Personnel safety and protective equipment

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Personal Protective Equipment (PPE) for firefighters refers to protective helmets, masks, boots, or other garments designed to protect firefighters or rescue workers from injury. Firefighter PPE is technically advanced to protect against the demands of firefighting and rescue. PPE addresses hazards from physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. PPE is also used by rescue and emergency teams for search and rescue.

Firefighter boots or fire boots are designed to meet the tough demands of a firefighter providing comfort and high levels of protection. Firefighter boots are generally waterproof and provide breathable qualities while ensuring fire fighter safety in the harshest of environments.

Firefighter gloves need to offer firefighters a high level of heat resistance and protection against other risks including falling debris and potentially harmful chemical risks. Firefighter gloves also need to offer flexibility, dexterity, and overall comfort to the fire services.

Firefighter helmets are made from tough fiberglass are heatproof and worn when firefighting or carrying out rescue work. A fire helmet protects the firefighter's head from falling objects or banging their head on low beams. At the front of the firefighter helmet there is a visor that moves down to protect the firefighter's face from the heat and sparks of the fire.

Fire-resistant fabric also known as fire-retardant fabric is used in protective clothing for firefighters and primarily designed to protect fire fighters from flames, heat, and heat stress when fighting fires. Fire fabric has to meet tough international safety standards.

PPE storage products include boxes, cabinets, and racks that all help protect the PPE equipment when not in use. Employers are legally required to provide suitable storage to protect PPE from damage, contamination or loss, covered by the Personal Protective Equipment Regulations. PPE storage is therefore essential for any company where PPE is used.

4.1 Head protection

In general, a safety helmet must be worn where a person may:

Be struck on the head by a falling object
Strike his/her head against a fixed object
Inadvertently come into contact with electrical hazards

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4.1.1 Accessories

A wide range of accessories can be fitted to helmets to make them more suitable for variable working conditions. Examples include:

- Retaining strap worn under the chin or at the nape of the neck
- Bracket and cable clip for the attachment of a lamp
- Eye shield, face shield, or welding shield
- Wide brim for additional shade in hot climates
- Neck flaps for protection against weather, molten metal splash, hot substances, etc.
- Lining for cold conditions
- Ear muffs

Care should be taken to ensure that accessories and their attachment systems do not reduce the safety characteristics of the helmet nor adversely affect the balance or comfort of the helmet. Particular care should be given to the electrical resistance.

4.1.2 Selection

The following should be considered:

- Nature and location of the work
- Extent of adjustment for comfort
- Accessories must be compatible with the make of helmet used
- Sweat bands
- White helmets will provide better heat reflection and are easily seen in poor lighting conditions

4.1.3 Unsafe practices

The following practices are considered detrimental to the safe working life and performance of the helmet and must be avoided:

- Storage or placement of helmets near any window, particularly the rear window of motor vehicles, through which excessive heat can be generated. Helmets placed on the rear window ledge of motor vehicles may also become dangerous missiles in the event of an accident or when sudden braking occurs.
- Failure to follow manufacturer's cleaning instructions. The helmet may be damaged and rendered ineffective by chemicals such as petroleum and petroleum products, cleaning agents, paints, and adhesives, without the damage being visible to the user.
- Alteration, distortion, or damage to the harness or to the shell such as splits and cracks.
- Use of safety helmets for any other purpose than that for which they are designed, e.g., as seats, liquid receptacles, or wheel chocks.

4.1.4 Cleaning

It is recommended that safety helmets be cleaned regularly. In general, normal washing methods using warm water and soap are adequate. The use of solvents, very hot water, or harsh abrasives is not advisable.

4.1.5 Inspection and maintenance

All safety helmet components and accessories should be visually inspected prior to use by the user for signs of dents, cracks, penetration, or other damage due to impact, rough treatment, or unauthorized alterations that could reduce the degree of safety provided. Helmets showing damage or deterioration to the shell should be immediately withdrawn from service and discarded (completely destroyed). Helmets with sound shells but with damaged or defective harness components should be withdrawn from service and the complete harness and cradle replaced.

4.1.6 Working life

Excessive discoloration of the shell color or weathering of the surface may indicate a loss of strength. Helmets that have been in service for longer than 3 years should be thoroughly inspected and replaced as necessary. Plastic components of harnesses may deteriorate more rapidly under aggressive service conditions and in these cases harnesses should be replaced at intervals not longer than 2 years.

4.1.7 Helmet types

- Type 1: These helmets should have a full brim.
- Type 2: These helmets have no brim but may include a peak.

4.1.8 Helmet classes

- Class A: These helmets are intended to reduce the force of impact of falling objects and to reduce the danger of contact with exposed low-voltage conductors. Representative sample shells are tested at 2200 volts (phase to ground).
  Note: This voltage is not intended to be an indication of the voltage at which the headgear protects the user.
- Class B: These helmets are intended to reduce the force of impact of falling objects and to reduce the danger of contact with exposed high-voltage conductors. Representative sample shells are proof-tested at 20000 volts (phase to ground).
  Note: This voltage is not intended to be an indication of the voltage at which the headgear protects the user.
- Class C: These helmets are intended to reduce the force of impact of falling objects. This class offers no electrical protection. All materials that come in contact with the user's head should be those generally known to be nonirritating to normal skin.

4.1.9 Construction

The construction of the helmet should be in the form of a hard shell having a smooth outer surface and fitted with a harness. The outer surface should be smoothly finished. All edges should be smooth and rounded. The shell may be shaped to form a brim and/or peak. If the shell is pierced with holes for any purpose other than for the attachment of the means of energy absorption, no internal chord of any such hole should exceed 4 mm, and the total area of such holes on either side of the helmet should not exceed 160 mm², making a total on both sides not exceeding 320 mm².

4.1.10 Physical requirements

Each helmet should consist of a shell and a means of absorbing energy within the shell. The harness should be securely attached to the shell. Provision should be made for ventilation between the headband and the shell. The shell should be generally dome shaped. There should be no holes in the shells of Classes A and B helmets that would cause the helmet to fail the electrical insulation test. Identification markers used on shells for Class B helmets should be affixed without making holes through the shell and without the use of any metal parts or metallic labels. The area under the peak or the front of the brim may be covered with a nonconducting antiglare material.

4.2 Headband, sweatband, crown straps, and protective padding

The headband, sweatband, crown straps, and protective padding should be made of any suitable materials that are comfortable.

Headbands should be adjustable in at least 1/8 hat size increments. The approximate size range that can be accommodated should be marked on the helmet in a permanently legible manner. When the headband is adjusted to the maximum designated size, there should be sufficient clearance between the shell and the headband to provide ventilation. Headbands should be removable and replaceable.

Sweatbands may be of the removable-replaceable type or may be integral with the headband. The sweatband should cover at least the forehead potion of the headband.

Crown straps, when assembled, should form a cradle for supporting the helmet on the user's head so that the distance between the top of the head and the underside of the shell cannot be adjusted to less than the manufacturer's requirements for that particular helmet. Protective padding may be used in conjunction with or in place of crown straps.

Mass: The mass of each helmet, complete with harness but exclusive of accessories, should not exceed 0.44 kg for Classes A, B, and C helmets.

4.2.1 Accessories

- Chin strap and nape strap: The chin strap and nape strap should be made of suitable material no less than 12.7 mm in width.
- Winter liners: The winter liner should be made of suitable materials. Colored materials should be colorfast. The outer surface may be water-resistant. There should be no metal parts in winter liners intended for use with Class B helmets.
- Lamp brackets: Headwear equipped with a lamp bracket should have a low-crown clearance for work in low-ceiling areas and should be made of lightweight, tough polycarbonate plastic material.
- Instructions: Each helmet should be accompanied by instructions explaining the proper method of adjusting the harness.

- Marking: Each helmet conforming to the requirements of this standard should bear identification on the inside of the shell stating the name of the manufacturer, the standard designation, and the class of the helmet.
- Labeling: A label should be attached to each helmet bearing the following information:
  The following words "for adequate protection this helmet must fit or be adjusted to the size of the user's head."
  This helmet is made to absorb the energy of a blow by partial destruction or damage to the shell and the harness or protective padding, and even though such damage may not be readily apparent, any helmet subjected to severe impact should be replaced.
  The attention of users is also drawn to the danger of modifying or removing any of the original parts of the helmet other than those recommended by the helmet manufacturer, and helmets should not be adapted for the purpose of fitting attachments in any way not recommended by the helmet manufacturer.
  Do not apply paint or solvents or adhesives or self-adhesive labels except in accordance with instructions from the helmet manufacturer.

4.2.2 Performance

Helmets should be certified by the manufacturer for the following tests in accordance with BS 5240 or ANSI Z89-1. No helmet that has been subjected to the testing should be offered for sale:

Shock absorption
Resistance to penetration
Electrical insulation
Resistance to flame
Water absorption

4.3 Recommendations for the material and construction of helmets

The materials used in the manufacture of helmets should be of durable quality, i.e., their characteristics should not undergo significant alteration under the influence of aging or of the circumstances of use to which the helmet is normally subjected, e.g., exposure to sun, rain, cold, dust, vibrations, contact with the skin, effects of sweat, or of products applied to the skin or hair. For those parts of the harness coming into contact with the skin, materials that are known to cause irritation should not be used.

For a material not in general use, advice as to its suitability should be sought before use. Any devices fitted to the helmet should be so designed that they are unlikely to cause any injury to the user in the event of an accident. In particular, there should be no metallic or other rigid projections on the inside of the helmet.

No part of the helmet should have sharp protruding edges. Where stitching is used to secure the harness to the shell, it should be protected against abrasion. No part of

the shock-absorbing device should be capable of being easily modified by the user. A chin strap should have sufficient strength to maintain the helmet on the user's head in circumstance where helmet retention would otherwise be unreliable. If other protective equipment is designed to be used with a particular industrial helmet, that helmet should still comply with this standard when worn in conjunction with the designed equipment.

4.4 Method for measuring wearing height, vertical distance, horizontal clearance, and precautions concerning helmet use, maintenance, and testing

4.4.1 Headforms

Headforms for these measurements are in accordance with BS 6489 and are of sizes B, D, F, J, L, and N.

4.4.2 Procedure

Mount the helmet on a headform of appropriate size, leveled, and in the normal wearing position. If the size of the harness is adjustable to such an extent that the helmet can fit more than one of the sizes of headform, carry out these measurements twice, once at each extreme of the range of appropriate sizes of headform. Measure the wearing height, the vertical distance, and the horizontal clearance.

4.4.3 Painting

Caution should be exercised if shells are to be painted, since some paints and thinners may attack and damage the shell and reduce protection. The manufacturer should be consulted with regard to paints or cleaning materials.

4.4.4 Periodic inspection

All components, shells, suspensions, headbands, sweatbands, and accessories, if any, should be visually inspected daily for signs of dents, cracks, penetration, and any damage due to impact, rough treatment, or wear that might reduce the degree of safety originally provided. Any industrial helmet that requires replacement or the replacement of any worn, damaged, or defective part should be removed from service until the condition of wear or damage has been corrected.

Note: All items constructed of polymeric materials are susceptible to damage from ultraviolet light and chemical degradation, and safety helmets are no exception. Periodic examinations should be made of all safety helmets and in particular those worn or stored in areas exposed to sunlight for long periods. Ultraviolet degradation will first manifest itself in a loss of surface gloss, called chalking. On further

degradation the surface will craze or flake away, or both. At the first appearance of either or both of the latter two phenomena the shell should be replaced immediately for maximum safety.

4.4.5 Cleaning

Shells should be scrubbed with a mild detergent and rinsed in clear water approximately 60°C. After rinsing, the shell should be carefully inspected for any signs of damage. Removal of tars, paints, oils, and other materials may require the use of a solvent. Since many solvents may attack and damage the shell, the manufacturer should be consulted with regard to an acceptable solvent.

4.4.6 Precautions

Because helmets can be damaged, they should not be abused. They should be kept free from abrasions, scrapes, and nicks and should not be dropped, thrown, or used as supports. This applies especially to helmets that are intended to afford protection against electrical hazards.

Industrial protective helmets should not be stored or carried on the rear-window shelf of an automobile, since sunlight and extreme heat may cause degradation that will adversely affect the degree of protection they provide. Also, in the case of an emergency stop or accident, the helmet might become a hazardous missile.

The addition of accessories to the helmet may adversely affect the original degree of protection, then precautions or limitations are indicated by the manufacturer, they should be transmitted to the user and care taken to see that such precautions and limitations are strictly observed.

4.5 Impact system calibration procedures

4.5.1 Medium calibration

This calibration step should be carried out with a guided-fall system and an accelerometer mounted on the 3.64-kg falling mass. The accelerometer should have the following characteristics:

Minimum Range	0–125	g's
Maximum Resolution	1	g
Minimum Frequency Response (±0.5 dB)	0.1–2000	Hz
Minimum Resonant Frequency	20	kHz
Linearity	1%	full scale
Repeatability and Stability	0.5%	full scale

The accelerometer should be mounted, according to the manufacturer's instructions, on the falling mass within 5° of true vertical. A suitable amplifier and peak meter

(or equivalent devices) are required; a storage oscilloscope is recommended but not required. Mount a calibrating medium over the load cell. Drop the mass from at least 915 mm to strike the medium. The centers of the load cell, medium, mass, and accelerometer must be co-linear. A means to verify the velocity at impact should be used.

The values shown on two peak meters should read such that the acceleration value a, in g's, times the weight of the falling mass m equals the force value F within 2.5% (F = ma). This accuracy must be repeatable through at least five impacts.

4.5.2 System calibration only

A calibrating medium that has been tested in accordance with A.3.1 may be used without the accelerometer or guided mass. The force value obtained when the medium was tested according to A.3.1 should be recorded and this information provided with the calibrating medium. The calibrating medium is mounted over the load cell with the centers of both aligned. The mass is then dropped directly on the center of the medium. The force value obtained should be within 2.5% of that achieved during testing. The calibrating medium should be retested at least three times a year and more often if a significant change in force becomes apparent.

4.5.3 Static calibration

A rough determination of the calibration of the system may be obtained as follows:

1. Apply a known weight of at least 45 kg to it
2. Zero the peak meter and amplifier
3. If the amplifier has an adjustable time constant, move it to the longest setting available
4. Slowly add the weight, being careful not to impart acceleration to it

The peak meter should indicate the weight. This method should be used before each series of tests. An error in weight can indicate the need for a more sophisticated calibration check.

4.6 Application of safety hats and caps

Hats have a full brim and are designed primarily for use in industrial situations requiring additional protection around the back and sides (1) from falling objects and (2) from the weather (rain) (see Figure 4.1). Caps have a peak without a full brim and are designed primarily for use in tight or confined areas. Cap configuration minimizes the possibility of accidentally dislodging the cap from the head.

The cap provides head protection from impact hazards in industrial plants and, at the same time, provides capability for wearing hearing protection devices, and faceshields or welding helmets. They are widely used in construction industry, government, utilities, and manufacturing plants (see Figure 4.2).

Figure 4.1 Safety hat full brim.

Figure 4.2 A safety cap.

Figure 4.3 The hat suitable for linemen and utility crews.

Hats and caps provide head protection for personnel likely to encounter electrical contact as well as impact hazards, such as linemen, electric utility, maintenance crews, and electricians. The hat model is especially suitable for linemen and utility crews because of the more complete protection given to the neck and back (see Figure 4.3).

Aluminum hats and caps are used for head protection in various industries, especially for workers exposed to hot weather conditions, such as those in the petroleum, forestry, and construction industries (see Figure 4.4). Winter liners can be worn alone or under protective hats and caps to provide warmth in cold weather (see Figure 4.5).

Headwear with a lamp bracket for work in low ceiling areas (see Figure 4.6)

Figure 4.4 Aluminum Hats.

Figure 4.5 A Winter Liner.

Figure 4.6 Headwear with a lamp bracket.

4.7 Eye protection

Eye-protective devices must be considered as optical instrument and they should be comfortable and carefully selected, fitted, and used. To give the widest possible field of vision, goggles should be fitted as close to the eyes as possible, without bringing the eye lashes in contact with the lenses. This section specifies material, design, and performance requirements of personal eye protection for industrial use and covers the following:

1. Eye protection for impact, dust, gas, liquid splashes, and combination of these that cover:
   Glasses type with and without side shield of plastic or tempered glass lenses
   Goggle type

Prescription lenses (glasses)
Sun-glare eye protection

2. Eye protection and backing lenses for welding and similar operations are included in Section 4 (face protection) of this standard.

4.7.1 Materials

- Corrosion resistance: Samples of all metal parts used in the eye-protector should show no sign of corrosion when viewed by the unaided eye of a trained observer and should be in a serviceable condition.
- Ignitability: When tested, no part of the eye-protector apart from headbands and textile edging should ignite or continue to burn after removal of the rod.
- Cleaning: When cleaned by the method recommended by the manufacturer, the eye-protector should show no visible deterioration.
- Skin irritation: All materials that come into contact with the user should be of a kind that is not known to cause skin irritation.
- Plastic material: Plastic material should have strength and elasticity suitable for the use and should not be flammable such as cellulose.

4.7.2 Design and manufacture

Eye-protectors should be free from patent defects. Eye-protectors should have no sharp edges and should be free from projections or other features likely to cause discomfort in wear. Headbands or harnesses, where provided, should have a width of no less than 9.5 mm. Adjustable parts or components incorporated in eye-protectors should be easily adjustable and replaceable. Where provided, ventilation features should be designed to prevent the direct access of any particle to the eye from any angle forward from the frontal plane of the eye-protector. Where eye-protectors have rims secured by a screw or screws, these should be penned, coated with adhesive, or otherwise treated or designed to ensure that they should not become loosened in use.

4.8 Lenses

The lens appearance should have smooth surfaces and have no visible flaws, striae, bubbles, waves, and other foreign objects in or on to it. Lenses both serve to afford the vision required for work and to protect the eyes during the performance of specific activities. There are limits to which both sets of requirements can be met at one and the same time. Since the use of eye-protectors always involves a certain degree of inconvenience of restriction in movement, in order to guarantee reliable protection, it is imperative that the properties of lenses undergo no substantial alteration during use.

Lenses should be made of plastic materials, of toughened glass or laminated glass, or any combination of these materials, or untreated glass.

4.8.1 Optical properties

- Conditioning: Lenses should be conditioned in accordance with BS 2092.
- Light transmittance: Lenses should transmit no less than 80% of the light energy within the visible spectrum unless they are in the impact resisting group and are double-layered, in which case the transmission should not be less than 70%. These limits should not apply to lenses claimed to be tinted.
  Note: Tinted lenses include those with metal coatings applied.
- Quality: Lenses should be free to within 3 mm of their edges from inherent faults that can be observed by the user when the eye-protector is worn. Inspection for faults should be done by the user with his eyes focused at a variety of focal distances likely to be encountered at work, i.e., the user should not attempt to focus on the lens itself. Where mold or crease lines are a design feature of the lens they should not occur within the minimum dimensions.

4.8.2 Construction and dimensions

The eye protection should conform to the following general requirements:

Eye-protector should not be excessively uncomfortable to the user.
Lenses of eye-protector should not easily come off from the frame nor reform their curve.
Each part of the eye-protector should be easily replaced.

- Eye-protector similar to glasses: Eye-protector of this type should consist of two lenses, frame, and two bows.
- Eye-protector with side-shield**:** Eye-protector of this type should be the one similar to the usual glasses with side-shield attached in a way that does not excessively obstruct the user's view.

4.8.3 Dimensions of lenses

The minimum dimensions of lenses should be as follows:

- For circular lenses: 48 mm diameter with a minimum aperture size of 40 mm diameter.
- For shaped lenses: 42 mm horizontal datum length × 35 mm mid. datum vertical depth, using the system of measurement described in BS 3199.
- For one piece rectangular lenses: 105 mm × 50 mm.
- For one piece shaped lenses: such that two circles 48 mm in diameter can be spaced symmetrically about the vertical center line of the eye-protector with the centers being 66 mm apart measured in the horizontal front plane of the eye-protector as worn. Refractive, astigmatic, and prismatic power for focal lenses, when measured by telescope in accordance with BS 2092. Eye-protectors should comply with the tolerances given in Table 4.1.

Spherical and astigmatic powers should be within the specified limits at all points on the lens lying within 25 mm of the test point. Individual lenses for glasses or goggles having separate eyepieces, should comply with Table 4.2. For impact-resistant eye-protectors the combined prismatic imbalance in the vertical direction should not exceed 0.30 for refractive, astigmatic, and prismatic powers for prescription lenses. Prescription lenses should comply with relevant standard.

Table 4.1 Tolerances for eye-protectors

Type of protector	Spherical effect D	Astigmatism D	Prismatic Effect
Impact	±0.12	±0.12	0.25
All other eye-protectors	±0.06	±0.06	0.15

Note: The unit of power is the dioptre (symbol). (see BS 3521).
The unit of prism power is the prism diopter.

Table 4.2 Classification and uses of sunglasses

Classification	Use
Cosmetic Spectacles	Lightly tinted spectacles not intended to give significant protection against sun glare and worn largely for their fashion properties.
General purpose	Sunglasses intended to reduce sun glare in bright circumstances including the driving of motor vehicles in daylight.
Special purpose	Sunglasses intended to reduce sun glare in abnormal environmental conditions, e.g. near large expanses of water or in snow and mountain altitudes, or for persons who may be abnormally sensitive to glare as a result of medical treatment or otherwise. Non-photochromic filters having a shade number of 4.1 are not considered suitable for use by persons when driving motor vehicles.
Refraction Class 1	Equivalent to prescription lens quality and recommended for continuous daytime wearing.
Refraction Class 2	Suitable for intermittent wearing.
Break resistant sunglasses	Suitable for conditions where mechanical abuse is possible but will not be severe, e.g. driving, cycling, walking, camping or boating.

4.8.4 Performance

Eye-protectors should be subjected to tests. Replacement lenses should be subject to the relevant tests when mounted in an appropriate housing. Prior to testing eye-protectors should be conditioned as described in BS 2092.

4.8.5 Robustness of construction

When tested as described in BS 2092, eye-protectors should not shown any of the following defects:

Lens fracture
Lens deformation
Lens housing and/or frame failure
Lateral protection failure

4.8.6 Protection against impact

- Type of eye-protector: Grade 1 impact eye-protectors should be goggles or face shields only. **Note:** Glasses are specifically excluded from grade 1.
- Impact eye-protectors: When tested as described in BS 2092 using a velocity of impact of 45 m/s for grade 2 and a velocity of impact of 120 m/s for grade 1, impact eye-protectors should not show any of the following:
  Lens fracture
  Lens deformation
  Lens housing and/or frame failure
- Lateral protection of impact eye-protectors: The lateral protection of impact eye-protectors should comply with the requirements for either grade 1 or 2 as in 6.6.4.2 or for robustness of construction as in 6.6.3. If the lateral protection of any eye-protector has a lesser impact resistance than that of its lenses, the eye-protector should be marked accordingly. When the lateral protection is tested in accordance with BS 2092 it should be considered to have failed to meet the particular impact grade or general robustness claimed with respect to the associated lens if it shown any of the defects listed in 6.6.3.(d).

4.8.7 Protection against molten metals and hot solids

- Type of eye-protector: Molten metals eye-protectors should be nonmetallic or should be treated to prevent molten metals adhering to the lenses or other parts of the eye-protector when tested as described in BS 2092. They should include goggles and face screens.
- Ocular area (face screens): Face screens should cover the ocular area defined in BS 2092. When assessed by the method described in 6.6.4.1 should apply only to that part of the face screen that provides protection to this ocular area.
- Hot-solids penetration: Complete penetration of the lenses and housings of goggles or brow guards and helmet mountings of face-screens should not occur within 7s when tested as described in BS 2092. Complete penetration of face-screens should not occur within 5s.

4.8.8 Protection against liquids

- Liquid droplets: When tested as described in BS 2092 eye-protectors for protection against liquid droplets should be deemed to comply with this standard if there is no coloration of the paper representing the ocular areas.
- Liquid splashes: When tested as described in BS 2092 eye-protectors for protection against liquid splashes should be considered to comply with this standard if they cover the ocular area as described.

4.8.9 Protection against dusts

When tested as described in BS 2092 eye-protectors for protection against dusts should be deemed to comply with standard if the reflectance of the white test paper is no less than 80% of that before the test.

4.8.10 Protection against gases

When tested as described in BS 2092 eye-protectors for protection against gases should be deemed to comply with this standard if no staining appears on the area enclosed by the eye-protector beyond the permitted limits.