BS 8468-6.1:2011

BSI Standards Publication

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

Part 6.1: Positive-pressure compressed airline equipment – Specification

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ISBN 978 0 580 68590 3

ICS 13.340.30

The following BSI references relate to the work on this standard:
Committee reference PH/4
Draft for comment 10/30207275 DC

Publication history
First published January 2011

Amendments issued since publication

Date	Text affected

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 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 positive pressure demand valve for use with a full face mask as a respiratory protective device 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.

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

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 and BS EN 134 and the following apply.

3.1 emergency breathing facility
EBF
facility, as specified by the manufacturer, which comes into operation when the normally operating respiratory protective device is not functioning; the facility provides an adequate level of protection for a period to enable the device wearer to exit the work area, unassisted, to a place of safety

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

3.3 compressed air line breathing apparatus with demand valve for use with a full face mask
apparatus, which is not self-contained, in which the wearer is supplied with breathable air from a source of compressed air

4 Description

Compressed air line breathing apparatus with positive pressure demand valve and full face mask (the apparatus), enables the wearer to be provided with breathable air, which conforms to BS EN 12021, which, on inhalation, flows through a lung governed demand valve at positive pressure to a suitable facepiece. A compressed air supply tube connects the wearer to a supply of compressed air. Exhaled air flows into the ambient atmosphere via an exhalation valve. The apparatus can be connected to an emergency breathing facility (EBF to BS 8468-3.1) or to a self-contained breathing apparatus (SCBA to BS 8468-1).

5 Requirements

5.1 General

The apparatus shall be positive pressure equipment conforming to BS EN 14593-1:2005, and conform to the inward leakage specified in **5.2** of this standard, and conform to the chemical agent permeation resistance and penetration specified in **5.3** of this standard.

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 14593-1:2005. Detection systems should take account of the increased sensitivity required.

5.3 Chemical agent permeation and penetration

The apparatus 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] 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 14593-1:2005 [1)].

6.2 In addition, each apparatus conforming to this standard shall be permanently marked with the identifier and year of this standard, i.e. BS 8468-6.1:2011 [1)].

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 14593-1:2005, and external to the operational packaging.

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 8468-6.1:2011 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).

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 either 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**

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

[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.3.2 *Two exposure 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%.

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 Turn on the breathing simulator (**A.3.8**). Ensure that the apparatus is in pressure-demand mode. Set the compressed air pressure at the minimum pressure specified by the manufacturer.

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 continue with the exposure tests, 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 Turn on the breathing simulator (**A.3.8**). Ensure that the apparatus is in pressure-demand mode. Set the compressed air pressure at the minimum pressure specified by the manufacturer.

A.5.1.5 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 droplets (20 µL each) of HD, using a syringe, on the apparatus, as specified in Figure A.1 and Figure A.2. Place 24 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 at least 12 droplets on the rest of the apparatus as specified in Figure A.2; where an emergency breathing facility (EBF) is fitted, place 8 droplets on the EBF as specified in Figure A.2; where a remote

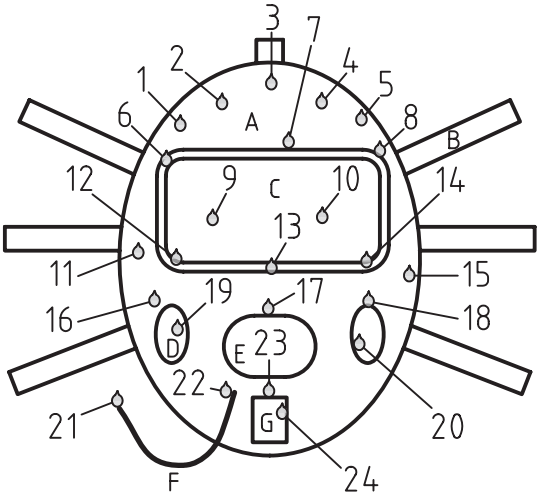
pressure gauge is fitted, place 2 drops on the gauge and airline. Mark the actual location of the drops on the digital photograph of the apparatus. If an external shroud is mounted on the facepiece, apply droplets as specified in Figure A.1 on the surface of the shroud.

A.5.2.2 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 **Schematic diagram of HD agent droplet placement on facepiece**



Key

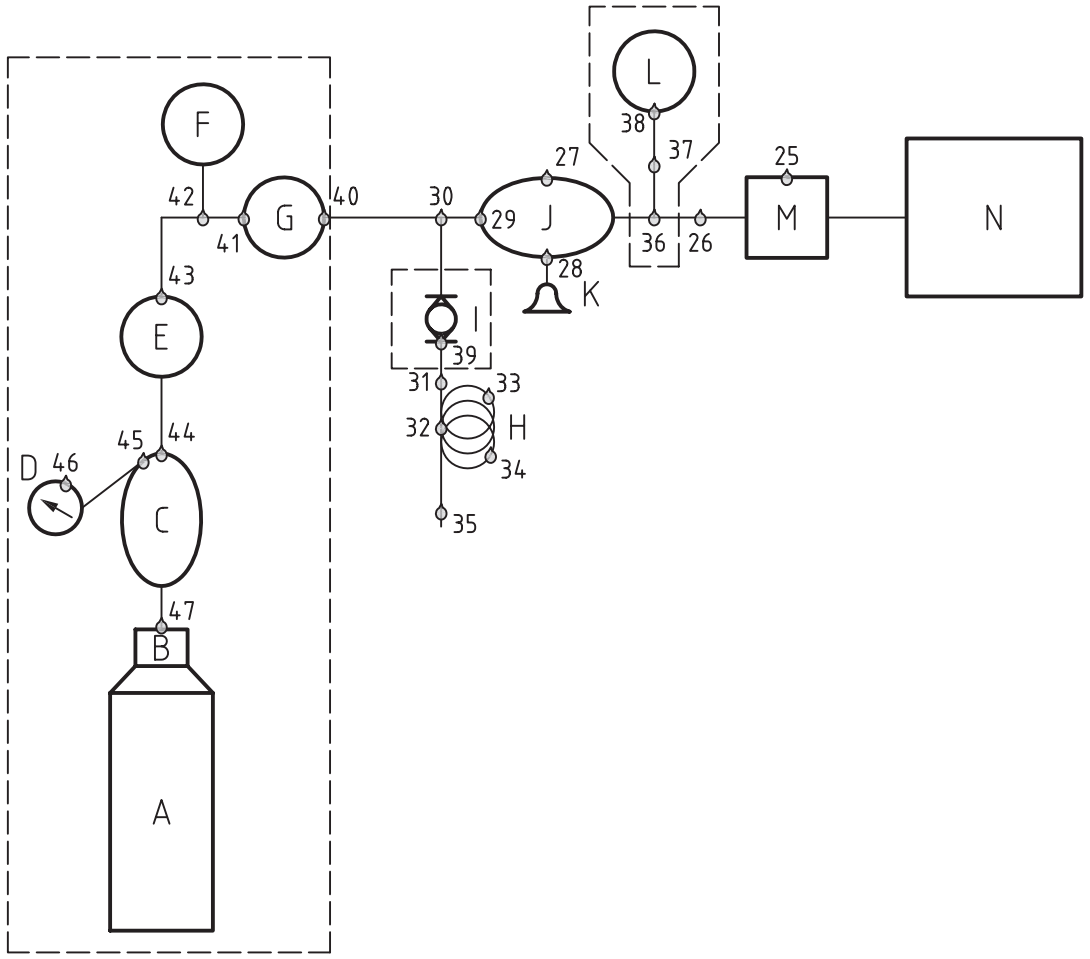
A Facepiece
B Head-harness strap
C Eye lens(es)
D Side voice-emitter (if present)
E Housing for second stage regulator
F Drink tube (if present)
G Exhalation valve

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.5.3**) is reached.

Figure A.2 **Schematic diagram of HD agent droplet placement on apparatus (excluding facepiece)**



Key

A	EBF cylinder (if present)	H	CAST
B	EBF cylinder neck (if present)	I	Rapid intervention team (RIT) fitting (if present)
C	EBF cylinder valve (if present)	J	Second stage pressure regulator
D	EBF cylinder gauge (if present)	K	Low/air pressure alarm
E	EBF male/female coupling (if present)	L	Remote pressure gauge and airline (if present)
F	First stage pressure regulator (if present)	M	Facepiece connector
G	Self-sealing coupler and non-return valve	N	Facepiece

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 (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.5.2.7 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.5.3 GB Test

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

A.5.3.1 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 in Table A.3.

Table A.3 **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/m^3
Relative humidity	(50 ±5) %
Temperature	(25 ±3) °C

A.5.3.2 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.5.3.3 After 30 min (+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.5.3.4 Continue flushing the chamber (**A.3.2**) with the airflow-temperature-humidity control system (**A.3.6**) for 5.5 h. Monitor the GB concentration throughout this period using the continuous air monitoring system (**A.3.4**) unless the equipment concentration upper limit (see **A.5.3**) is reached.

A.5.3.5 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 GB 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.

A.5.3.6 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 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.

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 8468-6.1:2011;

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 [1]. The Personal Protective Equipment Regulations 2002 [2] 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 [1] requirements against requirements in this standard.

Table B.1 **Basic Safety Requirements for PPE – Comparison between the PPE Directive, Annex II and BS 8468-6.1**

PPE Directive, Annex II subclause	Requirement type	Relevant BS 8468-6.1 clause	By reference to BS EN 14593-1:2005
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] 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.

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

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