

BRITISH STANDARD

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

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Foreword

Publishing information

This British Standard was published by BSI and came into effect on 31 July 2006. It was prepared by Subcommittee PH/3/3, *Protective clothing from chemicals and radioactive contamination*, under the authority of Technical Committee PH/3, *Protective clothing*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

This British Standard is intended to be used in conjunction with BS 8468 (all parts), which gives requirements for respiratory protective equipment for use with ensembles such as those covered by this standard.

NOTE All or some of the parts of BS 8468 might be appropriate depending upon the requirements identified. BS 8468 will be published in seven 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;*
- *Part 6: Positive-pressure compressed airline equipment – Specification;*
- *Part 7: Closed-circuit breathing apparatus – Specification.*

Information about this document

Increased threat 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.

Introduction

This Standard has been prepared using, wherever possible, British and European standards as a base in order to more easily facilitate both the availability of testing and the CE marking process.

This standard has been prepared bearing in mind existing individual items of PPE that when used together could form an ensemble.

The ensembles covered by this standard are intended for immediate or nearly immediate response to a CBRN challenge whether this is as a result of accidental release or through terrorist activity. Such ensembles are not necessarily intended for use some time after a release has occurred such as in the case of building decontamination (as opposed to casualty decontamination). In such cases, BS 7184 might provide suitable guidance.

NOTE The term CBRN is used in Home Office publications (e.g. The release of CBRN substances or material [1]) to describe a range of incidents that can occur as a result of a release of chemical, biological or radiological material.

The categories of ensemble have been selected based upon the anticipated activities expected to be undertaken by personnel, and the associated physiological demands, together with the knowledge of ensembles currently available.

1 Scope

This British Standard specifies requirements for personal protective ensembles intended to be used during rescue, evacuation, escape, hazard containment, decontamination and similar associated activities by first responders, fire, ambulance, police and associated civilian agencies and workers, for protection during chemical, biological, radiological and nuclear (CBRN) events.

This standard covers a variety of ensembles intended to provide a range of levels of protection against chemical warfare agents, toxic industrial chemicals and materials, biological agents and contamination by radioactive particles. It is assumed that an equivalent amount of protection from radioactive particles will be provided as a result of the protection that is provided from particulate chemical agents.

This standard does not cover ensembles intended to provide protection from irradiation by ionizing radiation, i.e. beta and gamma radiation, and for which no currently available chemical protective clothing will necessarily offer significant protection. Nor does it cover blast or heat protection from a nuclear device.

This standard is not necessarily appropriate for responders to releases from establishments where the nature of the hazardous material is known in advance and where the establishment has emergency plans that include provision of appropriate PPE.

NOTE 1 Ensembles conforming to this standard might be suitable for use in situations other than those involving the specific CBRN agents identified in the standard. Information supplied by the ensemble suppliers or individual component manufacturers will indicate such additional possible performance applications.

Some typical anticipated environments and activities for which the various categories of ensemble could be used are also provided.

This standard identifies categories of ensembles and their associated performance requirements and test methods in order that ensembles can be categorized. This includes both material specific requirements and full ensemble testing.

The performance requirements in this standard might be achieved by ensembles regardless of whether they are of the reusable, limited life or disposable type.

NOTE 2 Ancillary items that might be used with an ensemble (e.g. lifejackets, guns, ballistic vests, hydration systems) and/or their compatibility with the ensembles are not covered by the standard.

This standard also considers compatibility and interface with respiratory protective devices, and application and marking of the equipment, including user information.

Ensembles that conform to this standard are designed to be used with respiratory protective devices. This standard does not identify the specific performance requirements for such respiratory protective devices. However some additional requirements for the respiratory element when it is used as part of the ensemble are included in this standard, for example full system testing.

BS 8468 (all parts), will provide the performance requirements specific to the respiratory devices for protection against CBRN agents to be used in conjunction with the ensembles identified in this standard.

Annex A provides advice and guidance on selection, use, care and maintenance and Annex B provides an informative check list of performance requirements in relation to the Essential Health and Safety Requirements of the PPE Directive [2] in order to assist manufacturers and Notified Bodies in preparing certification against the PPE Directive. Annex C gives requirements for full ensemble system testing for CBRN agents. Annex D gives the test methodology for material swatch testing for CBRN agents. Annex E gives a test methodology for testing permeation resistance to challenge chemicals in droplet form.

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 8428:2004, *Protective clothing – Protection against liquid chemicals – Performance requirements for chemical protective suits with liquid-tight connections between different parts of the clothing for emergency teams (type 3-ET equipment)*

BS 8468-1, *Respiratory protective devices for use against chemical, biological, radiological and nuclear (CBRN) agents – Part 1: Positive pressure, self-contained breathing apparatus – Specification*¹⁾

¹⁾ BS 8468-2, -3, -4, -5, -6 and -7 were in preparation at the time of publication of this standard.

- BS EN 166:2002, *Personal eye protection – Specifications*
- BS EN 340, *Protective clothing – General requirements*
- BS EN 374-1:2003, *Protective gloves against chemicals and micro-organisms – Terminology and performance requirements*
- BS EN 388:2003, *Protective gloves against mechanical risks*
- BS EN 420, *Protective gloves – General requirements and test methods*
- BS EN 463, *Protective clothing – Protection against liquid chemicals – Test method – Determination of resistance to penetration by a jet of liquid (Jet test)*
- BS EN 464, *Protective clothing – Protection against liquid and gaseous chemicals, including liquid aerosols and solid particles – Test method – Determination of leak-tightness of gas-tight suits (Internal Pressure Test)*
- BS EN 468, *Protective clothing for use against liquid chemicals – Test method – Determination of resistance to penetration by spray (Spray Test)*
- BS EN 469:2005, *Protective clothing for firefighters – Requirements and test methods for protective clothing for firefighting*
- BS EN 812, *Industrial bump caps*
- BS EN 943-1:2002, *Protective clothing against liquid and gaseous chemicals, aerosols and solid particles – Part 1: Performance requirements for ventilated and non-ventilated “gas-tight” (Type 1) and “non-gas-tight” (Type 2) chemical protective suits*
- BS EN 943-2:2002, *Protective clothing against liquid and gaseous chemicals, aerosols and solid particles – Part 2: Performance requirements for “gas-tight” (Type 1) chemical protective suits for emergency teams (ET)*
- BS EN 13034:2005, *Protective clothing against liquid chemicals – Performance requirements for chemical protective clothing offering limited protective performance against liquid chemicals (type 6 and type PB [6] equipment)*
- BS EN 13274-1:2001, *Respiratory protective devices – Methods of test – Determination of inward leakage and total inward leakage*
- BS EN 13274-4:2001, *Respiratory protective devices – Methods of test – Flame tests*
- BS EN 20811:1992/ISO 811:1981, *Textiles – Determination of resistance to water penetration – Hydrostatic pressure test*
- BS EN 24920:1992/ISO 4920:1981, *Textiles – Determination of resistance to surface wetting (spray test) of fabrics*
- BS EN 25077:1994/ISO 5077:1984, *Textiles – Determination of dimensional change in washing and drying*
- BS EN ISO 1421:1998, *Rubber-or-plastics-coated fabrics – Determination of tensile strength and elongation at break*
- BS EN ISO 4674-1:2003, *Rubber-or-plastics-coated fabrics – Determination of tear resistance – Ballistic pendulum method*

BS EN ISO 6529:2001, *Protective clothing – Protection against chemicals – Determination of resistance of protective clothing materials to permeation by liquids and gases*

BS EN ISO 6530:2005, *Protective clothing – Protection against liquid chemicals – Test method for resistance of materials to penetration by liquids*

BS EN ISO 13934-1:1999, *Textiles – Tensile properties of fabrics – Determination of maximum force and elongation at maximum force using the strip method*

BS EN ISO 13935-2:1999, *Textiles – Seam tensile properties of fabrics and made-up textile articles – Determination of maximum force to seam rupture using the grab method*

BS EN ISO 20344, *Personal protective equipment – Test methods for footwear*

BS EN ISO 20345, *Personal protective equipment – Safety footwear*

PD CEN ISO/TR 11610, *Protective clothing – Vocabulary*

3 Terms and definitions

For the purpose of this British Standard the terms and definitions given in BS 8428, PD CEN ISO/TR 11610 and the following apply.

3.1 CBRN agents

chemical, biological, radiological and nuclear agents that might provide a threat to life

NOTE Such agents need not necessarily be from a terrorist origin. They might derive from other causes, e.g. accidental release.

3.2 compatibility

ability of items of an ensemble to ensure simultaneous protection

3.3 ensemble

various items of personal protective equipment, including respiratory devices, which when worn and used as a system are intended to provide full body protection

NOTE Requirements for respiratory devices are not covered by this standard; these are covered by BS 8468 (all parts). However, the way in which respiratory devices interface with the ensembles is covered by this standard.

3.4 gas-tight protective ensemble

ensemble which satisfies the requirements for “leaktightness” when tested according to the internal pressure test given in BS EN 464

3.5 interface area

area where items of an ensemble interface with each other whilst continuing to provide protection

3.6 item

physically separate constituent of an ensemble

3.7 nominal protection factor

PF

number derived from the specified maximum percentage of total inward leakage L_{imax} from the relationship:

$$PF = \frac{100}{L_{\text{imax}}}.$$

[Based on the definition in BS EN 529.]

4 Categorization and typical applications

Four categories of ensembles are described in this standard, together with typical applications in order to aid the user in identifying and selecting the category of ensemble most appropriate to the task being undertaken and the level of hazard against which protection is sought.

An ensemble conforming to this standard shall be classified within the following categories, in accordance with the performance requirements specified in Clause 5 and Clause 6.

NOTE 1 It may be possible for an ensemble to be categorized into more than one category.

Where ensemble items are supplied separately, the item shall be marked with, or its supporting documentation shall include information on, which other items are required to complete the ensemble in conformance with this standard, by listing product identification and manufacturer names.

Typical examples of potential operational environments and applications for each category of ensemble are also provided. However this is for guidance and should not be considered as definitive or limiting the possible applications for the ensembles conforming to this standard.

NOTE 2 A risk assessment process should be used to select the category of ensemble to be used in any particular application.

Category A: A gas-tight protective ensemble with a breathable air supply independent of the ambient atmosphere and protecting against CBRN agents in the form of vapours, liquids, gases, aerosols or particulates where the nature and quantity of the agent might or might not be known.

Typical application: *Environments where exposure to high levels of known or unknown agents is likely, probably in the form of bulk agent including vapours or gases. Low oxygen levels might exist requiring the use of an independent air supply. Deployment of such ensembles might be at the expense of either wear-time or mobility.*

Category B: A protective ensemble providing protection against CBRN contamination on surfaces by CBRN agents and their associated residual vapours and gases where the nature and quantity of the agent has been evaluated, and ensemble deployment has been assessed accordingly.

This category has been sub-divided to enable ensembles to be defined for use in a range of environments. Garments conforming to sub-category B1 are intended for use in environments with high levels of vapour challenge, but a breathable level of oxygen. Garments conforming to category B2 are intended for use in environments with mainly liquid challenge and a breathable level of oxygen.

Typical application: *Environments where exposure to potentially high levels of a known agent is likely. This would be primarily in the form of indirect contamination, for example contamination on personnel or equipment. Moderate-to-high levels of physical activity might be anticipated. They are not expected to be proof against immersion.*

Category C: An ensemble providing protection against low levels of known CBRN agents where airborne exposure is assessed to be not harmful by skin contact but might be harmful by ocular or respiratory exposure.

Typical application: *Environments where exposure to low levels of known agent is likely but where the risk from vapour contact to the skin is deemed acceptable. High levels of rugged physical activity might be anticipated such as during urban search and rescue.*

Category D: An ensemble providing protection against a very low level of known CBRN agent in circumstances where personal contamination is unlikely.

Typical application: *Environments involving very low risk of physical surface contamination. Ensembles will generally be used at large distance from any agent release and/or some considerable time after any such release, such as for outer cordon control.*

5 General ensemble requirements, excluding CBRN aspects

5.1 General

Ensembles shall fulfil the requirements of one or more of 5.2, 5.3, 5.4, or 5.5 when combined with the additional respiratory protective device(s) as specified in the manufacturer's instructions.

NOTE 1 *Many items already in use might meet some or all of the following requirements and be marked and/or certified accordingly. Consequently, the relevant tests need not be repeated to conform to this standard.*

NOTE 2 *A number of critical requirements for ensembles are met through conformity with the standards referenced.*

5.2 Category A

5.2.1 Ensembles

Ensembles shall conform to BS EN 943-2:2002 including inward leakage with a more stringent performance level of 0.01% (a nominal protection factor of 10 000), by testing using:

- Option A.4 from BS EN 943-1:2002; and either
- a dynamic mannequin in live agent test; or
- the mannequin/man-in-simulant test described in Annex C, with practical performance tests on human subjects according to 8.1.1 of BS EN 943-2:2002.

NOTE 1 The inward leakage requirement is intended to provide an indication of the protection against biological and radiological agents. A more stringent performance level may be specified by the consumer.

NOTE 2 Depending on the design of the ensemble, more sensors might be necessary to ensure full system performance is measured.

NOTE 3 BS EN 943-2:2002 contains a battery of representative permeation test chemicals, and allows exceptions to meeting all permeation requirements higher than class 2 for all chemicals. This might improve the choice of ensemble material for a specific application. In these circumstances, this information has to be provided to the user. For further explanation see Annex A.

NOTE 4 BS EN 943-2:2002 includes requirements for boots and gloves.

NOTE 5 BS EN 943-2:2002 includes requirements for practical performance testing.

NOTE 6 BS EN 943-2:2002 includes requirements for flex-cracking resistance for rubber- and plastic-coated materials. If necessary, when using textile-based materials, a demonstrably equivalent testing procedure may be used.

NOTE 7 BS EN 943-2:2002 includes requirements for abrasion resistance. If necessary, when using textile-based materials, a demonstrably equivalent testing procedure may be used.

Ensembles shall also be deemed to fail if:

- a) a subject finds it impossible to don an ensemble fitted for them;
- b) the ensemble will not stay closed or a constituent item will not stay in place;
- c) the ensemble or a constituent item compromises a vital function such as breathing;
- d) simple tasks that the wearer would expect to be able to perform are impossible;
- e) a subject refuses to continue the assessment due to pain induced by wearing the ensemble; or
- f) wearing the ensemble prevents the wearing of other essential PPE.

5.2.2 Respiratory protection

Respiratory equipment shall provide breathable air conforming to BS EN 12021. This requirement shall be met by using:

- a) self-contained breathing apparatus (SCBA) conforming to BS 8468-1;

- b) positive-pressure compressed airline equipment suitable for CBRN protection²⁾; or
- c) closed-circuit breathing apparatus suitable for CBRN protection³⁾.

All requirements of the respiratory equipment shall be shown to not be compromised by incorporation of the equipment into the ensemble.

5.3 Category B

5.3.1 Requirements common to both Category B1 and B2 ensembles

5.3.1.1 Ensembles

Ensembles shall conform to the following:

- a) the performance requirements of either Type 3a ET or Type 3b ET chemical protective suits identified in BS 8428:2004 together with an inward leakage performance level of 0.05% or better (a nominal protection factor of 2 000), by testing using:
 - Option A.4 from BS EN 943-1:2002 with additional sampling points in both the upper and lower body; or
 - a dynamic mannequin in live agent test; or
 - the mannequin/man-in-simulant test described in Annex C, with practical performance tests on human subjects according to 8.1.1 of BS EN 943-2:2002;

and with the exceptions, amendments and additional requirements that follow in b) to h) and the requirements of either 5.3.2 or 5.3.3;

NOTE 1 The inward leakage requirement is intended to provide an indication of the protection against biological and radiological agents. A more stringent performance level may be specified by the consumer.

NOTE 2 Depending on the design of the ensemble, more sensors might be necessary to ensure full system performance is measured.

NOTE 3 BS 8428:2004 contains a battery of representative permeation test chemicals, and allows exceptions to meeting all permeation requirements higher than class 2 for all chemicals. This might improve the choice of ensemble material for a specific application. For further explanation see Annex A.

NOTE 4 In relation to this standard, the caveat to the chemical permeation requirement of BS 8428:2004 could allow other materials, e.g. permeable fabrics meeting the CBRN challenges of this standard but not some or all of the other chemical permeation requirements of BS 8428:2004 to nevertheless conform to this standard. For further explanation, see Annex A.

NOTE 5 In the Note to 3.3 of BS 8428:2004, another example of a respiratory protective device that can be worn with a Type 3b suit is a powered respirator.

- b) the low-temperature flex-cracking resistance requirements in Table 1 of BS 8428:2004 shall not be made;

²⁾ A specification for positive-pressure compressed airline equipment is in preparation and will be published as BS 8468-6.

³⁾ A specification for closed-circuit breathing apparatus is in preparation and will be published as BS 8468-7.

- c) the requirement for safety footwear in **5.3** of BS 8428:2004 shall be amended to: “Permanently fitted or detachable safety footwear, including external bootees shall conform to BS EN ISO 20345”;
NOTE 6 Particular applications might require additional levels of protection.
- d) the requirement for visors in **5.4** of BS 8428:2004 shall not be made for additional sarin, mustard and VX challenge;
- e) the head protection requirement (e.g. a fire helmet inside the suit) in **7.1** of BS 8428:2004 shall not be made;
- f) all breathing apparatus requirements in **7.1** of BS 8428:2004 shall not be made;
- g) the requirement that the suit shall be without pockets or similar in **7.1** of BS 8428:2004 shall not be made; and
- h) if bootees or separate boots are supplied then a system for preventing ingress of liquid into the outer footwear shall be provided, e.g. overlapping flaps (also known as “outer legs”).

Ensembles shall also be deemed to fail if:

- i) a subject finds it impossible to don an ensemble fitted for them;
- j) the ensemble will not stay closed or a constituent item will not stay in place;
- k) the ensemble or a constituent item compromises a vital function such as breathing;
- l) simple tasks that the wearer would expect to be able to perform are impossible;
- m) a subject refuses to continue the assessment due to pain induced by wearing the ensemble; or
- n) wearing the ensemble prevents the wearing of other essential PPE.

5.3.1.2 Respiratory protection

Respiratory equipment shall protect the respiratory tract of the user of the ensemble. This requirement shall be met by using :

- a) any respiratory devices that meet the requirements of Category A;
- b) negative-pressure air-purifying devices (APDs) suitable for CBRN protection⁴⁾; or
- c) powered air-purifying respirators suitable for CBRN protection⁵⁾.

All requirements of the respiratory equipment shall be shown to not be compromised by incorporation of the equipment into the ensemble.

5.3.2 Subcategory B1

Ensembles and materials shall conform to the following requirements:

- a) resistance to penetration by liquids in **7.3** of BS 8428:2004, amended to “Three ensembles shall be prepared in accordance

⁴⁾ A specification for negative-pressure APDs is in preparation and will be published as BS 8468-2.

⁵⁾ A specification for powered air-purifying respirators is in preparation and will be published as BS 8468-4.

with **7.2** [of BS 8428:2004] and gas-tight tested in accordance with BS EN 464.”; and

- b) resistance to permeation by continuous contact, method A of BS EN ISO 6529:2001.

NOTE These tests will not necessarily guarantee resistance under full immersion.

5.3.3 Subcategory B2

Ensembles and materials shall conform to the following requirements:

- a) for resistance to penetration to liquids in **7.3** of BS 8428:2004: “Three ensembles shall be prepared in accordance with **7.2** [of BS 8428:2004] and jet tested in accordance with BS EN 463.”; and
- b) resistance to permeation by continuous contact or droplet contact, as described in Annex E, which is based upon NFPA 1994:2001, Class 2 test protocol [3].

NOTE These tests will not guarantee resistance under full immersion.

5.4 Category C

5.4.1 Materials

After pre-treatment, materials from which Category C garments are constructed shall conform to the following requirements.

Pre-treatment: the test materials shall be washed and dried or dry-cleaned according to the instructions of the care labelling and the manufacturer’s instructions. Materials shall be conditioned for 24 h at $(20 \pm 2) ^\circ\text{C}$ and $(65 \pm 5)\%$ RH before testing. Testing shall take place within 10 min after removing the specimen from the standard atmosphere.

NOTE 1 Performance requirements, with the exception of resistance to ignition, are based on those in BS EN 469:2005.

- a) Tensile strength: the outer material when tested in accordance with BS EN ISO 13934-1:1999 or BS EN ISO 1421:1998, method 1, shall give a breaking load in both machine and cross direction ≥ 450 N.

The main seams of the outer material when tested in accordance with BS EN ISO 13935-2:1999 shall give a breaking load ≥ 225 N.

- b) Tear strength: the outer material shall give a tear strength in both machine and cross direction ≥ 25 N, according to BS EN 469:2005.
- c) Surface wetting: the outer material when tested according to BS EN 24920:1992 at $20 ^\circ\text{C}$ shall give a spray rate of ≥ 4 . The evaluation criterion shall be the lowest value.

This test shall be carried out, even if the garment has a moisture barrier.

- d) Dimensional change: the dimensional change shall be less than or equal to $\pm 3\%$ in both directions when tested in accordance with BS EN 25077:1994 using the pre-treatment specified in g).

Each single layer material or component assembly of a multilayer clothing assembly shall be tested separately.

The combination of materials in a component assembly shall be prepared so that the layers of material are sewn together around all four sides of the test sample. One sample only shall be tested.

NOTE 2 This test does not apply to wristlet material.

- e) Resistance to penetration by liquid chemicals: the component assembly or multilayer clothing assembly shall be tested in accordance with BS EN ISO 6530:2005 using a chemical application time of 10 s using the liquid chemicals in Table 1 and in each case, shall either:
- 1) give no penetration to the innermost surface and a repellence rate of more than 80%; or
 - 2) meet the permeation requirements of BS EN 374-3:2003 and shall achieve at least level 1.

Table 1 **Chemical penetration testing**

Chemical	Concentration by weight %	Temperature of chemical $\pm 2^\circ\text{C}$ $^\circ\text{C}$
NaOH	40	20
HCl	36	20
H ₂ SO ₄	30	20
o-xylene	100	20

- f) Resistance to water penetration:

The layer (including seams) providing the resistance of water entry, when tested in accordance with BS EN 20811:1992 using a rate of increase in pressure of (0.98 ± 0.05) kPa/min shall achieve ≥ 20 kPa.

Test samples shall be taken from critical areas, e.g. shoulder seams.

- g) Resistance to ignition:

[BS EN 943-1:2002]: When tested in accordance with BS EN 13274-4:2001, Method 3, the protective clothing material shall not form droplets and shall prove to be “self-extinguishing”, i.e. it shall not be of a highly flammable nature and when tested shall not continue to burn for more than five seconds after removal from the flame.

5.4.2 Items

Items that constitute an ensemble shall conform to the following, where relevant.

- a) Headwear shall, as a minimum conform to BS EN 812.
- b) Where ocular protection is not provided by the respiratory equipment included, separate goggles for protection against gases conforming to BS EN 166:2002 class 5 or better shall be provided.
- c) The same or better CBRN protection shall be provided to the head and neck areas (e.g. with a fire hood) as for the rest of the body.

- d) Footwear shall conform to BS EN ISO 20345, including external bootees.

NOTE Particular applications might require additional levels of protection.

- e) If hand protection consists of a chemically resistant inner glove and a mechanically resistant outer glove, the inner gloves shall conform to the penetration and measured permeation breakthrough (> 30 min) requirements of BS EN 374-1:2003 for the chemicals listed in Table 1; the outer gloves shall conform to BS EN 388:2003: level 3 for resistance to abrasion, level 2 for cut resistance, level 3 for tear resistance and level 3 for puncture resistance. If hand protection consists of a single glove then the same requirements shall apply.

In neither case shall any of these gloves incorporate a knitted wrist or fabric cuff that could wick any chemical or biological agent into the glove.

Gloves shall be tested according to **6.3** of BS EN 407:2004 and achieve level 4. Furthermore, the outside material of the glove shall not melt and the seam shall not come apart in the test area after an ignition time of 15 s.

5.4.3 Ensembles

Whole ensembles shall conform to the following.

- a) Ensembles shall have an inward leakage performance level of 0.1% or better (a nominal protection factor of 1 000), by testing using:
- Option A.3 from BS EN 943-1:2002 with additional sampling points in both the upper and lower body; or
 - Option A.4 from BS EN 943-1:2002 with additional sampling points in both the upper and lower body; or
 - a dynamic mannequin in live agent test; or
 - the mannequin/man-in-simulant test described in Annex C, with practical performance tests on human subjects according to **8.1** of BS EN 943-2:2002;

NOTE 1 The inward leakage requirement is intended to provide an indication of the protection against biological and radiological agents. A more stringent performance level may be specified by the consumer.

NOTE 2 Depending on the design of the ensemble, more sensors might be necessary to ensure full system performance is measured.

- b) Ensembles shall pass the jet test in BS 8428:2004, the spray test in BS EN 468 or the gas-tight test in BS EN 464.

NOTE The requirements of the spray test are met by the jet test or gas-tight test.

- c) Ensembles shall pass the practical performance test in **8.1** of BS EN 943-2:2002.

Ensembles shall also be deemed to fail if:

- d) a subject finds it impossible to don an ensemble fitted for them;
- e) the ensemble will not stay closed or a constituent item will not stay in place;
- f) the ensemble or a constituent item compromises a vital function such as breathing;
- g) simple tasks that the wearer would expect to be able to perform are impossible;
- h) a subject refuses to continue the assessment due to pain induced by wearing the ensemble; or
- i) wearing the ensemble prevents the wearing of other essential PPE.

5.4.4 Respiratory protection

Respiratory equipment shall protect the respiratory tract of the user of the ensemble. This requirement shall be met by using any devices that meet the requirements of Category B.

All requirements of the respiratory equipment shall be shown to not be compromised by incorporation of the equipment into the ensemble.

5.5 Category D

5.5.1 Ensembles

Ensembles and items shall conform to the following, where these form part of the ensemble.

- a) Ensembles shall have an inward leakage performance level of 0.1% or better (a nominal protection factor of 1 000), by testing using:
 - Option A.3 from BS EN 943-1:2002 with additional sampling points in both the upper and lower body; or
 - Option A.4 from BS EN 943-1:2002 with additional sampling points in both the upper and lower body; or
 - a dynamic mannequin in live agent test; or
 - the mannequin/man-in-simulant test described in Annex C, with practical performance tests on human subjects according to 8.1.1 of BS EN 943-2:2002;

NOTE 1 The inward leakage requirement is intended to provide an indication of the protection against biological and radiological agents. A more stringent performance level may be specified by the consumer.

NOTE 2 Depending on the design of the ensemble, more sensors might be necessary to ensure full system performance is measured.

- b) Ensembles shall conform to BS EN 13034:2005 Type 6 equipment (not Type PB[6]) and shall include a hood.
- c) Gloves shall conform to the minimum permeation and penetration requirements of BS EN 374-1:2003, and to BS EN 388:2003: level 3 for resistance to abrasion, level 1 for cut resistance, level 2 for tear resistance and level 2 for puncture resistance.
- d) Footwear shall conform to BS EN ISO 20345.

Ensembles shall also be deemed to fail if:

- e) a subject finds it impossible to don an ensemble fitted for them;
- f) the ensemble will not stay closed or a constituent item will not stay in place;
- g) the ensemble or a constituent item compromises a vital function such as breathing;
- h) simple tasks that the wearer would expect to be able to perform are impossible;
- i) a subject refuses to continue the assessment due to pain induced by wearing the ensemble; or
- j) wearing the ensemble prevents the wearing of other essential PPE.

5.5.2 Respiratory protection

Respiratory equipment shall be any device conforming to BS 8468 (all parts except BS 8468-3), or devices that meet the requirements of Category B.

All requirements of the respiratory equipment shall be shown to not be compromised by incorporation of the equipment into the ensemble.

6 CBRN requirements

6.1 General

Materials and ensembles shall conform to the following requirements.

Testing for performance of the full ensemble when challenged with a chemical warfare agent or simulant shall be conducted using the methodology called up in Annex C.

Swatch testing of materials, when challenged with a chemical warfare agents shall be conducted using the methodology called up in Annex D. When tested against all of the liquid test chemicals listed in Annex D, the highest cumulative permeation for each chemical over 4 h shall not exceed 1.25 µg/cm².

NOTE The test methods in Annex D are intended to encompass equivalent methods used by DSTL, TNO, NATO, etc., in order to include the slight variation in comparable test methods.

Challenge levels for material swatch testing for each chemical shall be as specified in 6.2 to 6.5.

6.2 Category A

The liquid concentration density of each chemical shall be 100 g/m² and the test cell shall be assembled in the closed top configuration.

6.3 Category B

The liquid concentration density of each chemical shall be 10 g/m², applied as nominal 1 µl drops. Drops shall be applied uniformly over the sample surface. Where a seam closure or fixture is included, at least three drops shall be applied at each critical juncture, such as the seam edge. The test cell shall be assembled in the open configuration.

6.4 Category C

The liquid concentration density of each chemical shall be 10 g/m², applied as nominal 1 µl drops. Drops shall be applied uniformly over the sample surface. Where a seam closure or fixture is included, at least three drops shall be applied at each critical juncture, such as the seam edge. The test cell shall be assembled in the open configuration.

6.5 Category D

The liquid concentration density of each chemical shall be 10 g/m², applied as nominal 1 µl drops. Drops shall be applied uniformly over the sample surface. Where a seam closure or fixture is included, at least three drops shall be applied at each critical juncture, such as the seam edge. The test cell shall be assembled in the open configuration.

6.6 Report

The cumulative permeation after four or more hours for each chemical tested shall be reported in µg/cm².

NOTE For clarity the report should preferably include pass/fail results for each chemical tested.

7 Marking

Each item of an ensemble shall be marked with at least the following information.

- a) The name, trade mark or other means of identification of the manufacturer.
- b) The category (or categories) of ensemble of which it can form part, i.e. category A, category B1, category B2, category C or category D.
- c) The year and month of manufacture of the item.
- d) The manufacturer's type number, identification number or model number.
- e) The relevant size range (for suits, these are defined in BS EN 340; for boots BS EN ISO 20345; for gloves BS EN 420).
- f) The pictogram specified in BS EN 943-1:2002, Figure 2 showing that the ensemble is for protection against chemicals.
- g) The pictogram specified in BS EN 943-1:2002, Figure 2 showing that the manufacturer's instructions should be read.
- h) The following statement: "The user's attention is drawn to the quality assurance criteria of BS EN 374-2:2003".

The marking shall be clearly visible and as durable as necessary for the life of the item.

Where ensemble items are supplied separately, the item marking or information supplied by the manufacturer shall include information on which other items are required to complete the ensemble in conformance with this standard, by listing product identification and manufacturer names.

8 Information supplied by the manufacturer or supplier

Supporting documentation for an ensemble shall contain at least the following.

- a) A list of constituent items that when used together comprise the certified ensemble.
- b) The name, trade mark or other means of identification of the manufacturer and/or their authorized representative.
- c) The manufacturer's type number, identification number or model number.
- d) The relevant sizes (for suits, these are defined in BS EN 340; for boots BS EN ISO 20344; for gloves BS EN 420).
- e) Where relevant for the category of ensemble, the material performance achieved by the ensemble.
- f) The results of CBRN swatch testing.
- g) All other test performance levels achieved for properties that are not required to be specified by this standard but are seen as useful by the manufacturer, preferably in a table of performance.
- h) The expected shelf-life of the ensemble and its constituent items, including information on replacement cycles.
- i) Information necessary for trained persons on:
 - 1) application and limitations of use (temperature range, breathing air supply, etc.);
 - 2) tests to be carried out by the wearer before use (if required);
 - 3) fitting;
 - 4) use;
 - 5) donning and doffing;
 - 6) disinfection;
 - 7) storage;
 - 8) laundering;
 - 9) where appropriate, information on disposal and decontamination.
- j) A statement that compliance with this standard does not infer compliance with standards relating to other hazards, e.g. heat and flame standards.
- k) Information on any exceptions to the permeation requirements of BS EN 943-2:2002.

NOTE If helpful, part numbers for each of the ensemble items, illustrations and marking, etc. should be included as part of the information supplied by the manufacturer.

Information supplied by the manufacturer shall be unambiguous.

Annex A (informative) **Selection, use, care and maintenance**

A.1 General

Useful general information in relation to the selection, use, care and maintenance of PPE can be found in BS 7184 and PD CEN/TR 14560, and for respiratory protective equipment, BS EN 529.

In addition, the following are further points for guidance.

A.2 Selection

A.2.1 General

It should be recognized that this standard, unlike the majority of PPE documents, is for an ensemble, comprising a variety of items of PPE used together as a system. Thus care should be taken when selecting the ensemble to ensure that all items are designed and tested to work together to reach the performance requirements identified as a complete system rather than as individual items.

It should not be assumed that since an individual item conforms to a particular standard identified in this standard that the whole ensemble will necessarily conform with this standard. The whole suit and optional systems requirements are designed to ensure ensemble conformance.

It should be recognized that whilst this standard is an ensemble standard, conformance with a particular category identified within this standard does not provide a guarantee of protection under all circumstances.

When selecting either Category A or Category B ensembles, attention is drawn to Note 2 of **5.2**, and Note 2 and Note 3 of **5.3**, where it is noted that normative reference is made to standards that do not require ensembles to pass all the permeation tests. This is intended to improve the choice of materials from which ensembles can be manufactured.

When selecting the category of PPE the following areas need to be considered as part of a risk assessment for the proposed task to be carried out:

- a) that the level of chemical, biological or radiological protection is appropriate for the envisaged environment;
- b) the duration of and the physiological effort involved;
- c) the ergonomic requirements;
- d) the need for the PPE to be resistant to damage and maintain its integrity and protection throughout its use; and
- e) the need for the wearer to communicate effectively both with other PPE users and with the public.

Attention is drawn to the relaxation of the restriction on the inclusion of pockets in **5.3**. Although allowed, pockets might hinder decontamination.

A.2.2 Category A

Category A ensembles are appropriate for CBR environments where either the CBR hazard is unknown or high levels of vapour/gases are present that require either gas tight protection and independent air supply.

Due to the requirement for an independent air supply and the requirement for gas tight protection the physiological loading of such ensembles are likely to be high. Where tasks are being considered that involve high levels of physical exertion for prolonged periods, the ability to physically carry out the task safely may be a limiting factor.

The materials that Category A ensembles are constructed of might provide limited protection against tearing or cutting and therefore the likelihood of the ensemble being physically damaged during the task needs to be considered.

The additional burden of an independent air supply and the construction of the ensemble may reduce mobility or prove to be a limiting issue when considering tasks that require a high level of dexterity.

A.2.3 Category B

Category B ensembles are less physically demanding than Category A ensembles and therefore can be worn for longer periods and/or used for tasks that demand a higher level of physical exertion or higher levels of dexterity.

Such ensembles provide protection against contact with contaminated surfaces and residual vapours and where the level of protection has been assessed as adequate. They provide some liquid protection however they are not considered suitable for protection against gross liquid contact or immersion.

The material from which Category B ensembles are constructed may provide limited protection against tearing or cutting and therefore the likelihood of the ensemble being physically damaged in this way needs to be considered.

A.2.4 Category C

Category C ensembles provide protection against exposure to low levels of known agent and the risk from vapour contact to the skin is deemed minimal.

These ensembles provide a higher level of protection against tearing and cutting and therefore are appropriate for tasks that require high levels of ruggedization. e.g. rescue casualties from collapsed or damaged buildings structures.

A.2.5 Category D

Category D ensembles are intended for use in environments involving very low risk of physical surface contamination. Ensembles will generally be used at large distance from any agent release and/or some considerable time after any such release, such as for outer cordon control.

A.3 Use

It should be recognized that the deployment of ensembles conforming to this standard should be carried out in conjunction with appropriate detection and assessment systems to ensure safe operational use.

It should further be recognized that detection and assessment is a continual and ongoing process during the period when ensembles are deployed.

Whilst recognizing the importance of the use of detection equipment during the deployment of ensembles, physical senses such as taste or smell can also play a significant role in identifying the presence of agents.

Given the potential for long duration of use for some categories of ensemble the consequent physiological impact of this on wearers should be borne in mind.

Careful evaluation of the possible deployment of ensembles should be undertaken given the potential physiological issues and availability of breathable air supply.

As with the deployment of all PPE, consideration should be given to alternative means of dealing with the incident to avoid the use of these ensembles altogether.

Ensemble performance can be compromised by exposure to seemingly innocuous non-CBRN substances.

Care should always be exercised in both the donning and doffing of CBRN ensembles bearing in mind the likely nature of the incident and the consequent impact on wearers. Sufficient time should be allowed to ensure correct interface between items during donning.

Particular care should also be exercised during doffing to avoid contamination. In this respect training with simulants can be beneficial.

Consideration should be given to ensuring suitable decontamination facilities are available prior to the deployment of ensembles.

Care should be exercised in the disposal of any contaminated or suspected contaminated items of the ensemble.

A.4 Care

As ensembles can be subject to long term storage, guidance should be sought on the appropriate storage conditions including issues such as stock rotation, periodic sampling, appropriate transport conditions taking into account the possibility of personal issue factors.

It should be borne in mind that some items of the ensemble might be in day-to-day routine use for non CBRN purposes.

A.5 Maintenance

Consideration should be given to the disposal of ensembles following contamination as opposed to cleaning and returning to service.

Careful consideration should be given in relation to in-house maintenance and competence should be ensured.

A safety audit trail should be considered for ensemble use.

It should be recognized that non-CBRN exposure can still have potential to cause ensemble damage or degradation.

Annex B (informative)

Relationship between this British Standard and the Essential Requirements of EU Directive 89/686/EEC Personal Protective Equipment

It is a legal requirement in the EU that PPE conforms to the PPE Directive [2]. The Personal Protective Equipment Regulations 2002 [4] 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 8467

PPE Directive, Annex II subclause	Requirement type	Relevant BS 8467 subclause
1	General requirements (design, innocuousness, comfort and efficiency, and information supplied)	5
2.1	Adjustment systems	5
2.2	Ventilation or perspiration absorption	5
2.3	Face, eyes and respiratory tract	5
2.4	Ageing	5
2.7	Time of doffing	Annex A
2.8	Information for use in very dangerous situations	8h)
2.9	Adjustability	5
2.10	Connectivity to additional equipment	5
2.11	Fluid circulation systems	5
2.12	Health and safety identification marks	7g) and 7h)
2.14	Multiple use	5
3.1.1	Resistance to impact	5
3.1.2.1	Prevention of falls due to slipping	5
3.3	Protection against physical injury	5
3.6.1	Protection against heat	5
3.6.2	Prevention of overheating	5
3.7.1	Protection against cold	5
3.7.2	Insulation	5
3.9.2.1	Protection against external radioactive contamination	6
3.10	Protection against dangerous substances and infective agents	6
<p><i>NOTE Most of the requirements that would arguably be met by Clause 5 are met through the requirement that ensembles meet other specifications.</i></p>		

Annex C (normative)**Full ensemble system requirement**

C.1 Full system testing as described below is directly applicable to all ensembles.

C.2 Each ensemble shall be tested as a full system against one of the following for both a vapour and liquid challenge and the results reported;

- a) distilled sulfur mustard, HD;
- b) Sarin, GB;
- c) Soman, GD;
- d) V-agent, VX; or
- e) a recognized simulant such as dimethyl methylphosphonate (DMMP) or methyl salicylate.

NOTE Full system testing using live agent is both inherently hazardous and costly. Therefore simulant testing should be carefully considered as an alternative.

C.3 A procedure detailed in either:

- a) Chemical personal protective clothing systems evaluation [5]; or
- b) Man In Simulant Test (MIST) [6];

or equivalent shall be used.

Where not otherwise specified, the minimum challenge concentration shall be given by

$$C_{\text{chmin}} = 10C_{\text{dlmin}}/L_{\text{imax}} = 10 C_{\text{dlmin}}PF$$

where:

C_{chmin} is the minimum challenge concentration;

C_{dlmin} is the minimum detection limit;

L_{imax} is the specified maximum inward leakage, as a proportion;
and

PF is the specified minimum protection factor.

The procedure shall include body movement and an incident wind velocity of not less than five metres per second.

C.4 The results shall be reported in dosage of agent or simulant penetrating the system to the equivalent of skin level for at least 50 sampling positions over the whole body.

Annex D (normative)**Chemical testing – Test methodology**

D.1 The following liquid chemical CBRN agents shall be used individually for material swatch testing.

- a) Distilled sulfur mustard, HD;
- b) Sarin, GB;
- c) Soman, GD; and
- d) V-agent, VX.

D.2 The testing shall include the constituent materials used in all items of the ensemble including visors, closure assemblies, valves and connections, in the minimum thickness used in construction.

NOTE This requirement recognizes the difficulties associated with testing of closures.

Those items of the ensemble not intended to provide protection against the liquid chemical CBRN challenge agents (e.g. outer gloves intended only to provide mechanical protection or footwear worn over protective booties) need not be tested.

D.3 Three examples of each sample shall be tested and the highest cumulative permeation level reported.

D.4 Specimens shall be tested for permeation resistance testing for not less than 240 minutes in general accordance with BS EN ISO 6529:2001 with the following additions and modifications.

The flow of the collection medium shall be approximately five volume changes per minute through the bottom of the test cell.

- When used in the open top configuration the flow across the top of the cell shall be equivalent to a wind speed of 0.5 m/s.
- The samples shall be mounted on a 22µm sample of polyethylene film.
- Analytical methods shall be sensitive to concentrations of at least two orders of magnitude lower than the required end points.
- When required the test cell shall be modified to allow non flat samples to be sealed using a non-reactive sealant.
- The testing shall last in excess of 240 min.

Annex E (normative)

Droplet testing – Test methodology

Samples shall be tested for permeation resistance according to BS EN ISO 6529:2001, with the following modifications.

The test cells shall be operated with the sample in a horizontal position. Tests shall be conducted on chemicals according to BS EN 943-2:2002, with the same classification levels in terms of time to reach 1.0 µg/cm²/min (given in Table E.1) and the same requirement in terms of stating which chemicals do not meet the required classification.

Table E.1 **Classification against breakthrough time in droplet testing**

Class	Breakthrough time min
6	> 480
5	> 240
4	> 120
3	> 60
2	> 30
1	> 10

The liquid concentration density shall be (10^{+1}_{-0}) g/m² applied as nominal 1 µl droplets. Drops shall be applied uniformly over the sample surface. Where a seam, closure of fixture is included, at least one drop shall be applied to each critical juncture, such as the seam edge. The test cell shall be closed above the droplets with no air flow possible.

Bibliography

Standards publications

BS 7184, *Selection, use and maintenance of chemical protective clothing – Guidance*

BS EN 374-2:2003, *Protective gloves against chemicals and micro-organisms – Determination of resistance to penetration*

BS EN 529, *Respiratory protective devices – Recommendations for selection, use, care and maintenance – Guidance document*

PD CEN/TR 14560, *Guidelines for selection, use, care and maintenance of protective clothing against heat and flame*

Non-standards publications

- [1] GREAT BRITAIN *The release of CBRN substances or material. Guidance for Local Authorities 2003*. Home Office, August 2003.
- [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] NFPA 1994, *Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents*, National Fire Protection Association, Quincy, Massachusetts, USA. 2001. (<http://www.nfpa.org>)
- [4] GREAT BRITAIN *The Personal Protective Equipment Regulations 2002: Statutory Instrument 2002/1144*. The Stationery Office. (<http://www.tsoshop.co.uk>)
- [5] *A whole system test for assessing the protection afforded by NBC protective clothing after a liquid or vapour chemical agent challenge*. J. Battensby, A.E. Hayhurst and A.L. Webb, CB Systems, CBD, Porton Down, Salisbury, UK. *6th CBW Protection Symposium, Stockholm, Sweden*. 1998.
- [6] *Man In Simulant Test (MIST) Technical assessment of the US army chemical defense command Report 1 Technical Assessment of the Man in Simulant Test Programme*. National Academy Press, Washington 1997. (<http://books.nap.edu>)

Further reading

BS 1073-2, *Protective clothing against radioactive contamination – Requirements and test methods for non-ventilated protective clothing against particulate radioactive contamination*

GREAT BRITAIN *Personal protective equipment at work* (Second Edition) L25 HSE Books. ISBN 0717 661393

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