BS 8468-6.2:2011

BSI Standards Publication

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

Part 6.2: Constant flow compressed airline equipment – 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 14, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard was published by BSI and came into effect on 31 January 2011. 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 nine 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 6.1: 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 compressed air line breathing apparatus with constant airflow as a respiratory protective device intended to be used during 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.

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

BS EN 1073-1, *Protective clothing against radioactive contamination – Part 1: Requirements and test methods for ventilated protective clothing against particulate radioactive contamination*

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*

BS EN 14594:2005, *Respiratory protective devices – Continuous flow compressed air line breathing apparatus – Requirements, testing marking*

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 purpose of this British Standard the terms and definitions defined in BS EN 132, BS EN 134 and BS EN 14594:2005 apply.

4 Description

Compressed air line breathing apparatus with constant flow for use with a full face mask, hood, helmet or suit (the apparatus), which enables the wearer to be provided with breathable air conforming to BS EN 12021, which continuously flows through a flow control valve (if fitted) to a suitable facepiece or suit, possibly via a breathing hose or medium-pressure supply tube(s). A compressed air supply tube

connects the wearer to a supply of compressed air. The excess and exhaled air flows into the ambient atmosphere.

5 Requirements

5.1 General

The apparatus shall be constant flow equipment conforming to either of the following.

1) BS EN 14594:2005, class 4A or class 4B; or BS EN 14594:2005, class 4A or class 4B and the lower inward leakage specified in **5.2** of this standard. If the facepiece is a full facemask, it shall conform to BS EN 136:1998 class 2 or class 3.

OR

2) BS EN 1073-1.

The apparatus shall also conform to the chemical agent permeation and penetration resistance specified in **5.3** of this standard.

5.2 Lower inward leakage

Where a lower inward leakage is claimed, 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 14594:2005. Detection systems should take account of the increased sensitivity required.

5.3 Chemical agent permeation and penetration

For apparatus that can be tested on SMARTMAN (see **A.4.4**), the apparatus shall be resistant to chemical agents up to the maximum levels given in Table 1 when tested in accordance with Annex A.

Where the apparatus cannot be tested on SMARTMAN (see **A.4.4**), the highest cumulative permeation for the exposed materials of the apparatus, including the compressed-air supply tube (CAST), for each chemical over 4 h shall not exceed 1.25 µg/cm^2, when tested against all of the liquid test chemicals listed in BS 8467:2006, Annex D. (The liquid concentration density of each chemical is 10 g/m^2, applied as nominal 1 µL drops, drops applied uniformly over the sample surface. Where a seam closure or fixture is included, at least three drops are applied at each critical juncture, such as the seam edge. The test cell is assembled in the open configuration.)

NOTE Where components are made of materials identical (in composition and minimum thickness) to those used previously and have been shown to meet the requirements as part of other devices that conform to this standard then this information may be used to demonstrate compliance in this instance.

For each type of apparatus tested on SMARTMAN, six devices shall be tested, two devices (one for each agent) in as-received condition and four devices (two for each agent) conditioned in accordance with BS EN 14594:2005 or BS EN 1073-1, as appropriate.

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

Agent	Maximum acceptable peak excursion [C] mg/m^3	Maximum acceptable breakthrough (concentration integrated over time) [D), E)] mg·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	2.1

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 times test time integral ct, including all maximum peak excursion data points cannot be exceeded for the duration of the test. The test period begins upon initial generation of vapour concentration. The duration of the test is twice the identified rated duration.

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

6 Marking

6.1 Marking shall be in accordance with BS EN 14594:2005.

6.2 In addition, each apparatus conforming to this standard shall be permanently marked with the standard identifier and year, i.e. BS 8468-6.2:2011 [1)], and if applicable, if the apparatus meets the lower inward leakage requirement in **5.2**, i.e. "TIL 0.01%".

6.3 Sub-assemblies, compressed-air supply tube and other components with considerable bearing on CBRN performance shall be marked to indicate their suitability for use in a CBRN environment, and so that they can be identified.

7 Information supplied by the manufacturer

7.1 The information supplied shall be in accordance with BS EN 14594:2005.

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 and disposal.

1) Marking BS 8468-6.2:2011 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 methods developed and described by NIOSH (www.cdc.gov/niosh). This method is based on a method developed and described in NIOSH Procedure No. RCT-CBRN-STP-0550 [1] and NIOSH Procedure No. RCT-CBRN-STP-0551 [2]. The information contained therein augments the information provided in this standard and should be consulted for additional detail.

Performing the tests in accordance with the procedures described in [1] and [2] is an acceptable means of demonstrating conformance with the requirements of the relevant clauses of this standard. Other equivalent test procedures are acceptable if equivalence with the NIOSH test procedures can be demonstrated.

Detailed information on technical aspects of the methods are provided in [1] and [2].

A.1 Principle

Three sets of apparatus 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, 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.

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.2.5 *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 (CGA Grade D) characteristics for chemical agent permeation and penetration resistance test method**

Cylinder capacity	2400 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 % (1000 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*[2)] (or equivalent), simulant agent resistant test manikin, tested, with helium, monthly and when new, for leaks.

A.3.2 *Two test chambers*, 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 protection 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, and the other is for agent exposure.

*NOTE If it can be demonstrated that equivalent results are achieved using a single chamber then only one chamber is needed and the preparation stages (**A.4**) may be modified accordingly.*

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*; 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.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%.

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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.

A.3.10 *Compressed air system*; air compressor and cascade system, capable of delivering air to the demand valve at the minimum pressure specified by the manufacturer for the device.

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 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 apparatus following the manufacturer's instruction, including the compressed air supply tube (CAST).

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

A.4.4 If possible, mount the apparatus on the SMARTMAN (**A.3.1**) in the "clean" exposure chamber (**A.3.2**), following the manufacturer's instructions.

NOTE If the device cannot be mounted on the SMARTMAN, the exposed materials of the device are tested for permeation, in accordance with BS 8467:2006, Annex D.

A.4.5 Set the compressed air pressure at the minimum pressure specified by the manufacturer and check that the manufacturer's minimum flow rate is achieved or exceeded. Turn on the breathing simulator (**A.3.8**).

A.4.6 Connect the leak detector (**A.3.3**) to a port in 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**). Continue this leak-tightness test for 30 min. If a level of penetration less than 0.001% (0.10 mg/m^3) 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, with the concurrence of the manufacturer, either use alternative means to seal the apparatus to the headform or terminate the test.

A.5 Procedure

A.5.1 Set up common to all test agents

A.5.1.1 Remove the apparatus from the "clean" chamber and install on the SMARTMAN in the agent exposure chamber, following the manufacturer's instructions, and using any sealing methods devised under (**A.4.6**). Include at least 3 m of CAST, attached to the device, within the agent exposure chamber (**A.3.2**).

A.5.1.2 Set the compressed air pressure at the minimum pressure specified by the manufacturer and check that the manufacturer's minimum flow rate is achieved or exceeded. Turn on the breathing simulator (**A.3.8**).

A.5.1.3 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.5.2 HD test (liquid and vapour)

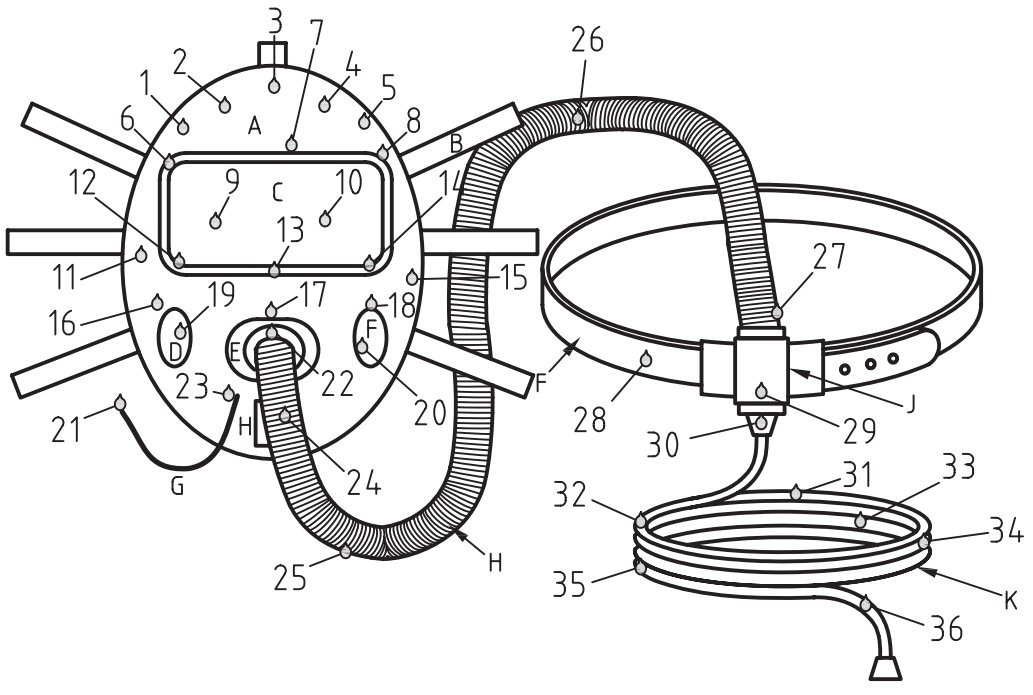
A.5.2.1 Place 36 droplets (20 µL each) of HD, using a syringe, on the apparatus, as specified in Figure A.1, Figure A.2, Figure A.3, Figure A.4 or Figure A.5, as appropriate. Mark the actual location of the drops on the digital photograph of the apparatus. If an external shroud is mounted on a facepiece, apply droplets as specified in Figure A.1 on the surface of the shroud.

A.5.2.2 Set the air flow-temperature-humidity control system (**A.3.6**) and syringe pump (**A.3.5**) to deliver the airflow characteristics and challenge concentrations given in Table A.2.

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

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

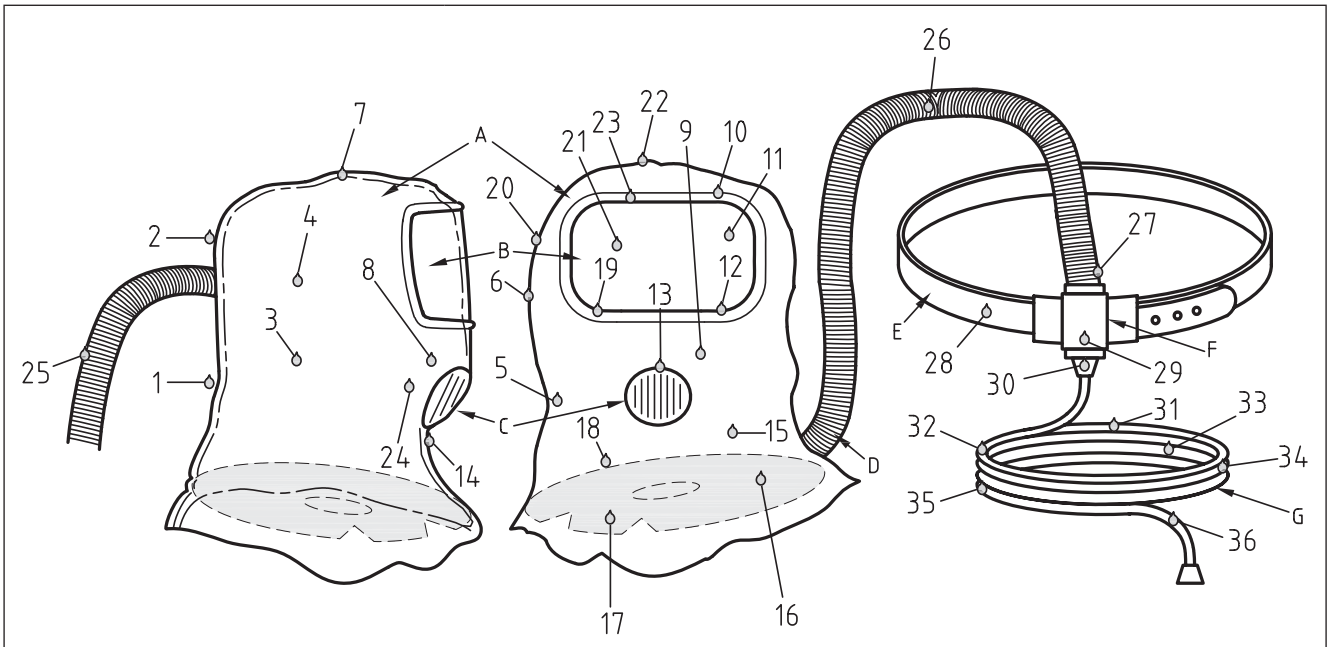
Figure A.1 **HD agent droplet placement for facepiece and belt-mounted air-supply equipment**



Key

A	Facepiece	E	Housing for air inlet connection	I	Breathing hose
B	Head-harness strap	F	Belt	J	Flow control valve
C	Eye lens(es)	G	Drink tube (if present)	K	CAST
D	Side voice-emitter (if present)	H	Exhalation valve		

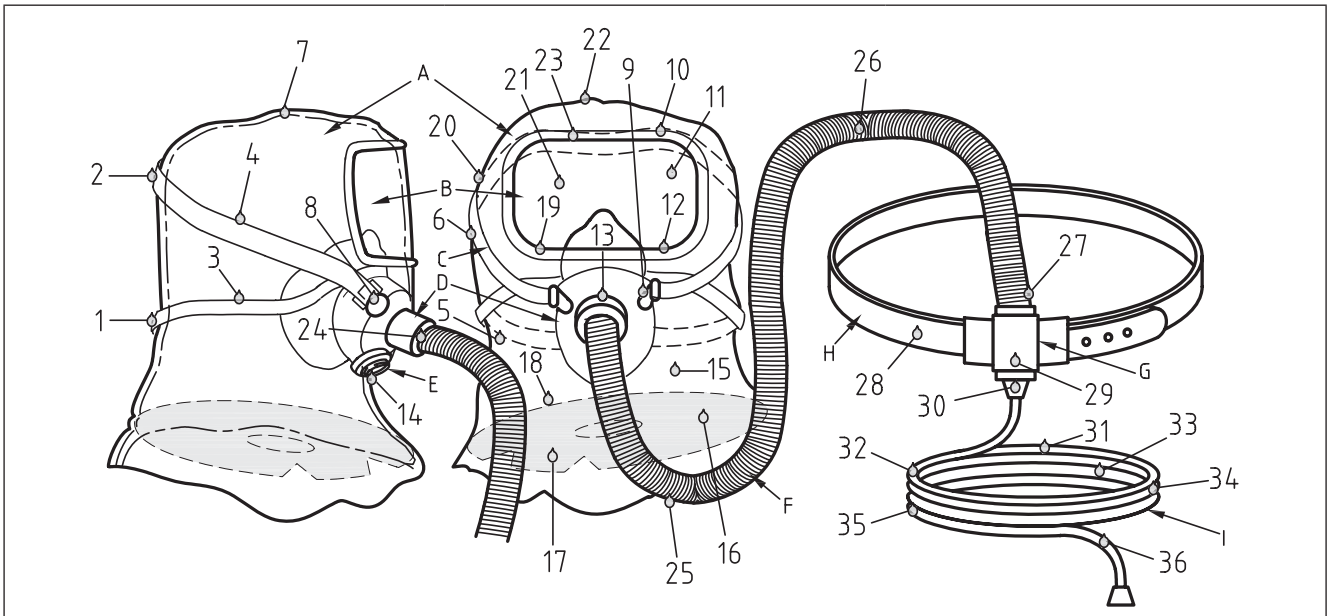
Figure A.2 **HD agent droplet placement for hood (including inner mask) and belt-mounted air-supply equipment**



Key

A Hood material
B Lens or lenses
C Exhalation valve
D Breathing hose
E Belt
F Flow control valve
G CAST

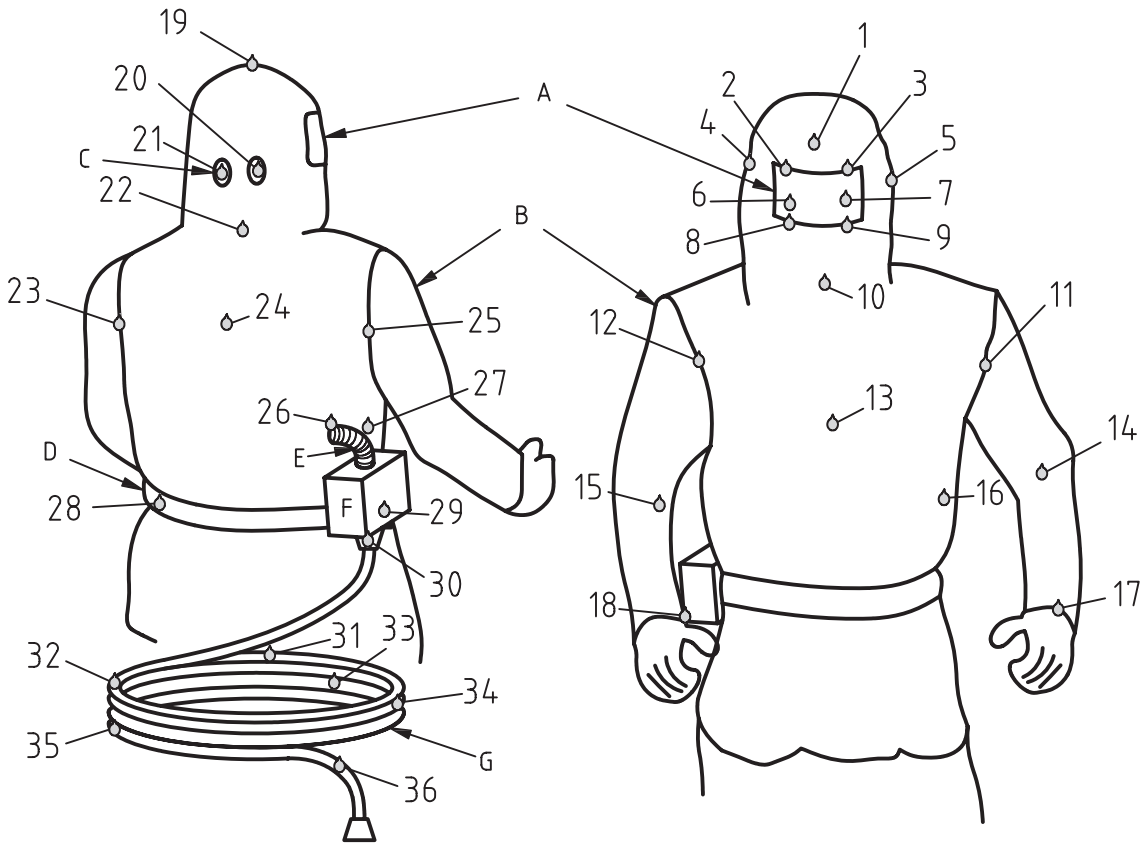
Figure A.3 **HD agent droplet placement for hood (including integrated mask) and belt-mounted air-supply equipment**



Key

A Hood material
B Lens or lenses
C Strap
D Hood/mask connector
E Flow control valve
F Breathing hose
G Exhalation valve
H CAST
I Belt

Figure A.4 **HD agent droplet placement for blouse with belt-mounted air-supply equipment**



Key

A	Visor	E	Breathing hose/inlet
B	Blouse material	F	Flow control valve
C	Exhalation valve(s)	G	CAST
D	Belt		

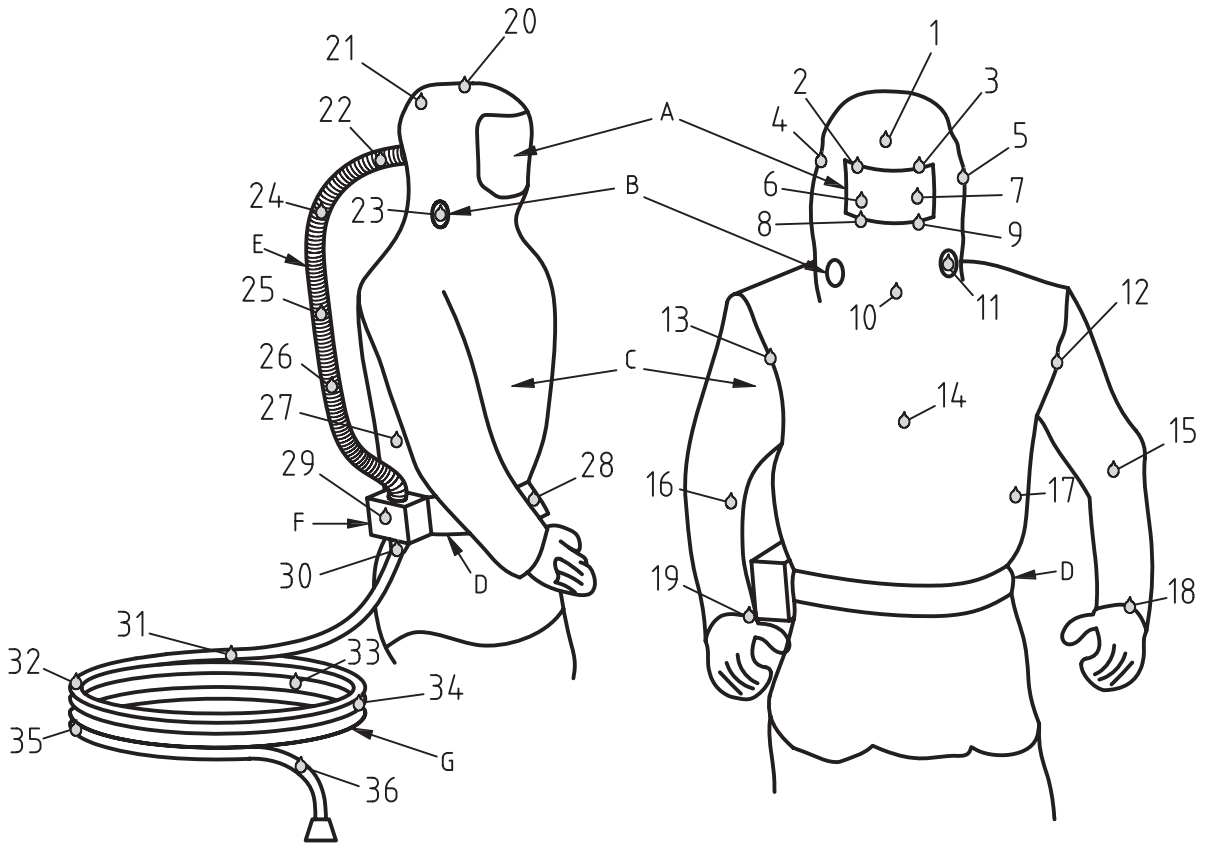
A.5.2.3 Take time zero as the first time when the chamber concentration reading rises above the lowest calibration point of the continuous air monitoring system (**A.3.4**).

A.5.2.4 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.5.2.5 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.5.1.3**) is reached.

A.5.2.6 Turn off the breathing simulator (**A.3.8**). Purge the air from the apparatus by opening the purge valve while maintaining the supply from the compressed air feed (**A.3.10**). When the gauge on the apparatus reads zero, close the purge valve and turn off the compressed air feed. Disconnect the apparatus. 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. If the measured value is within 10% of the expected one, continue the test.

Figure A.5 **HD agent droplet placement for blouse, belt-mounted air supply equipment and integrated breathing hose**



Key

A Visor
B Exhalation valve(s)
C Blouse material
D Belt
E Breathing hose
F Flow control valve
G CAST

A.5.3 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 apparatus 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 set of apparatus tested:

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

b) reference to this British Standard, i.e. BS 8468-6.2:2011;

c) name and manufacturer of the apparatus;

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 apparatus 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

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 [3]. The Personal Protective Equipment Regulations 2002 [4] enact the PPE Directive into UK legislation. The burden of proof that the product meets the basic safety requirements rests 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 PPE Directive [3] requirements against requirements in this standard.

Table B.1 **Essential requirements for PPE – Comparison between the PPE Directive, Annex II and BS 8468-6.2**

PPE Directive, Annex II subclause	Requirement type	Relevant BS 8468-6.2 clause	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-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] 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.

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

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