BS 8468-7:2012

BSI Standards Publication

Respiratory protective devices for use against chemical, biological, radiological and nuclear (CBRN) agents

Part 7: Closed-circuit breathing apparatus – Specification

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 12, an inside back cover and a back cover.

Foreword

Publishing information

This is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 April 2012. It was prepared by Technical Committee PH/4, *Respiratory protection*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

BS 8468 is issued in nine parts:

- Part 1: *Positive pressure, self-contained, open-circuit breathing apparatus – Specification*;
- Part 2: *Negative pressure, air purifying devices with full face mask – Specification*;
- Part 3.1: *Self-contained open-circuit compressed air breathing apparatus incorporating a hood for escape – Specification*;
- Part 3.2: *Air-purifying devices incorporating a hood for escape – Specification*;
- Part 4: *Powered air-purifying respirators – Specification*;
- Part 5: *Dual-mode apparatus – Specification*;
- Part 6.1: *Positive-pressure compressed airline equipment – Specification*;
- Part 6.2: *Constant flow compressed airline equipment – Specification*;
- Part 7: *Closed-circuit breathing apparatus – Specification*.

NOTE This standard may be used in conjunction with BS 8467, which gives categorization, requirements and test methods for personal protective ensembles against CBRN agents.

Information about this document

Increased threat to civilians, emergency and support agencies from chemical, biological, radiological and nuclear (CBRN) agents has led to a need for suitable personal protective equipment (PPE). The lack of coverage of combined CBRN protection in existing British Standards on PPE has recently been identified. This standard has been prepared to give requirements for such PPE.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies requirements for closed-circuit breathing apparatus (CCBA) intended to be used during firefighting, rescue, evacuation, escape, hazard containment and decontamination, and similar activities by emergency first responders (e.g. fire, ambulance, police, and associated civilian agencies and workers) in areas containing and contaminated by chemical, biological, radiological and nuclear (CBRN) agents.

NOTE CCBA conforming to this standard might be suitable for use in situations other than those involving the specific CBRN agents identified in the standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 132, *Respiratory protective devices – Definitions of terms and pictograms*

BS EN 134, *Respiratory protective devices – Nomenclature of components*

BS EN 136:1998, R*espiratory protective devices – Full face masks – Requirements, testing, marking*

BS EN 137:2006, *Respiratory protective devices – Self-contained open-circuit compressed air breathing apparatus with full face mask – Requirements, testing, marking*

BS EN 145:1998, *Respiratory protective devices – Self-contained closed-circuit breathing apparatus compressed oxygen or compressed oxygen-nitrogen type – Requirements, testing, marking*

BS EN 13274-1:2001, *Respiratory protective devices – Methods of test – Part 1: Determination of inward leakage and total inward leakage*

BS EN 14593-1:2005, *Respiratory protective devices – Compressed air line breathing apparatus with demand valve – Part 1: Apparatus with a full mask – Requirements, testing, marking*

3 Terms and definitions

For the purposes of this part of BS 8468, the terms and definitions given in BS EN 132 and BS EN 134 and the following apply.

3.1 full face mask
tight fitting facepiece covering mouth, nose, eyes and chin

3.2 closed-circuit breathing apparatus
CCBA
self-contained breathing apparatus which removes carbon dioxide from the exhaled air and adds oxygen or oxygen/nitrogen to the inhaled air for breathing by the wearer and is independent of the ambient atmosphere

4 Description

Self-contained, closed-circuit breathing apparatus is designed and constructed to supply the wearer with breathable air via an inhalation hose, connected to the facepiece by a breathing connector. The exhaled air passes from the facepiece via the breathing connector and exhalation hose back to the CCBA.

5 Designation

Two types of CCBA are described in this standard:

a) Type 1: a device with inward leakage <0.01% suited to use in any BS 8467 ensemble; and

b) Type 2: a device with inward leakage <0.05% suited to use in any BS 8467 ensemble except Category A.

6 Requirements

6.1 General

CCBA for use against CBRN agents shall conform to BS EN 145, and conform to the inward leakage specified in **6.2** of this standard, and conform to the chemical agent penetration and permeation resistance specified in **6.3** of this standard.

The facepiece shall conform to BS EN 136:1998, class 3 for Type 1 CCBA and class 2 or class 3 for Type 2 CCBA.

6.2 Inward leakage

NOTE The tests specified in this subclause require use of NaCl. If there is difficulty getting reliable results due to contamination from the soda lime used in CCBA, the test may be performed with SF6 or corn oil.

6.2.1 Type 1

The maximum inward leakage shall be <0.01% when tested as a complete system in accordance with BS EN 13274-1:2001, **8.4**c).

NOTE This requirement is more stringent than the one given in BS EN 136. Detection systems should take account of the increased sensitivity required.

6.2.2 Type 2

The maximum inward leakage shall be <0.05% when tested as a complete system in accordance with BS EN 13274-1:2001, **8.4**c).

6.3 Chemical agent permeation and penetration

CCBA shall be resistant to chemical agents up to the maximum levels given in Table 1 when tested in accordance with Annex A.

Table 1 **Maximum acceptable levels of permeation and penetration**

Agent	**Maximum acceptable peak excursion** [A] mg/m³	**Maximum acceptable breakthrough (concentration integrated over time)** [B] mg·min/m³
Distilled sulfur mustard (HD) (vapour) [simultaneous test with liquid HD]	0.60	6.0
Distilled sulfur mustard (HD) (liquid) [simultaneous test with HD vapour]	0.60	6.0
Sarin (GB) (vapour)	0.087	2.1

[A] Three sequential test data points, with sample times of two minutes, at or above the maximum peak excursion level constitute a failure.

[B] The maximum acceptable breakthrough is calculated over the six-hour duration of the test.

7 Marking

7.1 Marking shall be in accordance with BS EN 145:1998 and BS EN 136:1998.

7.2 In addition, each CCBA and facepiece conforming to this standard shall be permanently marked with the designation and year of this standard, i.e. BS 8468-7:2012 [1].

7.3 Sub-assemblies and components with considerable bearing on CBRN performance shall be marked so that they can be identified.

8 Information supplied by the manufacturer

8.1 The information supplied shall be in accordance with BS EN 145:1998 and BS EN 136:1998.

8.2 The information shall describe suitable procedures for decontamination.

[1] Marking BS 8468-7:2012 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Annex A (normative) Test method for chemical agent permeation and penetration resistance against distilled sulfur mustard (HD) and sarin (GB)

NOTE This method is based on a method developed and described in NIOSH Procedure CCBN CBRN 11 (Draft for Discussion) [1]. Other test set-ups that are identical in principle but vary in detail may be used if they can be shown lead to the same results.

A.1 Principle

Three CCBAs, including all components and accessories, are tested in each test, two conditioned in conformity with BS EN 14593-1:2005, **6.8.1**, or BS EN 137:2006, **6.24**, and one "as received", including all components and accessories, on an upper-torso manikin connected to a breathing machine. Three are tested in an atmosphere containing GB vapour, and three are tested in a separate test, in an atmosphere containing HD vapour with liquid droplets of HD applied to the surface of the apparatus. The peak excursion levels and breakthrough levels are measured for these agents.

NOTE It might be necessary to replace the oxygen source with an external supply of compressed air for the purpose of running an extended-duration test. If the oxygen source has been replaced, the alternative air supply needs to operate at the same flow rate.

A.2 Materials

A.2.1 *HD vapour.*

A.2.2 *HD liquid.*

A.2.3 *GB vapour.*

A.2.4 *Dilute HD,* to test the calibration of the continuous air monitoring system (**A.3.4**), at a concentration chosen to be at the mid-point of the continuous air-monitoring system calibration curve.

A.3 Apparatus

A.3.1 *SMARTMAN* [2)] (or equivalent), simulant agent resistant test manikin, tested, with helium, for leaks.

NOTE These tests should be carried out when new and in accordance with the laboratory's standard operating procedures for calibration.

A.3.2 *Two exposure chambers*, both constructed of clear, chemical resistant sheets (e.g. Plexiglas or Lexan), forming an approximate 0.60-m-sided cube with: a floor capable of supporting the SMARTMAN (approximately 40 kg); a removable front panel; four legs long enough to allow access for tubing and to the SMARTMAN face-adjustment handle; an M12A1 military air purifying collective filter (or equivalent) installed in the top; ports in the side to accommodate tubing for the challenge vapour and clean purge air; an electric fan, inside, near the top front, to achieve a well-mixed challenge vapour. One chamber is "clean" and only used to check for fit and leaks, the other is for agent exposure. The exposure chambers shall permit good mixing of the agent and air.

[2)] SMARTMAN is the trade name of a product supplied by ILC Dover, Frederica, Delaware, USA. This information is given for the convenience of users of this standard and does not constitute an endorsement by BSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

NOTE The chamber may be increased in size to accommodate the CCBA under test, taking care that the agent tested is not significantly dissipated in the increased air volume. A test set-up that uses only one chamber may be used.

A.3.3 *Leak detector*, capable of detecting aerosol particles at a concentration of less than 0.001% of the challenge concentration (e.g. a challenge concentration of 100 mg/m^3 mineral oil needs a detector capable of detecting 0.10 mg/m^3).

A.3.4 *Continuous air monitoring system*; capable of detecting GB and HD at the levels required, both in the test chamber (ambient) and in the nasal sampling port of the manikin (breakthrough).

NOTE 1 The following equipment has been found suitable for ambient detection:

- *an infrared absorption based detector; or*
- *a gas chromatograph, with a flame ionization detector (FID).*

NOTE 2 The following equipment has been found suitable for breakthrough detection: a gas chromatograph equipped with a hydrogen flame ionization detector (FID) and a preconcentrator tube (a small tube containing an adsorbent material to scrub out agent vapour from air drawn through it).

A.3.5 *Agent delivery system*, capable of delivering agent into an air stream at a controlled rate, to create a challenge vapour at a specified concentration.

A.3.6 *Regulated airflow-temperature-humidity control system*, supplied with laboratory air and distilled water, and capable of supplying air at rates of (50 to 200) L/min ±2%, relative humidity of (20 to 80)% ±3%, and temperatures of (20 to 30) °C ±3%.

A.3.7 *Breathing simulator,* to produce a sinusoidal breathing pattern, adjustable up to a tidal volume (volume per breath) of 1.5 L.

NOTE One method of achieving this is with a double pump, operated by a single, variable speed motor through a Scotch yoke (slotted link).

A.4 Preparation

A.4.1 Run a background characterization; connect the continuous air monitoring system (**A.3.4**) to a sampling port of the SMARTMAN (**A.3.1**) in the agent exposure chamber (**A.3.2**) and monitor for a period of 60 min. If the measured background level is lower than the lowest point on the continuous air monitoring system calibration curve, continue with the test. If the measured background level is higher than the lowest point on the continuous air monitoring system calibration curve, terminate the test.

A.4.2 Assemble the CCBA following the manufacturer's instructions and turn on the apparatus. Ensure that any monitor/warning device confirms that the CCBA is working as intended.

NOTE If the oxygen source has been replaced, the alternative air supply needs to operate at the same flow rate.

A.4.3 Take a digital photograph of the assembled CCBA.

A.4.4 Mount the CCBA on the SMARTMAN (**A.3.1**) in the "clean" exposure chamber (**A.3.2**), following the manufacturer's instructions.

A.4.5 Turn on the breathing simulator (**A.3.7**). Ensure that the CCBA is in pressure-demand mode, if applicable.

A.4.6 Connect the leak detector (**A.3.3**) to a port into the exposure chamber (**A.3.2**). Close the exposure chamber. Fill the exposure chamber with aerosol particles at the chosen challenge concentration (measured using the leak detector). Connect the leak detector to a sample line from the SMARTMAN (**A.3.1**). If, within five minutes, a level of penetration less than 0.001% is

detected, assume there is no leak in the apparatus. If there is evidence of a leak, attempt to find and eliminate it. If the leak cannot be eliminated, terminate the test.

A.5 Procedure

A.5.1 Set-up common to all test agents

A.5.1.1 Remove the CCBA from the "clean" chamber and install on the SMARTMAN in the agent exposure chamber (**A.3.2**), following the manufacturer's instructions, and continue with the exposure tests, using any sealing methods devised under **A.4.6**.

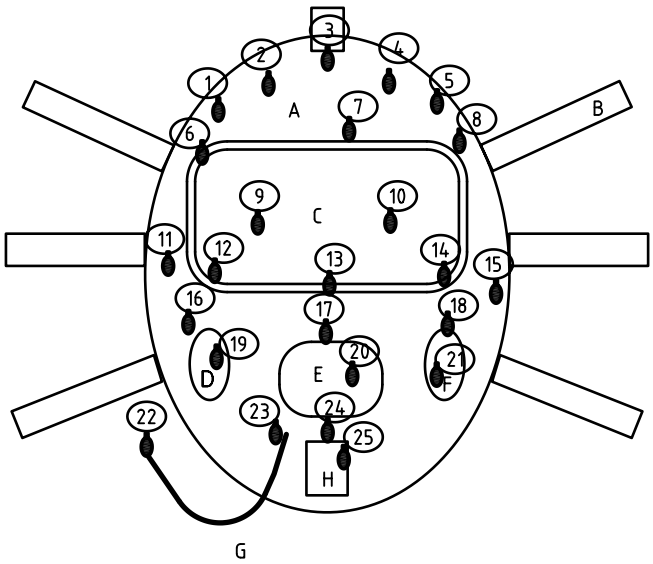
A.5.1.2 Turn on the breathing simulator (**A.3.7**).

A.5.1.3 Connect the breakthrough continuous air monitoring system (**A.3.4**) to a sampling port of the SMARTMAN (**A.3.1**) and begin monitoring. As soon as the criteria for failure (Table 1) have been reached or if the equipment concentration upper limit is reached at any time, terminate the test.

A.5.2 HD test (liquid and vapour)

A.5.2.1 Place 43 droplets (20 μL each) of HD, using a syringe, on the CCBA, as specified in Figure A.1 and Figure A.2. Place 25 droplets on the facepiece as specified in Figure A.1; where a component is not fitted, place droplets in the corresponding area of the facepiece. Place 18 droplets on the rest of the apparatus as specified in Figure A.2. Mark the actual location of the drops on the digital photograph of the CCBA. If an external shroud is mounted on the facepiece, apply droplets as specified in Figure A.1 on the surface of the shroud.

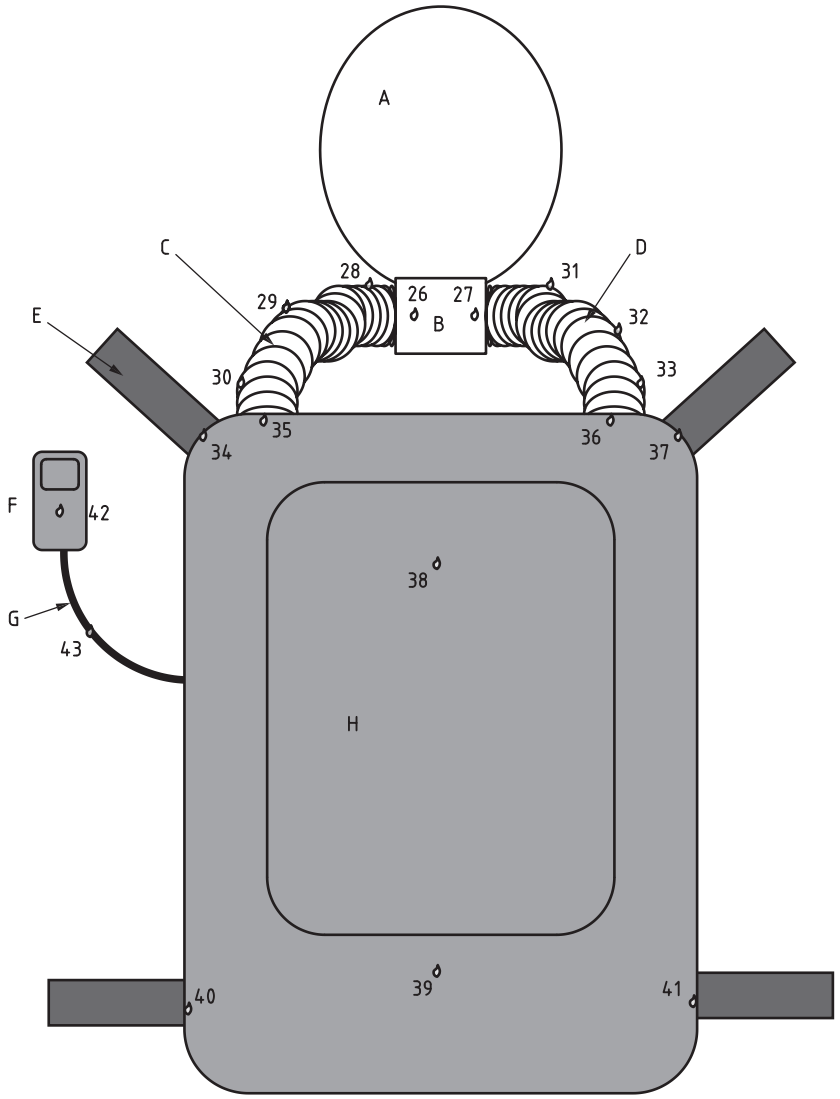
Figure A.1 **HD agent droplet placement for CCBA facepiece**



Key

A	Facepiece	E	Housing for inhale/exhale hoses
B	Head-harness strap	F	Voice-emitter
C	Eye lens(es)	G	Drink tube (if present)
D	Side voice-emitter (if present)	H	Front speech diaphragm (if present)

Figure A.2 **HD agent droplet placement between facepiece and cylinder thread**



Key

A	Facepiece	E	Harness
B	Breathing connector	F	Monitor/warning unit
C	Exhalation hose	G	Hose/cable connector
D	Inhalation hose	H	Casing

A.5.2.2 Take time zero as the time when the first droplet is placed on the CCBA.

A.5.2.3 Close the chamber, set the airflow-temperature-humidity control system (**A.3.6**) and agent delivery system (**A.3.5**) to deliver the airflow characteristics given in Table A.1, and allow the agent delivery system to run for 30 min ±10 s. Record the total volume, elapsed time and airflow rate delivered by the airflow-temperature-humidity control system (**A.3.6**).

Table A.1 **Airflow characteristics for chemical agent permeation and penetration resistance test method (HD)**

HD airflow	50 L/min
HD challenge concentration	(300 ±30) mg/m³
Relative humidity	(50 ±5)%
Temperature	(25 ±3) °C

A.5.2.4 Continue flushing the chamber (**A.3.2**) with the airflow-temperature-humidity control system (**A.3.6**) until 6 h after time zero. Monitor the HD concentration throughout this period using the continuous air monitoring system (**A.3.4**) unless the equipment concentration upper limit (see **A.5.1.3**) is reached.

A.5.2.5 Turn off the breathing simulator (**A.3.7**). Purge the air in the CCBA by opening the bypass valve. After at least 5 min, close the bypass valve, turn off and disconnect the CCBA. Inject 20 μL of HD in the nasal sampling port in use to check that the breakthrough continuous air monitoring system (**A.3.4**) is still operating accurately (and hence the levels of agent in the chamber are safe). If the measured value is within 10% of the expected one, continue the test.

A.5.2.6 Turn off the continuous air monitoring system (**A.3.4**). Turn off the airflow-temperature-humidity control system (**A.3.6**). Open the chamber (**A.3.2**) front panel. Remove the CCBA and separate it into its components. Double-bag the components and remove them for storage, decontamination, monitoring and/or disposal. Wipe down the interior of the chamber and the SMARTMAN (**A.3.1**) and dispose of the cleaning materials safely.

A.5.3 GB Test

NOTE This test should be performed separately from the HD vapour/liquid tests.

A.5.3.1 Take time zero as the time that corresponds to the first introduction of GB vapour.

A.5.3.2 Close the chamber, set the airflow-temperature-humidity control system (**A.3.6**) and agent delivery system (**A.3.5**) to deliver the airflow characteristics given in Table A.2, and allow the agent delivery system to run for 30 min ±10 s. Record the total volume, elapsed time and airflow rate delivered by the airflow-temperature-humidity control system (**A.3.6**).

Table A.2 **Airflow characteristics for chemical agent permeation and penetration resistance test method (GB)**

GB air flow	50 L/min
GB minimum challenge concentration	(2 000 ±200) mg/m³
Relative humidity	(50 ±5)%
Temperature	(25 ±3) °C

A.5.3.3 Continue flushing the chamber (**A.3.2**) with the airflow-temperature-humidity control system (**A.3.6**) until 6 h after time zero. Monitor the GB concentration throughout this period using the continuous air monitoring system (**A.3.4**) unless the equipment concentration upper limit (see **A.5.1.3**) is reached.

A.5.3.4 Turn off the breathing simulator (**A.3.7**). Purge the air in the CCBA by opening the bypass valve. After at least 5 min, close the bypass valve, turn off and disconnect the CCBA. Inject 20 μL of GB in the nasal sampling port in use to check that the breakthrough continuous air monitoring system (**A.3.4**) is still operating accurately (and hence the levels of agent in the chamber are safe). If the measured value is within 10% of the expected one, continue the test.

A.5.3.5 Turn off the continuous air monitoring system (**A.3.4**). Turn off the airflow-temperature-humidity control system (**A.3.6**). Open the chamber (**A.3.2**) front panel. Remove the CCBA and separate it into its components. Double-bag the components and remove them for storage, decontamination, monitoring and/or disposal. Wipe down the interior of the chamber and the SMARTMAN (**A.3.1**) and dispose of the cleaning materials safely.

A.6 Test report

The test report shall contain the following for each CCBA tested:

a) the laboratory's name and date of test;

b) reference to this British Standard, i.e. BS 8468-7:2012;

c) name and manufacturer of the CCBA;

d) agents used, and for each agent:

   1) the agent breakthrough in mg·min/m^3 (integrated concentration over time); and

   2) the three highest consecutive peak excursions in mg/m^3;

e) the digital photograph of the CCBA tested with droplet positions marked.

Annex B (informative) Relationship between this British Standard and the basic safety requirements of EU Directive 89/686/EEC Personal Protective Equipment

It is a legal requirement in the EU that personal protective equipment (PPE) conforms to the PPE Directive [2]. The Personal Protective Equipment Regulations 2002 [3] transpose the PPE Directive into UK legislation. Guidance notes on the PPE Regulations 2002 are published by the Department of Trade and Industry.

The burden of proof that the product meets the basic safety requirements will rest on the person affixing the CE marking (the producer, his authorized representative in the EU or by the importer of the product). Table B.1 provides a checklist of PPE Directive [2] requirements against requirements in this standard, which could be offered to a Notified Body as evidence that a product is suitable for CE marking.

Table B.1 **Essential requirements for PPE – Comparison between the PPE Directive, Annex II and BS 8468-7**

PPE Directive, Annex II subclause	Requirement type	Relevant BS 8468-7 clause	By reference to BS EN 136 and BS EN 145 Y/N
1	General requirements (design, innocuousness, comfort and efficiency, and information supplied)	**6**	Y
2.1	Adjustment systems	**6**	Y
2.2	Ventilation or perspiration absorption	**6**	Y
2.3	Face, eyes and respiratory tract	**6**	Y
2.4	Ageing	**6**	Y
2.8	Information for use in very dangerous situations	**6**	Y
2.9	Adjustability	**6**	Y
2.10	Connectivity to additional equipment	**6**	Y
2.11	Fluid circulation systems	**6**	Y
2.12	Health and safety identification marks	**7**	N
2.13	Visibility	**6**	Y
2.14	Multiple use	**6**	Y
3.1.1	Resistance to impact	**6**	Y
3.1.2.1	Prevention of falls due to slipping	**6**	Y
3.3	Protection against physical injury	**6**	Y
3.6.1	Protection against heat	**6**	Y
3.6.2	Prevention of overheating	**6**	Y
3.7.1	Protection against cold	**6**	Y
3.7.2	Insulation	**6**	Y
3.9.2.1	Protection against external radioactive contamination	**6**	N
3.10	Protection against dangerous substances and infective agents	**6**	N

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8467, *Protective clothing – Personal protective ensembles for use against chemical, biological, radiological and nuclear (CBRN) agents – Categorization, performance requirements and test methods*

Other publications

[1] National Institute for Occupational Safety and Health. *NIOSH Concept Standard for Chemical, Biological, Radiological, and Nuclear (CBRN), Full Facepiece, Closed-Circuit, Self-Contained Breathing Apparatus (SCBA)*. (www.cdc.gov/niosh/database.html)

[2] EUROPEAN COMMUNITIES. 89/686/EEC. *Council directive on the approximation of the laws of the Member States relating to personal protective equipment*. Luxembourg: Office for Official Publications of the European Communities, 1989.

[3] GREAT BRITAIN. *The Personal Protective Equipment Regulations 2002: Statutory Instrument 2002/1144*. London: The Stationery Office.

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