BRITISH STANDARD

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

Part 1: Positive pressure, self-contained, open-circuit breathing apparatus – Specification

ICS 11.040.10; 13.340.30

Publishing and copyright information

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 11 and a back cover.

Foreword

Publishing information

This British Standard was published by BSI. 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 will be issued in five parts:

- *Part 1: Positive pressure, self-contained breathing apparatus – Specification;*
- *Part 2: Negative pressure air purifying devices with full face mask – Specification;*
- *Part 3: Escape hoods – Specification;*
- *Part 4: Powered air-purifying respirators – Specification;*
- *Part 5: Dual-mode 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 positive pressure, self-contained, open-circuit breathing apparatus (SCBA) intended to be used during firefighting, rescue, evacuation, escape, hazard containment and decontamination, and similar activities by emergency first responders (fire, ambulance, police, and associated civilian agencies and workers) in areas containing and contaminated by chemical, biological, radiological and nuclear (CBRN) agents.

NOTE SCBA 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 referenced documents are indispensable for the application of this document. 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, *Specification for respiratory protective devices: self-contained open-circuit compressed air breathing apparatus*

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

3 Terms and definitions

For the purpose of this British Standard the terms and definitions defined 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 positive pressure, self-contained, open-circuit breathing apparatus
positive pressure SCBA
self-contained breathing apparatus which is designed to maintain the pressure in the mask above ambient pressure and the exhaled air passes, without recirculation, from the facepiece via the exhalation valve to the ambient atmosphere

4 Description

Positive pressure, self-contained, open-circuit compressed air breathing apparatus are designed and constructed to enable the wearer to breathe air on demand from pressure vessel(s), carried by the wearer, via a pressure reducer and/or a lung governed demand valve connected to the facepiece. The exhaled air passes without re-circulation from the facepiece via the exhalation valve to the ambient atmosphere.

5 Requirements

5.1 General

SCBA for use against CBRN agents shall be positive pressure equipment conforming to BS EN 137, and conforming to the inward leakage specified in **5.2** of this standard, and conforming to the chemical agent penetration and permeation resistance specified in **5.3** of this standard.

The facepiece shall conform to BS EN 136:1998 class 3.

5.2 Inward leakage

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 137. Detection systems should take account of the increased sensitivity required.

Where the apparatus has been designed to be used at temperatures outside those specified in this standard, the manufacturer shall have tested and marked the product appropriately.

5.3 Chemical agent permeation and penetration

SCBA 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/m^3	**Maximum acceptable breakthrough (concentration integrated over time)**[B] mg·min/m^3
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.

6 Marking

6.1 Marking shall be in accordance with BS EN 136:1998 and BS EN 137

6.2 In addition, each SCBA and facepiece conforming to this standard shall be permanently marked with the designation and year of this standard, i.e. BS 8468-1:2006.

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

7 Information supplied by the manufacturer

7.1 The information supplied shall be in accordance with BS EN 136:1998 and BS EN 137.

7.2 The information shall describe precisely and comprehensibly which permissible combinations of components are to be used.

7.3 The information shall describe suitable procedures for decontamination.

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 No. RCT-CBRN-STP-0002 [1].

A.1 Principle

Three SCBAs, including all components and accessories, are tested on an upper-torso manikin connected to a breathing machine, in an atmosphere containing HD and GB vapour, and with droplets of HD liquid applied to the surface of the SCBA. The peak excursion levels and breakthrough levels are measured for these agents.

A.2 Materials

A.2.1 *HD vapour*

A.2.2 *HD liquid*

A.2.3 *GB vapour*

A.2.4 *High-pressure compressed air*, conforming to BS EN 12021, or CGA Grade D (see Table A.1), or Grade E liquified air.

Table A.1 **Air supply characteristics for chemical agent permeation and penetration resistance test method**

Cylinder capacity	2 400 l (minimum)
Temperature	(25 ± 5) °C
Oxygen content	(19.5 to 23.5)%
CO by volume	< 0.001% (10 ppm)
CO_2 by volume	< 0.1% (1 000 ppm)
Condensed hydrocarbons by weight	< 5 mg/m^3
Odour	No odour detectable by olfactory senses
Dew point	< – 40 °C at 101 kPa (one atmosphere)

A.3 Apparatus

A.3.1 *SMARTMAN*[1)] (or equivalent), simulant agent resistant test manikin, tested, with helium, monthly and when new, for leaks.

1) 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.

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.

A.3.3 *Leak detector*, capable of detecting mineral oil aerosol particles at a concentration of 0.10 mg/m^3.

A.3.4 *Continuous air monitoring system*; a gas chromatograph equipped with a hydrogen flame emission detector and a preconcentrator tube (a small tube containing an adsorbent material to scrub out agent vapour from air drawn through it), coupled, where relevant to either:

A.3.4.1 *Infrared absorption based detector*, capable of detecting GB at the levels required.

A.3.4.2 *Gas chromatograph*, with a flame ionization detector (FID), capable of detecting HD at the levels required.

A.3.5 *Syringe pump*; a multirange, variable rate infusion pump, capable of injecting liquid agent into an air stream at a controlled rate, to create a challenge vapour at a specified concentration.

A.3.6 *Automated 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 *Mixing chamber*, made of PVC pipe, with: caps on both ends and three baffles fixed inside to ensure mixing of agent vapour and air; and a pressure gauge mounted on the chamber to indicate internal pressure.

A.3.8 *Breathing simulator*; a double pump, operated by a single, variable speed motor through a Scotch yoke (slotted link) to produce a sinusoidal breathing pattern, adjustable up to a tidal volume (volume per breath) of 1.5 l.

A.3.9 *Mass flow controllers*, capable of controlling the flow of samples in the continuous air monitoring system and the flow of air to flush out the exposure chamber, with an accuracy of ±2%.

A.3.10 *Compressed air system*; air compressor and cascade system, capable of maintaining a pressure in the range 3.45 MPa to 31.0 MPa and of cycling between these values.

A.4 Preparation

A.4.1 Run a background characterization; connect the continuous air monitoring system (**A.3.4**) to a nasal sampling port of the SMARTMAN (**A.3.1**) in the agent exposure chamber (**A.3.2**) and monitor for a period of 60 mins. 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 SCBA following the manufacturer's instruction, with the exception of the air cylinder, and connect the compressed air system (**A.3.10**). Ensure that the air inlet gauge reads the rated service pressure for the SCBA ±340 kPa.

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

A.4.4 Mount the unit 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.3.8**). Ensure that the SCBA is in pressure-demand mode.

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 mineral oil aerosol particles to a concentration of 100 mg/m^3 (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% (0.10 mg/m^3) is detected, assume there is no leak in the facepiece. 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 Remove the SCBA from the "clean" chamber and install on the SMARTMAN in the agent exposure chamber (**A.3.2**), following the manufacturer's instructions.

A.5.2 Turn on the breathing simulator (**A.3.8**). Ensure that the SCBA is in pressure-demand mode.

A.5.3 Connect the continuous air monitoring system (**A.3.4**) to a nasal sampling port of the SMARTMAN (**A.3.1**) and begin monitoring. If the equipment concentration upper limit (15 ng/200 ml for GB and 40 ng/500 ml for HD) is reached at any time, terminate the test.

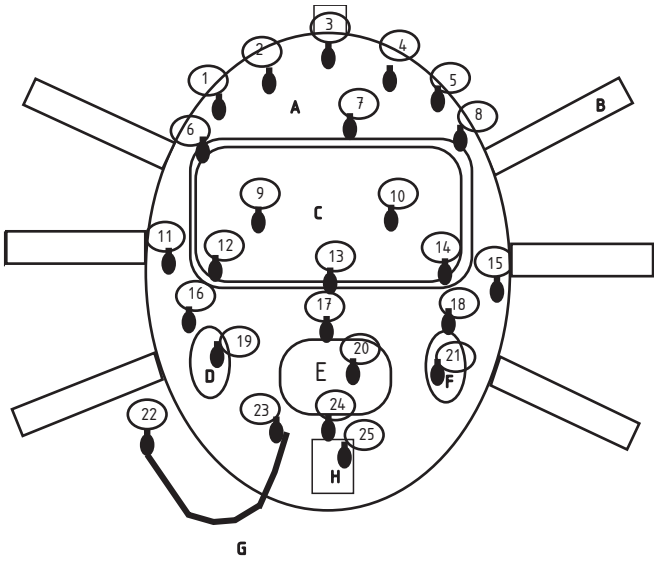
A.5.4 Place 43 droplets (20 μl each) of HD, using a syringe, on the SCBA, as specified in Figure A.1 and Figure A.2. Mark the actual location of the drops on the digital photograph of the SCBA. If an external shroud is mounted on the facepiece, apply droplets as specified in Figure A.1 on the surface of the shroud.

A.5.5 Set the air flow-temperature-humidity control system (**A.3.6**) and syringe pump (**A.3.5**) to deliver the airflow characteristics given in Table A.2.

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

GB airflow	50 l/min
GB challenge concentration	(2 000 ±200) mg/m^3
HD airflow	50 l/min
HD challenge concentration	(300 ±30) mg/m^3
Relative humidity	(50 ±5)%
Temperature	(25 ±3) °C

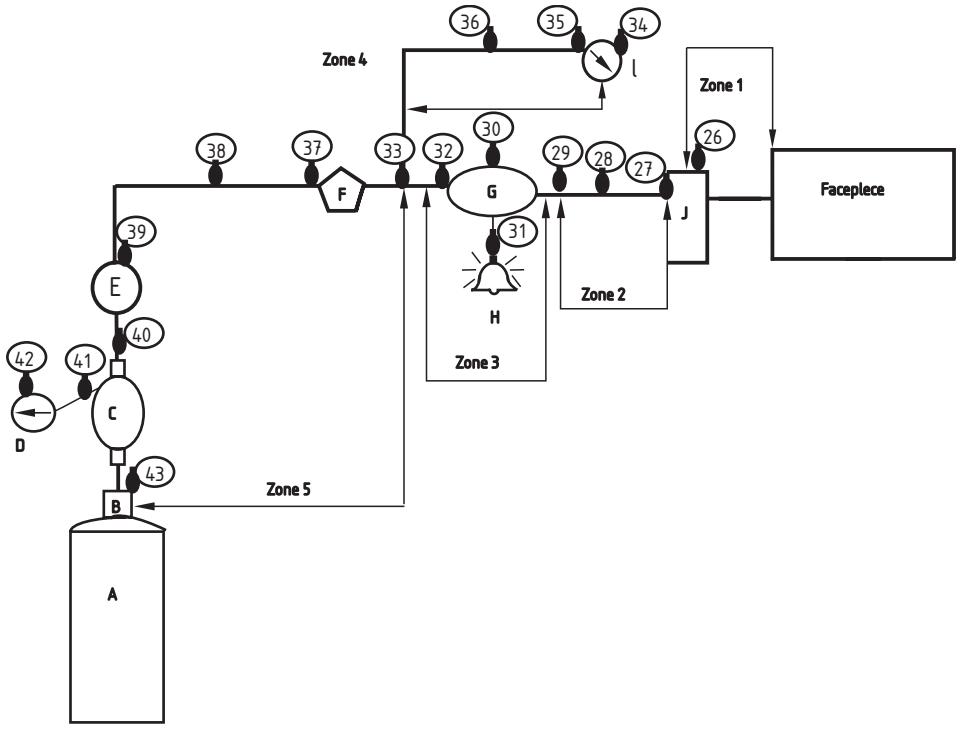
Figure A.1 **HD agent droplet placement for SCBA facepiece**



Key

A Facepiece
B Head-harness strap
C Eye lens(es)
D Side voice-emitter (if present)
E Housing for second stage regulator
F Side voice-emitter (if present)
G Drink tube (if present)
H Exhalation valve

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



Key

A Cylinder
B Cylinder neck
C Cylinder valve
D Cylinder pressure gauge
E Male/female threaded connection
F Rapid intervention team (RIT) fitting (if present)
G First stage pressure regulator
H Low air pressure alarm
I Remote pressure gauge and airline
J Second stage pressure regulator
K Facepiece assembly

A.5.6 Take time zero as the first time when the chamber concentration reading rises above the lowest calibration point of the continuous air monitoring system (**A.3.4**).

A.5.7 After 30 min ±10 s, turn off the syringe pump (**A.3.5**). Record the total volume, elapsed time and air flow rate delivered by the airflow-temperature-humidity control system (**A.3.6**).

A.5.8 Continue flushing the chamber (**A.3.2**) with the airflow-temperature-humidity control system (**A.3.6**) for 5.5 h. Monitor the HD concentration throughout this period using the continuous air monitoring system (**A.3.4**) unless the equipment concentration upper limit (see **A.5.3**) is reached.

A.5.9 Turn off the breathing simulator (**A.3.8**). Purge the air from the SCBA by opening the purge valve while maintaining the supply from the compressed air feed (**A.3.10**). When the gauge on the SCBA reads zero, close the purge valve and turn off the compressed air feed. Disconnect the SCBA. Inject 20 μl of HD in the nasal sampling port in use to check that the 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.5.10 Turn off the continuous air monitoring system (**A.3.4**). Turn off the air flow-temperature-humidity control system (**A.3.6**). Open the chamber (**A.3.2**) front panel. Remove the SCBA 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 SCBA tested:

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

b) reference to this British Standard, i.e. BS 8468-1:2006;

c) name and manufacturer of the SCBA;

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 SCBA 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 8468-1**

PPE Directive, Annex II subclause	Requirement type	Relevant BS 8468-1 subclause	By reference to BS EN 137 Y/N
1	General requirements (design, innocuousness, comfort and efficiency, and information supplied)	**5**	Y
2.1	Adjustment systems	**5**	Y
2.2	Ventilation or perspiration absorption	**5**	Y
2.3	Face, eyes and respiratory tract	**5**	Y
2.4	Ageing	**5**	Y
2.8	Information for use in very dangerous situations	**5**	Y
2.9	Adjustability	**5**	Y
2.10	Connectivity to additional equipment	**5**	Y
2.11	Fluid circulation systems	**5**	Y
2.12	Health and safety identification marks	**6**	N
2.13	Visibility	**5**	Y
2.14	Multiple use	**5**	Y
3.1.1	Resistance to impact	**5**	Y
3.1.2.1	Prevention of falls due to slipping	**5**	Y
3.3	Protection against physical injury	**5**	Y
3.6.1	Protection against heat	**5**	Y
3.6.2	Prevention of overheating	**5**	Y
3.7.1	Protection against cold	**5**	Y
3.7.2	Insulation	**5**	Y
3.9.2.1	Protection against external radioactive contamination	**5**	N
3.10	Protection against dangerous substances and infective agents	**5**	N

Bibliography

[1] National Institute for Occupational Safety and Health. *NIOSH Procedure No. RCT-CBRN-STP-0002*. (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.* The Stationery Office. (http:www.tsoshop.co.uk)

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