DIFFERENT TYPES OF HAZARDS

Material	Protection Against Hazard
Asbestos	Sparks, hot materials and heat.
Plastic/rubber	Hot liquids, moisture, acids, alkalis, electric shocks and dermatitis.
Cotton wool	Sparks and heat, dermatitis and machinery.
Metal	Falling objects, flying particles, cuts and abrasions.
Plastic	Sparks, falling objects, flying particles, electric shock, cuts and abrasions.

Soft caps and hoods made of appropriate materials are used for protection against heat, spark, and other dangerous materials. Sometimes hoods are made with rigid frame, which is held away from the head.

ANNEXURE - III

TYPES OF HAZARDS TO EYE AND FACE ENCOUNTERED IN DIFFERENT TYPES OF OPERATIONS

Hazards	Operations
Relatively large flying objects	Chipping, felting, riveting, sledging, caulking, etc.
Dust and small flying objects	Scaling, grinding, stone dressing, wood - working.
Splashing of metals	Babbiting, pouring of lead joints, casting of metals, galvanising and dripping in molten metals.
Splashing of liquids	Handling of acids and other chemicals.
Reflected light, glare and radiant energy	Foundry works, glass furnaces, gas welding and cutting, arc welding.

ANNEXURE - IV

TYPES OF EYE AND FACE PROTECTION EQUIPMENT

There are several types of eye and face protection equipment available in the market but it is important that employees use the proper type for the particular job.

The main classes of eye and face protection equipment required for industrial operations are as follows:

IV.1 Eye Protection Equipment

i) Safety Goggles

They fit the contour of the face to enclose the optical area and are held in position by a headband. Goggles come in different designs for different situations as eye-cups, flexible or cushioned, plastic eye shields, foundryman's goggles etc. These may also be of wide vision type. Some of the goggles are provided with ventilation arrangement also.

ii) Safety Spectacles

The oculars of safety spectacles are mounted in robust metal or plastic frame with or without side-shields. The lenses may be of toughened glass, cellulose acetate, acrylic or polycarbonate materials. Side shields are provided where lateral protection is needed.

iii) Safety Clip-ons

Safety clip-ons are protective lenses designed to clip-on over the front of non-safety spectacles. These are covered cut-type goggles designed to fit over corrective spectacles.

IV.2 Eye and Face Protection Equipment

i) Eye Shield

It is a transparent visor supported in front of the face to shield the eyes.

ii) Face-shield

It is a device, including a transparent visor, supported in front of the face to shield the eyes, face, forehead and front of neck.

iii) Wire Mesh Screen Guard

It is a device consisting of woven metal gauze support in front of the face and incorporating a transparent lens in front of the eyes.

These are designed to provide protection to the face from flying particles and spray of hazardous liquids. Some of these are designed to provide protection against glare also.

Hand-held face-shields are also used in welding operations or for observing the welding process.

ANNEXURE - V

DESIGNATION OF WELDING FILTERS

Sl. No.	Welding Filters	Ultra-Violet Filters		Infra-Red Filters	Daylight Filter	
(1)	Shade No.(2)	Code No.2 (3)	Code No.3 (4)	Code No.4 (5)	Code No.5 (6)	Code No.6 (7)
1	1.2	2-1.2	3-1.2	4-1.2	5-1.2	6-1.2
2	1.4	2-1.4	3-1.4	4-1.4	5-1.4	6-1.4
3	1.7	_	3-1.7	4-1.7	5-1.7	6-1.7
4	2	_	3-2	4-2	5-2	6-2
5	_	_	_	4-2a*	_	_
6	2.5	_	3-2.5	4-2.5	5-2.5	6-2.5
7	_	_	_	4-2.5a	_	_
8	3	_	3-3	4-3	5-3	6-3
9	4	_	3-4	4-4	5-4	6-4
10	4a *	_	_	_	_	_
11	5	_	3-5	4-5	_	_
12	5a*	_	_	_	_	_
13	6	_	_	4-6	_	_
14	6a*	_	_	_	_	_
15	7	_	_	4-7	_	_
16	7a*	_	_	_	_	_
17	8	_	_	4-8	_	_
18	9	_	_	4-9	_	_
19	10	_	_		4-10	_
20	11	_	_	_	_	_
21	_	_	_	_	_	_
22	13	_	_	_	_	_
23	14	_	_	_	_	_
24	15	_	_	_	_	_
25	16	_	_	_	_	_

Note : Filters shall be designated for their transmittance characteristics by a combination of two numbers, namely, a code number and the shade number of the filter, separated by a hyphen. The designation of welding filters, however, shall not include a code number, for example, a filter meant for protection against ultraviolet radiation having code number 2 and shade number 1.2 shall be designated as 2-1.2.

* Further details of filters can be referred to in IS: 5983-1980.

ANNEXURE -VI

TYPES OF HAND AND ARM PROTECTIVE DEVICES

Arm and hand protection equipment can be classified into the following groups, based on their shape and part of the arm and hand protected:

(i) Gauntlet Gloves:

Cover the hand and forearm.

(ii) Wrist Gloves:

Cover the hand and the wrist. In these gloves the thumb and each of the fingers are in separate divisions which helps in dexterous movement of fingers and control.

(iii) Mittens:

Cover the entire hand and the wrist with the thumb in a separate division.

(iv) Hand Pads:

Primarily protect the palm and the other working areas of the hand.

(v) Thumb and Finger Guards:

Protect the thumb and the individual fingers.

(vi) Sleeves:

Protect the wrist and the arm. These may be cuff guards and also elbow and shoulder sleeves.

Mittens and gloves are provided with different types of cuffs. The common types are:

(i) Hand-cuff:

Very short cuffs extending only to the wrist.

(ii) Gauntle-cuff:

A long cuff extending to the elbow.

(iii) Knit Wrist-cuff:

A short, closely-fitting, knitted wristlet which prevents particles from getting inside the gloves or mitten.

Cuff type should be selected according to the amount of protection required for the forearm.

Safety arm and hand protection equipment are also classified into the following groups based on the nature of work:

- rubber gloves for electrical work,
- rubber and plastic gloves for chemical work,
- leather and cotton gloves for material handling,
- leather gauntlets and mittens for welding, and
- asbestos gloves for hot work.

ANNEXURE -VII

MATERIALS USED FOR HAND AND ARM PROTECTION EQUIPMENT AGAINST DIFFERENT TYPES OF HAZARDS

Sl. No.	Material	Protection Against Hazard
1.	Asbestos	Sparks, hot materials and heat.
2.	Chrome leather	Sparks, hot materials, hot liquids, flying particles, cuts and abrasions.
3.	Flame-proofed duck	Sparks, hot materials, heat, flying particles and machinery.
4.	Plastic	Hot liquids, moisture, acids, alkalis and materials causing dermatitis.
5.	Rubber	Hot liquids, moisture, acids and alkalis, electric shock and materials causing dermatitis.
6.	Chemical resistant materials	Acids and alkalis.
7.	Reflective fabric	Hot liquids, radiative heat.

ANNEXURE - VIII

MATERIALS USED FOR FOOT AND LEG PROTECTION EQUIPMENT AGAINST DIFFERENT TYPES OF HAZARDS

Sl. No.	Material	Protection Against Hazard
1	Asbestos	Sparks, hot materials and heat.
2	Chrome leather	Sparks, hot materials, hot liquids, flying particles and cuts and abrasions.
3	Flame-proofed duck	Sparks, hot materials, heat, flying particles and machinery.
4	Plastic	Hot liquids, moisture, acids and alkalis.
5	Rubber	Materials causing dermatitis, hot liquids, moisture, acids, alkalis and electric shock.
6	Fibre metals	Sparks, flying objects, flying particles, cuts, and abrasions and machinery.
7	Chemical resistant	Acids and alkalis.
8	Reflective fabric	Hot liquids.

ANNEXURE - IX

TYPES OF SAFETY SHOES TO BE USED FOR DIFFERENT TYPES OF HAZARDS

Sl. No.	Type of Safety Shoes	Protection Against Hazard
1.	Steel toe caps	Falling objects.
2.	Non-skid shoes	Moisture.
3.	Wooden soles	Hot materials, heat, hot liquids, moisture, acids and alkalis, slips and falls and cuts and abrasions.
4.	Chrome leather	Sparks, hot materials, heat and hot liquids.
5.	Rubber	Hot liquids, moisture, acids and alkalis, electric shock and materials causing dermatitis.
6.	Conductive rubber	Explosive.

ANNEXURE -X

MATERIALS USED FOR BODY PROTECTION EQUIPMENT AGAINST DIFFERENT TYPES OF HAZARDS

Sl. No.	Material	Protection Against Hazard
1.	Asbestos	Sparks, hot materials and heat.
2.	Chrome leather	Sparks, hot materials, hot liquids, flying particles, cuts and abrasions.
3.	Plastic	Hot liquids, moisture, acids and alkalis, electric shock, materials causing dermatitis and machinery.
4.	Rubber	Hot liquids, moisture, acids and alkalis, electric shock, materials causing dermatitis, and machinery.
5.	Canvas	Flying particles, cuts, abrasions, and machinery.
6.	Chemical resistant fabric	Acids and alkalis.
7.	Reflective fabric	Hot liquids.

ANNEXURE - XI

USE OF RESPIRATORY PPE FOR DIFFERENT TYPES OF HAZARDS
(Based on Fig. 1 of IS : 9623 - 1980)

Sl. No.	Type of Hazard	PPE Specified	Remarks
1.	Dust or fume	(a) Dust respirator (b) Air line respirator	
2.	Gas or vapour(non-toxic)	(a) Cartridge respirator (b) Air line respirator	
3.	Gas or vapour (toxic)	(a) Canister respirator (b) Self-contained breathing apparatus (c) Air line respirator	For IDLH situations, only SCBA is recommended. Level of contaminant in air should be known.
4.	Dust, gas and vapour (non-toxic)	(a) Cartridge respirator with particulate filter (b) Air line respirator	
5.	Dust, gas and vapour (toxic)	(a) Canister respirator with particulate filter (b) Self-contained breathing apparatus (c) Air line respirator	
6.	Oxygen deficiency (O_2 < 19%) apparatus	(a) Self-contained breathing apparatus (b) Air line respirators	
7.	Toxic substances that can be absorbed through skin	Positive-pressure-ventilated plastic suits.	

ANNEXURE - XII

COLOUR IDENTIFICATION MARKINGS FOR AIR PURIFYING CANISTERS AND CARTRIDGES (IS : 8318-1977)

Sl. No.	Atmospheric Contaminants to be Protected Against	Colour Assigned
1.	Acid gases	White
2.	Organic vapours	Black
3.	Ammonia gas	Green
4.	Carbon monoxide gas	Blue
5.	Acid gases and organic vapours	Yellow
6.	Acid gases, ammonia and organic vapours	Brown
7.	Acid gases, ammonia, carbon monoxide and organic vapours	Red
8.	Other vapours and gases not listed above	Olive
9.	Radioactive materials, except for tritium and noble gases	Purple
10.	Dusts, fumes and mists (non radioactive)	Orange

Marking:

The following shall appear on each canister and cartridge.

1) Canister for ……..(name of contaminant).

2) For respiratory protection in atmospheres containing not more than …..(concentration) by volume of ……(contaminant).

3) Do not use in atmospheres containing less than 16 per cent oxygen by volume.

ANNEXURE - XIII

MARKING ON RESPIRATORY PROTECTION EQUIPMENT

XIII.1 Face-piece

The face-piece shall be marked by the following:

a) name and trademark of the manufacturer,

b) size, and

c) the year of manufacture.

XIII.2 Container

The month and year of manufacture shall be marked on the supply container.

XIII.3 Canisters (> 200 ml. Size)

The canister shall be marked with the following:

a) name and or trade mark,

b) colour coding,

c) colour identification marking as given in Annexure - XII,

d) month and year of filling,

e) minimum working life and shelf life,

f) instructions for use, and

g) ISI certification mark.

XIII.4 Chemical Cartridge Respirators (< 200 ml. Size)

The respirators shall be marked with the following:

a) the manufacturer's name, trade name or registered mark,

b) the month and year of manufacture,

c) the gases against which the cartridge will give protection,

d) the particulate contaminants against which the respirator will give protection, and

e) a warning as follows:

'WARNING': DO NOT USE

- in highly toxic atmosphere,
- in confined spaces, and
- where there may be deficiency of oxygen.

f) instructions for use,

g) ISI certification mark, and

h) appropriate colour coding as given in Annexure -XII.

XIII.5 Hose

a) Name, trademark or other means of identification of the manufacturer.

b) Designed minimum air flow in litres per minute.

c) Working pressure of high pressure hose.

XIII.6 Control valves

Maximum and minimum working pressure.

XIII.7 Marking on SCBA:

a) Name, trademark or other means of identifying the manufacturer.

b) Effective working duration.

c) Year and month of manufacture on breathing tubes, mouthpiece, face piece and diaphragm.

d) The apparatus may also be marked with ISI certification mark.

ANNEXURE - XIV

PROTECTION FACTORS OF RESPIRATORY PROTECTIVE EQUIPMENT AS PER BRITISH STANDARD

The efficiency of a respirator is expressed in terms of protection factor (PF) which is defined as follows:

$$\text{Protection Factor} = \frac{\text{ambient air concentration}}{\text{concentration inside face-piece}}$$

The values of protection factors for all the types of respiratory protective equipment are not given in BIS publications. However, the value of protection factor needs to be specified for procuring a suitable type of respiratory PPE for adequate protection of the user. Such values, known as nominal protection factors (NPF), are contained in the British Standard Publication BS: 4275-1974 and the typical protection factors for various respiratory PPE are as listed below for guidance:

Respiratory Protective Equipment	**Nominal Protection Factor**
Single-use filtering facemask respirator	6 to 20
Half-mask respirator (cartridge type)	10 to 20
Full-mask respirator (canister type)	40 to 1000
Powered air purifying respirator	20 to 500
Powered visor respirator	10 to 20
Fresh air hose apparatus	50 to 2000
Compressed airline apparatus	1000 to 1,00,000 *
Self-contained breathing apparatus	2000 to 10,00,000*

* When used with positive pressure.

ANNEXURE - XV

ASSIGNED PROTECTION FACTORS OF RESPIRATORY PROTECTIVE EQUIPMENT FROM ANSI Z88.2 (1992)

Type of Respirator	Respiratory Inlet Covering			
	Half Mask[1]	Full Face-Piece	Helmet/ Hood	Loose-Fitting Face-Piece
Air purifying	10	100		
Atmosphere-supplying				
SCBA (demand -type)	10	100		
Airline (demand-type)	10	100		
Powered air-purifying	50	1000[2]	1000[2]	25
Atmosphere-supplying air-line type				
Pressure-fed demand type	50	1000	—	—
Continuous flow	50	1000	1000	25
Self-contained breathing apparatus				
Positive pressure (demand open/closed circuit)	—	3	—	—

1. Includes one-quarter mask, disposable half masks and half masks with elastomeric face-pieces.

2. Protection factors listed are for high efficiency filters and sorbents (cartridges and canisters). With dust filters an assigned protection factor of 100 is to be used due to the limitations of the filters.

3. Although positive pressure respirators are currently regarded as providing the highest level of respiratory protection, a limited number of recent simulated workplace studies concluded that all users may not achieve protection factors of 10, 000. Based on this limited data, a definite assigned protection factor could not be listed for positive pressure SCBAs. For emergency planning purposes, where hazardous concentrations can be estimated, an assigned protection factor of no higher than 10, 000 should be used.

Note: Assigned protection factors are not applicable for escape respirators. For combination respirators, air-line respirators equipped with an air purifying filter, the mode of operation in use will dictate the assigned factor to be applied.

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SPECIAL DEFINITIONS

Astigmatic Power

The maximum refractive power difference between two 'meridians' along the same sighting axis; expressed in 'dioptres'. ('Meridian' is a line passing through the centre of a lens surface, from edge to edge.)

Brim

The rim surrounding the shell of the helmet.

Chromaticity of a Filter

This is defined by the chromaticity co-ordinates of the light reflected from a truly white screen (that is, magnesium oxide screen), illuminated only by light, which passes through

the filter in the manner intended in service.

Cradle

The adjustable assembly comprising of anti-concussion tape and draw lace for affording adequate clearance for ventilation and to ensure proper fitment. This also absorbs impact energy.

Harness (helmet)

The complete assembly by means of which the helmet is maintained in position on the head, which includes the headband, cradle, etc.

Hood

A device covering the head and neck and which includes eye protection.

Ocular

The part of an eye-protector through which a user sees.

Prismatic Power

The apparent angular displacement of an object by an optical system. It is expressed in 'prism dioptres'.

Refractive Power

The reciprocal of the back focal length of an optical system; expressed in 'dioptres'. ('Back focal length' is the distance from the last lens surface of the optical system to its image plane).

Shell (helmet)

The hard, smoothly finished material that constitutes the general outer form of the helmet.

Thermal Resistance

An inverse measure of the capability to transmit heat and may be defined as the ratio of temperature difference across a material to the heat flowing through it.

Warp

The length wise threads on a woven fabric or loom.

Weft

The cross (breadth wise) threads in a woven fabric.

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