BS 8468-3.1:2009

BSI British Standards

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

Part 3.1: Self-contained open-circuit compressed air breathing apparatus incorporating a hood for escape – 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 10, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard was published by BSI and came into effect on 30 April 2009. 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

When finished, BS 8468 will be issued in eight parts:

— *Part 1: Positive pressure, self-contained 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: Positive-pressure compressed airline equipment – Specification;*

— *Part 7: Closed-circuit breathing apparatus – Specification.*

Information about this document

Recent changes in international politics have given rise to a threat from weapons previously expected to be confined to military operations. In the event that they are used against civilian targets, emergency and support agencies will need suitable 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 standard applies to self-contained open-circuit compressed air breathing apparatus incorporating a hood intended to be used only during escape by emergency responders (fire, ambulance, police) and adult civilians from areas contaminated by chemical, biological, radiological and nuclear (CBRN) agents. It contains requirements for designation, classification, testing and marking of the device.

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 1146:2005*, Respiratory protective devices – Self-contained open-circuit compressed air breathing apparatus incorporating a hood for escape – Requirements, testing, marking*

BS EN 12021*, Respiratory protective devices – Compressed air for 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 hood
respiratory interface that completely covers the head and neck and may also cover portions of the shoulders and torso

4 Description

Self-contained open-circuit compressed air breathing apparatus incorporating a hood are devices designed and constructed to enable the wearer to breathe air supplied to a hood, covering at least the head and neck, from a pressure vessel(s) via a pressure reducer giving a continuous flow of air, or via a lung demand valve connected to the hood. The exhaled air passes without re-circulation from the hood via an exhalation valve(s) or other outlet to the ambient atmosphere.

This apparatus typically comprises pressure vessel(s), body harness, pressure indicator(s), warning device (optional), connecting hoses and tubes and a hood.

5 Classification

Compressed air escape apparatus with hood are classified according to the rated working duration in accordance with BS EN 1146:2005, Clause **5**, except that the rated working duration starts with 15 min as a minimum and with no defined maximum, and the CBRN requirements of this standard, e.g. "class 15 CBRN".

6 Requirements

6.1 General

The complete device for use against CBRN agents shall be self-contained open-circuit compressed air breathing apparatus incorporating a hood conforming to BS EN 1146:2005 and to the additional requirements specified in **6.2**, **6.3** and **6.4** of this standard.

In all tests, all test samples shall meet the requirements.

6.2 Inward leakage

The maximum inward leakage shall be $\leqslant$ 0.05% when tested as a complete system in accordance with BS EN 13274-1:2001 **8.4** with ten test subjects.

6.3 Chemical agent permeation and penetration

Devices 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**[C]	**Maximum acceptable breakthrough (concentration integrated over minimum service life)** [D], [E]
	mg/m^3	$mg \cdot min/m^3$
Distilled sulfur mustard (HD) (vapour)[A]	0.60	6.0
Distilled sulfur mustard (HD) (liquid)[A]	0.60	6.0
Sarin (GB) (vapour)[B]	0.087	0.9 for durations $\leqslant$ 30 min
		2.1 for durations > 30 min

[A] Vapour challenge concentration will start immediately after the liquid drops have been applied and the test chamber has been sealed.

[B] Vapour challenge concentration will start immediately after the test chamber has been sealed.

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

[D] The cumulative concentration including all maximum peak excursion data points cannot be exceeded for the duration of the test.

[E] Devices are monitored in the oral/nasal and ocular regions.

6.4 Donning

When meeting BS EN 1146:2005 **6.9**, the time to don the device from the ready-to-use configuration shall be no greater than 30 s.

NOTE The ready-to-use configuration is the operational packaging state prior to use such that immediately upon opening allows the user to don the device.

7 Marking

7.1 Marking shall be in accordance with BS EN 1146:2005.

7.2 In addition, each device conforming to this standard shall be permanently marked with the designation and year of this standard, plus classification of the device, e.g. BS 8468-3.1:2009, class 15 CBRN.

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 1146:2005.

8.2 The information shall explain the markings listed in Clause **7**.

8.3 The information shall describe suitable procedures for decontamination and disposal.

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-0550 [1], NIOSH Procedure No. RCT-CBRN-STP-0551 [2] and NIOSH Procedure No. RCT-CBRN-STP-0200, 0201 [3].

A.1 Principle

Three devices are tested on an upper-torso manikin connected to a breathing machine, in an atmosphere containing either GB vapour or, in a separate test, HD vapour with liquid droplets of HD applied to the surface of the device. 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.

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

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.

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/breather pump*; 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 30 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 device 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 device ±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 air supply to the device is turned on.

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 hood. 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 device from the "clean" chamber and install on the SMARTMAN (**A.3.1**) 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 device 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 droplets (20 µL each) of HD, using a syringe, on the device, as specified in Figure A.1 and Figure A.2. Mark the actual location of the drops on the digital photograph of the device.

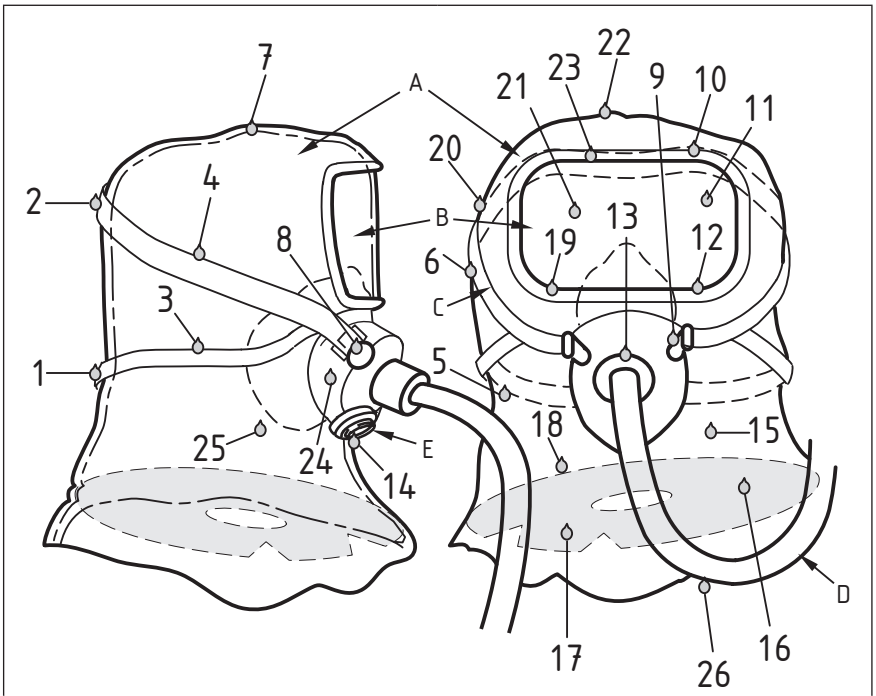
A.5.5 Set the airflow-temperature-humidity control system (**A.3.6**) and syringe pump (**A.3.5**) to deliver the airflow characteristics given in Table A.2.

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**).

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

GB airflow	50 L/min
GB challenge dose (concentration × time)	(10 000 ±1 000) mg·m/m^3
Minimum GB challenge concentration for at least two continuous minutes	(2 000 +200/–0) 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 **Schematic diagram of HD agent droplet placement on hood and supply hose**



Key

A Hood material
B Lens or lenses
C Strap
D Supply hose
E Exhalation valve

A.5.7 After the rated duration of the device (+1 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**).

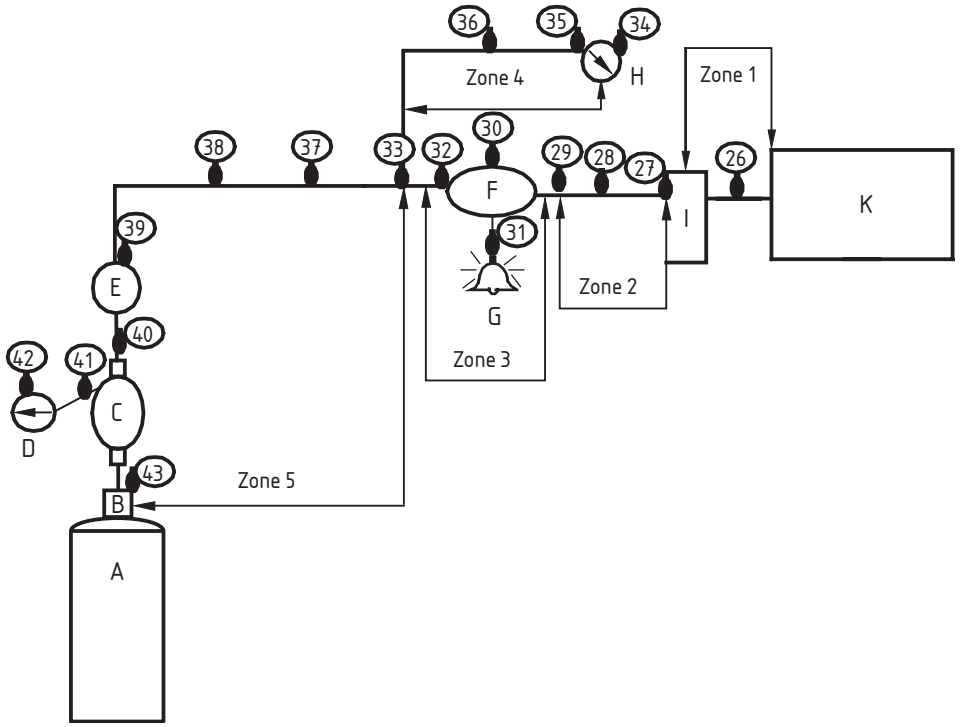
A.5.8 Continue flushing the chamber (**A.3.2**) with the airflow-temperature-humidity control system (**A.3.6**) for the rated duration of the device. Monitor the HD concentration throughout this period using the continuous air monitoring system (**A.3.4**) unless the equipment concentration upper limit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

NOTE The maximum total duration of the test will be twice the rated duration of the device.

A.5.9 Turn off the breathing simulator (**A.3.8**). Purge the air from the device by opening the purge valve while maintaining the supply from the compressed air feed (**A.3.10**). When the gauge on the device reads zero, close the purge valve and turn off the compressed air feed. Disconnect the device. 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 airflow-temperature-humidity control system (**A.3.6**). Open the chamber (**A.3.2**) front panel. Remove the device 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.

Figure A.2 **Schematic diagram of HD agent droplet placement between hood and cylinder thread**



Droplets that would be applied to components not exposed to ambient atmosphere (i.e. internal to the breathing area) should be added to the external surface of the hood.

Key

A Cylinder
B Cylinder neck
C Cylinder valve
D Cylinder pressure gauge
E Male/female threaded connection
F First stage pressure regulator
G Low/air pressure alarm
H Remote pressure gauge and airline (if fitted)
I Second stage pressure regulator
K Hood
Zone 1 Second stage regulator to hood connector
Zone 2 First stage regulator to second stage regulator
Zone 3 First stage regulator
Zone 4 Remote pressure gauge to main line
Zone 5 Cylinder neck valve to first stage regulator

A.6 Test report

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

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

b) reference to this British Standard, i.e. BS 8468-3.1:2009;

c) name and manufacturer of the device;

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 device tested with droplet positions marked.

Annex B (normative) Relationship between this British Standard and the Basic Safety Requirements of EU Directive 89/686/EEC Personal Protective Equipment

This standard is not mandated and therefore cannot be considered to offer automatic presumption of conformity.

It is a legal requirement in the EU that personal protective equipment (PPE) conforms to the PPE Directive [4]. The Personal Protective Regulations 2002 [5] enact the PPE Directive into UK legislation. The burden of proof that the product meets the essential requirements will rest on the person affixing the CE marking (the producer, his authorized representative in the EU or the importer of the product).

Table B.1 provides a checklist of some PPE Directive [4] basic safety requirements against requirements in this standard.

Table B.1 **Basic Safety requirements for PPE – Comparison between the PPE Directive, Annex II and BS 8468-3.1**

PPE Directive, Annex II subclause	Requirement type	Relevant BS 8468-3.1 subclause
1	General requirements (design, innocuousness, comfort and efficiency, and information supplied)	**6.1**, **6.2**, **6.3**, **6.4**, **7**, **8**
2.1	Adjustment systems	**6.1**
2.2	Ventilation or perspiration absorption	**6.1**
2.3	Face, eyes and respiratory tract	**6.1**
2.4	Ageing	**6.1**
2.7	Time of doffing	**6.1**
2.8	Information for use in very dangerous situations	**8**
2.9	Adjustability	**6.1**
2.10	Connectivity to additional equipment	**6.1**
2.11	Fluid circulation systems	**6.1**
2.12	Health and safety identification marks	**7**
2.13	Visibility	**6.1**
2.14	Multiple use	**6.1**
3.1.1	Resistance to impact	**6.1**
3.1.2.1	Prevention of falls due to slipping	**6.1**
3.3	Protection against physical injury	**6.1**
3.6.1	Protection against heat	**6.1**
3.6.2	Prevention of overheating	**6.1**
3.7.1	Protection against cold	**6.1**
3.7.2	Insulation	**6.1**
3.9.2.1	Protection against external radioactive contamination	**6.2**
3.10	Protection against dangerous substances and infective agents	**6.2**, **6.3**

Bibliography

[1] National Institute for Occupational Safety and Health. NIOSH Procedure No. RCT-CBRN-STP-0550. (www.cdc.gov/niosh/npptl/stps/respirator_testing.htm)

[2] National Institute for Occupational Safety and Health. NIOSH Procedure No. RCT-CBRN-STP-0551. (www.cdc.gov/niosh/npptl/stps/respirator_testing.htm)

[3] National Institute for Occupational Safety and Health. NIOSH Procedure No. RCT-CBRN-STP-0200, 0201. (www.cdc.gov/niosh/npptl/stps/respirator_testing.htm)

[4] 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.

[5] GREAT BRITAIN *The Personal Protective Equipment Regulations 2002: Statutory Instrument 2002/1144*. The Stationery Office. (http:www.tsoshop.co.uk)

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