Urban search and rescue personal protective equipment specification for high dust and chemical, biological, radiological, nuclear environments

Fire Research Report: 7/2010

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Health and Safety Laboratory
December 2010

Department for Communities and Local Government

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December 2010

ISBN: 978-1-4098-2669-9

Contents

EXECUTIVE SUMMARY 2

1 Introduction 6

2 Helmets 15

3 Clothing 20

4 Hearing protection 40

5 Respiratory protective equipment 44

6 Footwear 61

7 Gloves 67

8 Elbow and knee protection 73

9 Eye and face protection 79

10 Fall arrest 80

11 Personal protective equipment ensembles 85

12 Summary 95

13 References 97

14 Appendix 1 - List of representative cbr materials 98

15 Appendix 2 - Normative references 103

16 Appendix 3 - Glossary 112

17 Appendix 4 – ASTM f1001 chemicals: emergency response exposure guidelines (eregs) 115

Executive summary

Objectives

This report contains the results of the work conducted by Health and Safety Laboratory for the Department for Communities and Local Government (DCLG) on urban search and rescue (USAR) personal protective equipment. USAR operations are divided into three separate scenarios:

> **Scenario 1**
> Level 2 (minor/significant) structural collapse (and possibly the lower end of Level 3 without hazardous material (HAZMAT) contamination), with no exceptional contamination by chemical, radioactive or microbiological substances. Moderate levels of airborne and settled dust without enhanced concentrations of highly hazardous or toxic components can be expected, together with the mechanical, thermal, electrical and climatic hazards inherent in USAR activity.
>
> **Scenario 2**
> Level 3 (major) and Level 4 (catastrophic) collapse without either HAZMAT or chemical, biological, radiological, nuclear (CBRN) contamination. Concentrations of airborne and settled dusts may be exceptionally high, and as a result potential exposures to the inherent low hazard components of the dust reach damaging concentrations.
>
> **Scenario 3**
> Level 3 (major) or Level 4 (catastrophic) collapse with either or both of HAZMAT and chemical, biological, radiological, nuclear (CBRN) materials present.

The Health and Safety Laboratory have extended the existing specification for USAR personal protective equipment, which broadly covers Scenario 1, to cover Scenarios 2 and 3 (Vaughan *et al* 2007a, 2007b), and assessed options for enhancing current USAR personal protective equipment (Webb et al, 2008) for:

- hazards generated in large scale dust clouds arising from building collapse (Scenario 2); and
- hazards from the release of toxic materials, including chemical, biological and radiological materials, with structural collapse (including those hazards generated in large scale dust clouds arising from building collapse) (Scenario 3).

This report draws on the work and develops a stand-alone performance based specification for personal protective equipment ensembles for Scenario 3, high dust and chemical, biological and radiological materials. This specification will assist manufacturers, certification bodies and procurement authorities in producing and sourcing appropriate personal protective equipment for these applications. Wherever possible, the specifications relate to existing personal protective equipment standards and test methods for commercial off-the-shelf (COTS) equipment.

Note that the protection factors for Scenario 3 (high dust and chemical, biological and radiological materials) exceed those required for high dust alone, so personal protective equipment for Scenario 3 (high dust and chemical, biological and radiological materials) should offer the more than adequate protection for Scenario 2 (high dust). However, personal protective equipment for Scenario 3 (high dust and chemical, biological and radiological materials) may be more of a physiological and ergonomic burden than is necessary for Scenario 2 (high dust). In addition, personal protective equipment for Scenario 3 (high dust and chemical, biological and radiological materials) should also be suitable for chemical, biological and radiological materials and HAZMAT incidents without high dust levels.

Use of this report for selection and procurement

The layout of this report is modelled closely on the format of product performance standards used by British, European and International standards bodies. This form is readily understood by and familiar to equipment manufacturers and testing/certification authorities. To aid clarity, more explanatory text has been incorporated than is usual in standards.

The key feature of the specification is that a skin protection factor of 1000 and a respiratory protection factor of 10000 are required from a personal protective equipment ensemble if it is to be considered suitable for high dust and chemical, biological and radiological materials Scenario 3. The type of personal protective equipment and respiratory protective equipment which provides this protection is relatively open, as long as it is capable of delivering the required level of protection, which mirrors the operational requirements in BS 8467 and 8468. The usual adequacy and suitability aspects (oxygen deficiency, confined spaces, required mobility, required working duration) will determine whether breathing apparatus or filtering devices are appropriate for a given operational scenario.

The specifications for individual items of personal protective equipment ensure that each individual item is capable of the performance required to form part of such an ensemble. There are two main reasons for these individual item specifications:

1. to allow procurers and manufacturers/suppliers to assess the suitability of COTS equipment for inclusion in ensembles; and
2. to allow procurers and manufacturers/suppliers to screen new equipment designs for their suitability for inclusion in ensembles without running full ensemble tests.

Using individual item specifications as a filter for equipment to be included in personal protective equipment ensembles is well established in its selection and procurement.

Having established that individual items are capable of the performance required to form part of an ensemble, the specification then gives performance requirements for the ensemble. These requirements cover not only protection, but also the suitability of the ensemble for likely USAR work tasks (including ergonomic and physiological considerations). The ensemble specification uses principles and reasoning from BS 8469:2007 "*Personal protective equipment for firefighters – Assessment of ergonomic performance and compatibility – Requirements and test methods*", adapted to be more specific to USAR applications.

One particularly important advantage of ensemble testing is that it can generate simulated workplace protection factors (SWPFs). In a SWPF test, the measured levels of protection may be taken as representative of likely workplace protection, and will supersede any generally accepted or assigned protection factors (APF) for individual items of equipment (such as assigned protection factors for respiratory protective equipment). A SWPF needs the duration of the test and activities carried out as test exercises to be sufficiently close to operational use to be considered as representative of the performance of the ensemble in a real deployment. The ensemble tests of barrier performance in this specification would form such a SWPF test.

As an example, in this specification one respiratory protective equipment option is a full face mask respirator (negative pressure). This has an assigned protection factor of only 40 if used with particle filters alone, and 20 if gas/vapour filters are fitted. It is likely that such a device, if fitted and used correctly, can achieve a SWPF greater than 10000 for both filter types. Without any SWPF tests, selection should use the assigned protection factor, making the device unsuitable for USAR work. The SWPF data resulting from ensemble testing is likely to demonstrate that the device is suitable for USAR work. This shows the potential importance of the ensemble testing, and the resulting SWPFs, for USAR personal protective equipment selection. It should be noted that even this procedure will not fully assess the protection provided, as the test only measures filter penetration against a single surrogate challenge.

Selection and procurement of ensembles can be a complex, time-consuming and expensive process. There are two main approaches:

1. allow manufacturers/suppliers to submit suitable individual items so that potential users/procurers can assess all the combinations of these considered appropriate; and
2. follow a turnkey approach where a single manufacturer/supplier (or consortium) submits a full personal protective equipment ensemble to be assessed by the user/procurer.

There may be rules or legal liability issues which affect the choice of approach. If there is a choice between the two approaches the turnkey approach is likely to be most cost-effective for a potentially complex ensemble such as for USAR Scenario 3 (high dust and chemical, biological and radiological materials). The turnkey approach can also have advantages when the provision of consumable items, spares, maintenance, training and product support are considered as there is one clear manufacturer/supplier responsible.

Recommendations

The Health and Safety Laboratory recommends that the specification in this report is used as part of the process for selection and procurement of USAR PPE for Scenario 3, high dust levels and chemical, biological and radiological materials. Where there is the need for input from USAR teams or others, it is recommended that a wide-ranging consultation is conducted so that the best information can be gathered on the relative importance of aspects of ensemble performance, including more subjective characteristics like comfort and usability. It is also recommended that the assumptions on USAR operations that have been used to inform this specification are regularly reviewed.

SECTION 1
Introduction

1.1 Introduction

The Health and Safety Laboratory (HSL) were contracted by the Department of Communities and Local Government (DCLG) to undertake a development to the existing specification for Urban Search and Rescue (USAR) Personal Protective Equipment (PPE) [Contract no. FR71-01]. This work was reported in Vaughan et al (2007a, 2007b). HSL were further contracted [Contract no. CPD/004/078/062] (Webb et al, 2008) to evaluate options for enhancing current USAR PPE to cope with:

- those hazards generated in large scale dust clouds arising from building collapse (Scenario 2); and
- hazards from the release of toxic materials including chemical, biological and radiological materials with structural collapse (including those hazards generated in large scale dust clouds arising from building collapse) (Scenario 3).

This report draws on these previous pieces of work to develop a stand-alone performance based specification for PPE ensembles for Scenario 3 to assist manufacturers, certification bodies and procurement authorities in producing and sourcing appropriate PPE for these applications. Wherever possible, the specifications relate to existing PPE standards and test methods for commercial off-the-shelf (COTS) equipment.

1.2 Background

DCLG document *Protecting the Public – New Dimension programme: National Seminar Briefing* includes three levels of incident which have been further defined by internal DCLG documents:

Level 2 - Minor/Significant – Collapse of buildings up to four storeys; traditional construction; fewer than 10 persons trapped; less than 1000m^2 of debris; normal contamination only.

Level 3 - Major – Collapse of buildings between 4 and 10 storeys; concrete or modular construction; between 10 and 100 persons trapped; 1000 to 10000m^2 of debris; hazardous material (HAZMAT) contamination.

Level 4 - Catastrophic – Collapse of buildings over 10 storeys; steel frame or reinforced concrete; more than 100 persons trapped; over 10,000m^2 of debris; chemical, biological, radiological and nuclear materials (CBRN) involved.

The operations considered in the revision of USAR PPE specification contained in this volume of the final report on this work are considered to fall into three separate scenarios.

Scenario 1
Level 2 (minor/significant) structural collapse (and possibly the lower end of Level 3 without HAZMAT contamination), with no exceptional contamination by chemical, radioactive of microbiological substances. Moderate levels of airborne and settled dust without enhanced concentrations of highly hazardous or toxic components can be expected, together with the mechanical, thermal, electrical and climatic hazards inherent in USAR activity.

Scenario 2
Level 3 (major) and Level 4 (catastrophic) collapse without either HAZMAT or CBRN contamination. Concentrations of airborne and settled dusts may be exceptionally high, and as a result potential exposures to the inherent low hazard components of the dust reach damaging concentrations.

Scenario 3
Level 3 (major) or Level 4 (catastrophic) collapse with either or both of HAZMAT and CBRN materials present.

References to HAZMAT type substances are abbreviated in this document to TIC (toxic industrial chemical) or TIM (toxic industrial material). CBR in this context includes HAZMAT, TIC, TIM and other chemical/biological agents (including those classified as potential “warfare agents”) present in significant quantities in any physical form - solid, liquid, vapour or gas. Appendix 1 gives a list of representative CBR materials – some of these are “common industrial” chemicals. The amount which constitutes a significant quantity relates to the level of hazard and will vary with the substance in question, i.e. it will be smaller for materials with higher toxicity (e.g. microlitres or millilitres for CWAs *vs* centilitres or litres for TICs and TIMs).

This report contains the PPE specifications for Scenario 3 applications. The PPE specifications for Scenario 2 applications are given in a DCLG report “Urban search and rescue personal protective equipment specification for high dust environments”.

Note that the protection factors for Scenario 3 (high dust and CBR) exceed those required for high dust alone, so PPE for Scenario 3 (high dust and CBR) should offer the more than adequate protection for Scenario 2 (high dust). However, PPE for Scenario 3 (high dust and CBR) may be more of a physiological and ergonomic burden than is necessary for Scenario 2 (high dust). In addition, PPE for Scenario 3 (high dust and CBR) should also be suitable for CBR and HAZMAT incidents without high dust levels.

1.3 Layout

The layout of this document has been modelled closely on the established format of product performance standards used by British, European and International standards bodies. This is the form which is most readily understood by and familiar to equipment manufacturers, testing and certification authorities. Rather more in the way of explanatory text has been incorporated than is usual in standards, to aid clarity.

In the following sections, individual parts and variants that form a PPE ensemble are specified in turn, referring wherever possible to existing standard test methods, and drawing performance requirements from comparable forms of equipment to those being considered. In a relatively small proportion of instances, the need to assess a particular type of performance has necessitated the proposal of new tests to address the unique combination of hazards which the PPE may have to mitigate.

For those ensemble components which together make up the barrier between environmental contaminants and the wearer, testing of protective performance must be carried out with all these components used together and correctly interfaced. Section 11.5 of this report gives more detail on how this can be achieved. Where relevant for individual items of PPE, these performance requirement are flagged as needing to be tested "as part of a compatible ensemble".

In line with the objective to produce the performance specification in "standards format", the requirements it contains are worded in normative language (i.e. requirement x "shall" be tested according to y). Where such requirements refer one of our suggested new test methods, this normative requirement must be relaxed. Our suggested methods are based on experience of what may be possible and meaningful to carry out, but they have not at this stage been practically assessed or validated in any way. Alternative, as yet unknown, means of testing may be equally or more valid, and cannot be excluded at this stage.

In general, specification of particular materials has been avoided, relying on the performance specification to determine whether or not a given item is acceptable or not. The general requirement for innocuousness of PPE materials (materials and parts must not adversely affect user hygiene or health; freedom from roughness and sharp edges) applies for all PPE types described here.

Unless specifically addressed by performance requirements called up for the separate PPE items described in the specification, the equipment covered can be expected to be capable of operation normally over an ambient temperature range of at least $5^{\circ}C$ to $40^{\circ}C$ (for example, where low temperatures may adversely affect PPE performance, requirements already included in the specification address the problem). Whether this range of operating conditions which PPE can withstand will also be safe for the users of this equipment requires separate and careful consideration in terms of thermal stress potential, strategies for alleviating the environmental conditions, and maximum working durations.

Subject to agreement by a notified body, this specification may form the basis of a technical file, for the purposes of CE-marking[1] of the ensembles described.

Appendix 2 lists the referenced standards for each of the types of PPE covered. In most cases, the reference is to a specific clause or clauses within the listed standards, and not the entire referenced document. Standards may be revised or superceded at any time, so checks should be made of the referenced standards status when this report is used. However, even if a standard has been revised or superceded, the dated references to clauses in this report will remain technically consistent and valid.

When the performance requirements or test methods in this report refer to another section of this report the section number only is given (e.g. "tested as described in 3.4.4"). Where reference is to part of a published standard, this is referred to as clause x and the standard number given (e.g. the requirements of EN ISO 20345:2004 clause 6.2.3.2).

Throughout this report the term "chemical" can mean general chemicals (TIC & TIMs) or CBR materials as is appropriate. Where reference is specifically to CBR materials or CBR chemicals the prefix CBR is used.

1.4 Assumptions

Previous reports (Vaughan et al, 2007a; 2007b, Webb et al, 2008) have sought not to limit the means by which a PPE manufacturer or specifier could satisfy the necessary performance requirements for USAR activities. Table 1.1, adapted from Vaughan et al (2007a) shows the full range of possible approaches which were considered. The notation (e.g. A1b; D2e) used to describe the options, which was developed in Vaughan et al (2007a) is used throughout this document. Scenario 1 and 2 recommendations, which are not covered in this report, are included in Table 1.1 (greyed text) to give a full picture.

In this document we have taken a pragmatic view of the most likely means by which these requirements may be most easily satisfied in practice, and have restricted the options accordingly. Table 1.2 summarises these more restricted PPE options which would meet the operational needs in Scenario 3. The similarly selected options for Scenario 2 situations are included so that the similarities and differences between our recommendations for the two scenarios can be seen. It is important to note that for helmets, hearing, footwear, gloves, elbow/knee and fall arrest although the specification is basically the same for

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[1] CE Marking on a product is a manufacturer's declaration that the product complies with the **essential requirements** of the relevant European health, safety and environmental protection legislation.

Scenarios 2 and 3 the chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including CBR substances.

There may be further scope for reduction of these options if Scenario 3 (catastrophic collapse with CBR contamination) equipment is procured and deployed in both Scenario 2 (catastrophic collapse without CBR contamination) and Scenario 3 operations. This is likely to be practicable for all the listed items of PPE except for some clothing and RPE filters, which are likely to be relatively high cost and short operational lifetime items. However, PPE for Scenario 3 (high dust and CBR) may be more of a physiological and ergonomic burden than is necessary for Scenario 2 (high dust).

The drivers behind this reduction of options include:

- allows USAR operatives to have a simplified and more practical approach to the selection of PPE
- reduced overall purchase cost by avoidance of equipment duplication
- reduction of storage space required
- logistics of supply and resupply; and
- reduced training requirement.

Table 1.1 The full range of possible PPE types anticipated to be required for USAR – The PPE Matrix (adapted from Vaughan et al, 2007a)

	PPE Type	Scenario 1 Conventional collapse with no exceptional aspects	Scenario 2 Additional exceptional dust/microorganisms	Scenario 3 Additional exceptional toxic hazards inc. CBRN
A	Helmet	A1a lower protection A1b higher protection	A1b	A1b as compatible with CBRN
B	Clothing	B1a (± thermal layer) B1b (B1a + waterproof layer)	B2a	B3a
C	Hearing	C1a (plug – sound restoration) C1b (plug – no electronics) C1c (muff – sound restoration) C1d (muff – no electronics)	C1a C1b C1c C1d	C1a C1b
D	RPE	D1a (SCBA) D1b (CCBA) D1c (CABA) D1d (PAPR) D1e (FFM) D1f (FFP3)	D2a D2b D2c D2d D2e	D3a D3c D3d D3e
E	Boots	E1a	E1a	E3a (Overboots) E3b (Wellington) E3c (CBRN sock)
F	Gloves	F1a (basic + mech) F1b (biohaz)	F1a (mech) F1b (biohaz)	F1a (mech) F3a (full chem)
G	Elbow/Knee	G1a	G1a	G1a
H	Eye/Face	H1a – spectacle H1b – goggle H1c – faceshield RPE if incorporates a visor	H1c RPE incorporating a visor	H1c CBRN uses full face RPE
I	Fall arrest	I1a	I1a	I1a

Table 1.2 PPE options considered. Items under Scenario 3 are described in this report			
Item	**Scenario 2** **High dust**	**Scenario 3** **CBR**	**Comments**
Helmet	A1b	A1b	Higher protection helmet option.
Clothing	B2a (includes B1b)	B3a	CBR chemical barrier for hands and feet incorporated into the B3a garment.
Hearing	C1a	C1a	Sound restoration earplug worn inside hood of garment. Optional communications built in.
RPE	D2a D2d D2e ABEK/P3 filters	D3a D3d D3e CBR/P3 filters	a = SCBA d = PAPR e = full face respirator "CBR" filters usually handle ABEK, Hg and NO.[1]
Footwear	E1a	E1a	E1a provides mechanical protection to the CBR sock barrier component of the garment
Gloves	F1a F1b	F1a	F1a provides mechanical protection to the CBR glove barrier component of the garment
Elbow/knee pads	G1a	G1a	
Eye/face	N/A	N/A	Relevant mechanical and vision aspects are included in RPE facepiece specification.
Fall arrest	I1a	I1a	

[1] BS 8468 specifies markings for filters for devices conforming to BS8468.

1.5 Use of this specification for selection and procurement

This specification is intended to provide requirements for PPE ensembles suitable for high dust and CBR Scenario 3. As described in section 1.3, the specification includes requirements for both individual types of PPE and ensembles.

The key feature of the specification is that a skin protection factor of 1000 and a respiratory protection factor of 10000 are required from an ensemble if it is to be considered suitable for high dust and CBR Scenario 3.

The specifications for individual items of PPE (sections 2 to 10) ensure that each individual item is capable of the performance required to form part of such an ensemble. There are two main reasons for the individual item specifications:

1. to allow procurers and manufacturers/suppliers to assess the suitability of COTS equipment for inclusion in ensembles; and

2. to allow procurers and manufacturers/suppliers to screen new equipment designs for their suitability for inclusion in ensembles without running full ensemble tests.

This approach of using individual item specifications as a filter for equipment to be included in PPE ensembles is well established in PPE selection and procurement. Notified bodies and test houses can advise on the most cost-effective and logical testing sequences.

Having established that individual items are capable of the performance required to form part of an ensemble, the specification then gives performance requirements for the ensemble (Section 11). These requirements cover not only protection, but also the suitability of the ensemble for likely USAR work tasks (including ergonomic and physiological considerations). The ensemble specification uses principles and reasoning from BS 8469:2007 “Personal protective equipment for firefighters – Assessment of ergonomic performance and compatibility – Requirements and test methods”, adapted to be more specific to USAR applications.

One particularly important aspect of ensemble testing is that it can act as a simulated workplace protection factor (SWPF) test. In a SWPF test, the measured levels of protection may be taken as representative of likely workplace protection, and will supersede any generally accepted or assigned protection factors for individual items of equipment, such as APFs for RPE. A SWPF needs the duration of the test and activities carried out as test exercises to be sufficiently close to operational use to be considered as representative of the performance of the ensemble in a real deployment. The ensemble tests of barrier performance specified in section 11 would form such a SWPF test.

For example, in this specification RPE option D3e is a full face mask respirator (negative pressure). This has an assigned protection factor (APF) of 40 if used with particle filters alone, and 20 if gas/vapour filters are fitted. It is likely that such a device, if fitted and used correctly, can achieve a SWPF greater than 10000 for both filter types. Without any SWPF tests, selection should use the APF, making the device unsuitable for USAR work. The SWPF data resulting from ensemble testing is likely to demonstrate that the device is suitable for USAR work. This shows the potential importance of the ensemble testing, and resulting SWPFs, for USAR PPE selection. It should be noted that even this procedure will not fully assess the protection provided, as the test only measures filter penetration against a single surrogate challenge.

Selection and procurement of ensembles can be a complex, time-consuming and expensive process. There are two main approaches to this:

1. allow manufacturers/suppliers to submit suitable individual items so that potential users/procurers can assess all the combinations of these considered appropriate; and

2. follow a turnkey approach where a single manufacturer/supplier (or consortium) submits a full PPE ensemble to be assessed by the user/procurer.

There may be rules or legal liability issues which affect the choice of approach. For example, in option 1, from a safety regulation perspective the user/procurer becomes the “manufacturer” of the ensembles that are created, whereas in option 2 the “manufacturer” remains the manufacturer/supplier/consortium.

If there is a choice between the two approaches the turnkey approach is likely to be most cost-effective for a potentially complex ensemble such as USAR high dust and CBR Scenario 3. The turnkey approach can also have advantages when the provision of consumable items, spares, maintenance, training and product support are considered as there is one clear manufacturer/supplier responsible.

SECTION 2

Helmets

2.1 General introduction

This section describes the minimum performance specification for helmets. Performance levels incorporated here are largely based on requirements in existing standards for equipment for use in comparable activities (firefighting, mountaineering, equestrian and industrial).

Helmets provide protection to the wearer against:

- striking their head against stationary objects
- falling objects
- heat and flame
- molten metal splash; and
- accidental contact with live electrical conductors.

A helmet will have a retention system that is designed to be effective under the likely conditions of use for the helmet. If the retention system uses a chinstrap it can be:

> **OPTION 1**
> Designed not to release during impact where there is a risk of multiple impacts (e.g. where the wearer is mostly off the ground);
>
> **OPTION 2**
> Designed to release when subject to a given (relatively low) force where there is a risk of strangulation (e.g. where the wearer is mostly on the ground); and
>
> **OPTION 3**
> Designed to release when subject to a given force higher than option 2 where there is a risk of both strangulation and multiple impacts (e.g. where the wearer works both on and off the ground and works in enclosed or other spaces with projections that might catch the helmet).

Option 3 is the most suitable for USAR, where there are both risks of the wearer falling and of the helmet being caught and strangling the wearer. The standard firefighters helmet to EN 443:2008 has a chinstrap which is required to release between 500 and 1000 N. In contrast, the industrial safety helmet (EN 397:1995) has a chinstrap which is required to release between 150 and 250 N because it is not intended for multiple impact (e.g. fall) protection.

Helmets can incorporate mountings for other head-mounted personal protective equipment (PPE), or even the head mounted PPE itself.

The wearing of a helmet will reduce, but not eliminate, the likelihood of head injury. There are limits to the amount of protection that can be provided. In the workplace, it remains the responsibility of the employer to judge the helmet's suitability for their particular purpose.

2.2 Scope

The specifications in this section use both new performance requirements and those from existing standards. In turn, these require test methods that are both new and based on existing standards.

The specification for use in urban search and rescue (USAR) Scenario 3 is based upon the current BS/EN/ISO product standards with some additional requirements. Laboratory and practical performance tests are included for the assessment of compliance with the requirements.

Helmets will be used with other head-mounted PPE. All the PPE in a head-mounted ensemble needs to be selected such that it still offers its full individual protection, i.e. so that there is compatibility between the different items of PPE. The same applies where other PPE such as clothing overlaps with head-mounted PPE. PPE ensembles and ensemble testing are discussed further in Section 11.

2.2.1 Full protection helmet A1b

This helmet is intended for use in scenarios where the hazards to the head are relatively severe, and includes the heat and flame protection of a structural fire-fighting helmet. The higher level of protection and head coverage that it offers means that the helmet is likely to be heavier and less comfortable in use. (If the need can be identified and justified for a helmet with less protection (which is likely to be more comfortable) then a specification can be created based on the options given in Section 2 of report *Urban Search and Rescue PPE – Final report* Volume 2: Specification (IR/PE/07/04/2) Vaughan *et al*. 2007.)

The helmet has additional performance requirements over those in existing standards to specify its performance after exposure to chemicals.

It may be possible to use a two helmet system where a lower protection lightweight helmet (e.g. A1a in Vaughan et al, 2007a) is worn all the time and A1b can be added over the top of A1a for more hazardous environments. Such systems can also cater for strangulation avoidance by allowing the outer helmet to come off while the inner helmet remains in place.

It is important to note that A1b is basically the same for Scenarios 2 and 3 the chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including CBR substances.

2.3 Performance requirements for A1b helmets

2.3.1 Innocuousness and design

The helmet shall meet EN 443:2008 clause 4.1 for general characteristics.

The helmet shall meet the following clauses of EN 443:2008:

- clause 4.14, field of vision
- clause 4.11, flame resistance
- clause 4.10, heat resistance
- clause 4.7, radiant heat (resistance)
- clause 4.9, protection against molten metals
- clause 4.8, protection against hot solids
- clause 4.12.1, electrical properties; and
- clause 4.15, extent of protection.

2.3.2 Retention system

When selecting a retention system the risks of strangulation and the helmet coming off the head during multiple impacts must be considered. This allows the selection of a retention system which addresses whichever of the two represents the greater risk.

The retention system shall meet the requirements of EN 443:2008 clauses 4.5 and 4.6.

This is suitable for USAR, where there are both risks of the wearer falling and of the helmet being caught and strangling the wearer. The helmet chinstrap is required to release between 500 and 1000 N.

2.3.3 Impact protection

The helmet shall meet the impact requirements of EN 443:2008 clauses 4.2 and 4.3, and the area tested for impact shall be as defined in that standard.

2.3.4 Mechanical rigidity

The helmet shall meet the requirements of EN 443:2008 clause 4.4.

2.3.5 Chemical resistance

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the helmet shall continue to meet the requirements for:

- flame resistance
- radiant heat resistance
- electrical properties
- molten metal splash
- impact protection; and
- mechanical rigidity.

> **Note:** this performance requirement is intended to give a helmet whose impact, heat/flame and electrical resistance are not compromised by exposure to chemicals.

This performance requirement needs new test methods as it extends beyond the requirements of EN 443:2008 clause 4.13. Options for these new test methods are suggested in 2.4.2.

2.4 New helmet test methods needed

2.4.1 General introduction

All the new test methods in this section are given where there are none in existing standards which can be used to completely assess the new performance requirements given in this specification.

As noted in section 1.3, these new test methods are given as suggestions only, and have not been practically evaluated. They describe the principles involved, and are not fully defined and ready to be used “as written”. Where possible, these new test methods use, or give as examples, test methods from existing standards.

2.4.2 Test method for helmet chemical resistance

The chemicals used for testing are as given in 5.6.2.1, Table 5.1.

The test method is similar in principle to that in 5.6.2.2. It can be adapted for a helmet as follows:

"*Test chemicals shall be at a temperature of (20 ± 2) °C. The chemical shall be applied with the helmet mounted in the in-use position, oriented as though being worn by a standing subject.*

100 ml, or an appropriate amount, of the test chemical shall be poured onto the outer surface of the helmet. The chemical shall be poured moving from one side to the other using half the amount of chemical, and the rest going back, thus covering the assembly twice. This operation shall take (10 ± 3) seconds.

Five minutes after having applied the chemical, residues shall be removed (using any appropriate method such as rinsing in clean water and drying). The helmet shall then be subjected to examination and testing as required by 2.3.5."

SECTION 3

Clothing

3.1 General introduction

This section describes the minimum performance specification for the garment(s) providing protection to the body, including the arms to the wrists and the legs to the ankles. Clothing may also provide protection against contact with chemicals and chemical, biological or radiological (CBR) materials to the hands by the inclusion of suitable gloves, the feet with the inclusion of suitable bootees/socks, or to the head with the inclusion of a suitable hood. The performance requirements may be met by a single garment, or by combinations of different garment layers worn simultaneously. In this work we have assumed that the barrier performance against CBR materials for the hands and feet is provided by integral or attached accessory glove/sock components of the clothing.

Note: We did not include an integral chemical protective boot (option E3b) in the items listed in Table 1.2. Our assessment of what forms of equipment are likely to be pragmatic solutions for CBR excluded this option.

Performance levels incorporated here are largely based on requirements in existing standards for equipment for use in comparable activities (firefighting, welding and allied processes, first response, chemical and nuclear industry). To evaluate durability of the protection provided against contaminants, more rigorous pre-conditioning of garments has been included in the test procedures, by requiring measurement of protection after suits have been subjected to ambient or low temperature practical performance testing.

Protective clothing for civil responder agencies against chemical, biological, radiological and nuclear (CBRN) hazards have evolved along two principal lines of development from related applications. The first line of development is from military nuclear biological chemical suits with a battlefield “rugged” application and the second from the gas-tight suits used by fire and rescue services for industrial chemical incidents. Industrial chemical incidents are typically relatively simple to support logistically compared with military operations, so traditionally self-contained breathing apparatus has been supported in industrial scenarios where the limited operational duration of these devices has not been an issue.

In recent times the industrial line of development has produced chemical protection suits using impervious barrier materials (which are similar in construction to gas-tight suits) and which use powered filtering respiratory protection. The ventilation from the powered filtering, combined with the looser fit of such ensembles, allows sufficient air circulation to lower the physiological burden. The looser fit of these kinds of ensembles does mean that they are prone to snagging hazards and would therefore be considered unsuitable for urban search and rescue (USAR) activities. The chemical industry use very close fitting impermeable materials in some applications but these do not allow enough air movement to give sufficient endurance in the USAR environment.

The military line of development has produced materials which are selectively chemically permeable, and moisture vapour permeable (MVP) garments that utilise activated carbon or charcoal textiles to prevent the ingress of chemical contamination and have the advantage that they allow moisture from perspiration to escape. The strength of these types of garment is their open structure, providing moisture vapour permeability. However, if the structure is too open it will allow biological or radiological particles to pass through the materials. This creates an operational dilemma when specifying a protective garment that meets the requirements for chemical liquids and vapours but also needs to meet requirements for biological and radiological particles. The garment selected for CBRN protection in a USAR environment must balance these chemical protective requirements against the physiological burden and the ruggedness required for USAR operations. For longer term operations, having separate garments for chemical, and for biological and radiological materials, could reduce the physiological burden and benefit operational endurance for those situations where only one form of hazard exists.

Garments of type B3a when used as part of a compatible ensemble are designed to protect against concentrations up to1000 times the relevant exposure levels for dermal contact of solid particles and gases/vapours. Ensembles of this type must not be used in environments where concentrations in excess of 1,000 times (i.e. allowing for the protection factor) the emergency responder exposure guidelines (EREGs) or occupational exposure limits (in the absence of EREGs) may be found.

Note*:* The EREGs represent an airborne concentration that, according to available information, could be tolerated for a single two hour period without causing significant health effects or substantial discomfort, with no impairment in the ability to effectively carry out emergency procedures and would not cause serious longer term adverse health effects. The EREGs are given in Appendix 4, which includes a note of those materials which can be absorbed through the skin and make a significant contribution to the body burden.

Note: In this specification we have excluded the situation where ensemble manufacturers would be able to claim protection factors in excess of that required by the specification, and use these levels to increase the hazard concentration level which can be protected against. While this could be done, it would be subject to the manufacturer providing acceptable test data.

Statistically, there is a huge difference between being able to claim a PF of at least 1,000, and proving that an ensemble provides a PF of significantly more than 1,000. The number of test measurements required for the latter is likely to be an order of magnitude higher than for the former. Those wishing to adopt the approach outlined using the hazard level of (EREG x (proven PF in excess of 1,000)) would have to undertake significantly more testing than those who just adopt the 1,000, and this is outside the scope of the testing we have considered.

3.2 General scope

Type B3a clothing provides:

- limited protection to the wearer from rough surfaces and abrasions and has levels of mechanical strength and conspicuity consistent with intended USAR applications
- protection against sprays, splashes or contact with highly toxic liquids, gases and vapours, including CBR materials

Note: The tests in this specification address the garment against spray, splash and contact with liquids, and the materials are tested against defined chemicals. Taken together, these will offer protection against splashes of highly toxic liquids.

- protection against exceptional high levels of dusts, including microbiological substances which may be of a highly infectious nature.

Clothing of this type will reduce exposure to solid particles, gases and vapours by a nominal factor of 1000.

This clothing is not intended to protect the wearer from hazards associated with immersion in liquids. Neither does it guarantee complete protection against liquid spray exposure.

Note: The pass/fail criterion for the spray test is not "zero penetration". A small quantity of penetration is allowed, hence the clothing "does not guarantee complete protection" against sprays, although it should against splashes.

3.3 Performance requirements for B3a clothing

3.3.1 Introduction

Garments shall conform to the general requirements of EN 340:2003 concerning:

- innocuousness
- design
- comfort
- ageing
- dimensional change due to cleaning (if relevant)
- washing and dry cleaning methods (if relevant)
- size designation
- marking, and
- information supplied by the manufacturer.

Where appropriate, design of garments shall also take the following aspects into consideration:

- EN 510:1993 – Clothing for use where there is a risk of entanglement
- ISO 11611:2007 clause 4, where there is a risk of exposure to molten spatter
- Where garments may be used in a flammable/explosive atmosphere, they shall have no exposed light alloys which may on frictional impact give rise to incendive sparks.

These aspects shall be assessed by visual inspection and by means of practical performance testing. Basic ergonomic performance during practical performance testing shall be assessed in accordance with the guidance in EN 340:2003 Annex C.

3.3.2 Sampling, conditioning and pre-treatment

Numbers of samples, pre-treatment and conditioning of samples, shall be as described in the standards referenced, unless specified differently in this document.

3.3.3 Resistance to minor impacts

The garment shall incorporate integral padding to knees/elbows. The position and performance of this padding shall be deemed adequate during practical performance testing according to 3.4.2 and 3.4.3.

Note: Specific additional protection to knees and elbows is covered by Section 8 of this specification.

3.3.4 Mechanical strength

Materials from which garments are made shall meet at least the performance levels given in Table 3.1, when tested as specified in the relevant standard, subject to any variations given in Table 3.1.

Table 3.1 Mechanical performance requirements for clothing materials			
Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Abrasion	EN 14325:2004, 4.4	5 (>1500 cycles)	Use visual end point if pressure pot method inappropriate
Flex cracking resistance	EN 14325:2004, 4.5	5 (>40000 cycles)	Use visual end point if pressure pot method inappropriate
Flex cracking resistance at low temperature	EN 14325:2004, 4.6	5 (>2000 cycles)	Shall be conducted at one or more of –10°C, -20°C or -30°C . Marking and Manufacturer's instructions to state lowest successful test temperature.
Tear resistance:			
Non-woven material	EN 14325:2004, 4.7	3 (>40N)	Use EN ISO 9073-4:1997
Non-coated textiles	EN 469:2005, 6.7	>25N	Use EN ISO 13937-2:2000
Coated textiles	EN 469:2005, 6.7	>25N	Use EN ISO 4674-1:2003 method B
Bursting resistance	EN 14325:2004, 4.8	3 (>160kPa)	Apply to materials and seams
Tensile strength	EN ISO 13934-1:1999	>450N	-
Puncture resistance	EN 14325:2004, 4.10	4 (>100N)	-

Seams, joins and assemblages shall achieve at least strength class 5 (>300N) of EN 14325:2004, clause 5.5.

3.3.5 Heat and flame resistance

3.3.5.1 MATERIALS HEAT RESISTANCE

Garment materials, or material assemblages for multi-layered construction, shall achieve at least the performance levels given in Table 3.2, when tested as specified in the relevant standard, subject to any variations given in Table 3.2.

Table 3.2 Clothing materials heat resistance

Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Contact heat resistance	ISO 12127:1996	Threshold time >5s	Test at 250°C
Radiant heat resistance	ISO 6942:2002	RHTI >7s	Method B at 20 kW/m^2
Molten spatter resistance	ISO 11611:2007, 6.8	Class 1	-

3.3.5.2 FLAME RESISTANCE

Garment materials, or material assemblages for multi-layered construction, shall achieve the performance levels given in Table 3.3, when tested as specified in the relevant standard, subject to any variations given in Table 3.3. For garments of multi-layer construction, samples of the complete assemblage shall be tested.

Table 3.3 Flame resistance			
Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Materials flame resistance	EN 469:2005, 6.1	EN 469:2005, 6.1	Only outer face tested
Seams and closures	EN 469:2005, 6.1	EN 469:2005, 6.1	Only outer face tested.
Hardware (e.g. non-fabric items of the garment such as buttons, zip fasteners and similar closure systems, and rank/identification markings)	EN 469:2005, 6.1	EN 469:2005, 6.1. After testing, the main closure system shall operate once.	6.1.6 replaced by: If hardware is used on the protective clothing, this shall be tested as attached to the garment material, by applying the flame to the outer surface of the hardware item. Hardware of the main closure system shall be tested in the configuration in which it is present in the donned garment.

3.3.5.3 GARMENT FLAME PROTECTION (OPTIONAL)

If users/specifiers (or DCLG in consultation with these groups) determine the need for information on how garments will perform in the event of accidental exposure to flame engulfment, garments shall be subjected to the test procedure of EN 469:2005 clause 6.15, using exposure conditions of 4s at 84kW/m^2. The reporting requirements stated in EN 469:2005 for this test shall be fulfilled.

Note: As the performance of the clothing in an in-use flame engulfment situation will be very significantly affected by the performance of other items of equipment used at the same time, consideration should be given to subjecting the complete ensemble to this test, and not just the clothing. See section 11.

3.3.6 Cold resistance

Note: Requirements in this clause may be met with the addition of thermal insulative/protective layers, including defined underwear, to the garment. Manufacturer's instructions should make clear when to use such layers.

3.3.6.1 COLD CONTACT PROTECTION

Areas of the garment likely to be subjected to pressure against cold surfaces (e.g. knees or elbows) shall achieve at least level 2 of EN 511:2006 clause 4.6, when tested as described in clause 5.6 of that standard.

3.3.6.2 RESISTANCE TO COLD CONDITIONS

In addition to the flex cracking resistance tests at low temperature (3.3.4 above), the complete garment shall be subjected to practical performance tests according to 3.4.3 at the lowest temperature claimed by the manufacturer for flex cracking resistance (-10°C, -20°C or -30°C).

No failure or degradation of materials, seams or closures shall be observed, and no test subject shall report the clothing to be unusable or withdraw from the test as a result of problems with the clothing.

Note: For natural environmental conditions –10°C is likely be adequate. However, some USAR teams may have artificial environments in their area where direct intervention at lower temperatures may be required (e.g. collapse of large racking system in a –30°C coldstore with people trapped).

3.3.6.3 PROTECTION AGAINST COLD CONDITIONS

Protection against cold conditions shall be assessed as given in Table 3.4. Where the garment includes removable thermal layer(s), performance shall be reported for the garment with and without the layer(s) present, where indicated in Table 3.4.

Based on the information in Annex B of EN 342:2004, the manufacturer shall provide advice on the limitations to use of the garment in cold conditions.

Table 3.4 Protection against cold conditions			
Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Garment insulation	EN 342:2004, 4.2	Report I_{cle}	For each garment configuration
Garment breathability	EN 31092:1993	<40 m^2.Pa/W	For assembled garment configuration only
Air permeability	EN 342:2004, 4.3	Class 3	For each garment configuration

3.3.7 Visibility and conspicuity

3.3.7.1 GENERAL

The requirements of 3.3.7 apply to the outermost layer of any garment assemblage. Where separate layers may be worn independently, the requirements shall apply to each possible outer layer.

3.3.7.2 RETROREFLECTIVE MATERIAL

Retroflective material shall as a minimum meet the following requirements of EN 471:2003:

a) clause 4.1 - minimum visible area class 2 (0.13 m^2)
b) clause 4.2.2 -minimum width 50 mm
c) clause 6.1 - coefficient of reflection level 2
d) clause 6.2 – retroreflective performance after test exposure (wear effects).

3.3.7.3 BACKGROUND/FLUORESCENT MATERIAL

Background fluorescent material shall as a minimum meet the following requirements of EN 471:2003:

a) clause 4.1 minimum visible area class 2 (0.5 m^2)
b) clause 4.2.1 location of material,
c) clause 5.1 colour performance
d) clause 5.2 colour after xenon test
e) clause 5.3 colour fastness after pretreatment.

Note: Consideration should be given to the colours/patterns in which retroreflective/fluorescent materials are arranged, to assist with individual and role identification.

3.3.8 Electrical properties

3.3.8.1 RESISTANCE TO LIVE ELECTRICAL CONTACT

Note: The requirement below minimises the possibility of electrical shock by short term, accidental contact with live electric conductors at low voltages, up to approximately 100V DC. It may not prevent injury or electrocution by longer contacts or higher voltages.

Note also: This performance requirement is likely to be suitable for protection against brief accidental contact with 240V AC. The requirement comes from the welding clothing standard (EN 470-1) requirement for arc welding uses voltages up to 100V DC. (EN 470-1 has been superseded by EN ISO 11611.) According to the as-written requirement 100V DC at 10^5 ohms will give a “safe” current of 0.1mA. It is generally accepted that the minimum current which can be felt by a human is not less than 1mA, so there is a factor of 10 safety margin here – probably because repeatability of the test is only within about 1 order of magnitude. To a first order approximation, based on information on equivalent performances for insulating gloves against AC and DC (EN 60903), equivalent DC voltage is 50% higher than AC voltage. On this basis 240V AC approximates to 360V DC, which at 10^5 ohms gives a current of 0.36mA, reducing the safety margin to about 3. Raising the resistance requirement to 10^6 ohms would reduce the current to 0.036mA, which is below the previously accepted “safe value”.

If formal 240V AC protection is considered necessary, the requirements and test methods could be changed to conform with relevant parts of EN 50286 (Electrical insulating protective clothing for low-voltage installations). However, it is important to be aware that this standard contains onerous additional design and performance requirements which may be incompatible with USAR garments. Insulation is assessed by a “low voltage” proof test in this standard at 2.5kV for dry samples and 1.5kV for wet ones, which may be considered to be excessive protection for brief accidental contact with 240V AC.

The test called up in EN ISO 11611 clause 6.10 is identical to the “vertical resistance” test in 3.3.8.2 below, bracketing the garment resistance between 10^5 and 10^8 ohms. Garment materials shall meet the requirements of ISO 11611:2007, clause 6.10 ($>10^5$ ohms).

3.3.8.2 ANTISTATIC PROPERTIES

Garment materials shall satisfy the following requirements in Table 3.5 for vertical and surface resistance.

Table 3.5 Electrostatic properties of materials

Property	Standard reference	Minimum performance level	Variations from referenced standard
Surface resistivity	EN 1149-1:2006	$<10^{11}$ ohms	-
Vertical resistance	EN 1149-2:1997	$<10^{8}$ ohms	-

3.3.9 Protection against solid particles

Garments shall be tested as part of a compatible ensemble. The method of 3.4.4 shall be used, but the performance requirement shall be as given in Table 3.6.

Testing of inward leakage shall be carried out on six subjects immediately after completion of the practical performance tests detailed in 3.4.2 and 3.4.3, using the same subjects, without removal and refitting of the garments. (A total of six sets of inward leakage measurements shall be made, three after ambient temperature practical performance testing, and three after low temperature practical performance testing.).

Table 3.6 Inward leakage of solid particles for clothing B3a

Inward leakage measured (see EN 13982-2:2002)	Inward leakage shall not exceed:
TIL_E (exercise mean)	0.15%
TIL_A (overall mean)	0.1%

3.3.10 Liquid penetration resistance of garment

Garments tested as part of a compatible ensemble shall achieve the requirements of EN 14605:2005 clause 4.3.4.3 (“Type 3”) when tested according to EN 468:1994, omitting the seven movement sequence preconditioning. Four suits shall be tested; two after conducting the ambient temperature practical performance test (3.4.2) and two after conducting the low temperature practical performance test (3.4.3).

3.3.11 Resistance of materials and seams to penetration of TIC liquids

The chemicals listed in Table 3.7 shall be used for both of the following tests. Appendix 1 provides the rationale for the choice of chemicals.

Garment materials and seams shall pass ISO 13994:1998, procedure C1, or C2 if the specimen requires additional support.

Materials shall achieve at least class 2 repellency of EN 14325:2004 clause 4.12.

Table 3.7 Liquid chemicals to be used for clothing testing

Common name	Synonym	Chemical Abstract Registry Service (CAS) number
Acetone	2-propanone, dimethyl ketone	[67-64-1]
Acetonitrile	cyanomethane, methyl cyanide	[75-05-8]
Carbon Disulfide	carbon bisulfide	[75-15-0]
Dichloromethane	methylene chloride/dichloride	[75-09-2]
Diethylamine	N,N-diethylamine	[109-89-7]
Dimethylformamide	DMF	[68-12-2]
Ethyl Acetate	ethyl ethanoate, acetic ester, acetic ether	[141-78-6]
n-Hexane	-	[110-54-3]
Hydro Fluoride Acid (80%)	hydrofluoric acid	[7664-39-3]
Methanol	methyl alcohol, carbinol, wood alcohol	[67-56-1]
Nitrobenzene	oil of mirbane	[98-95-3]
Sodium Hydroxide (50	caustic soda, lye	[1310-73-2]

Table 3.7 Liquid chemicals to be used for clothing testing		
% w/w)		
Sulfuric Acid (93.1 % sp gr 1.84, 66° Be8)	electrolyte acid, hydrogen sulfate	[7664-93-9]
Tetrachloroethylene	perchloroethylene, carbon dichloride	[127-18-4]
Tetrahydrofuran	THF, 1,4-epoxybutane, diethylene oxide	[109-99-9]
Toluene	toluol, methyl benzene	[108-88-3]

3.3.12 Resistance of materials and seams to permeation by TIC liquids

When tested against at least the liquids listed in Table 3.7, using the methodology of BS 8467:2006 Annex E, materials and seams of the garment shall achieve at least class 4 for breakthrough. If class 6 is not reached for any chemical, the manufacturer shall state the maximum breakthrough time for that liquid.

3.3.13 TIC liquid degradation resistance

Separate samples of garment materials shall be chemically preconditioned by 60 minutes continuous contact exposure to each of the liquids listed in Table 3.7. The samples shall then be tested according to EN 14325:2004, clause 4.10, in comparison with unexposed samples. There shall be no change to the measured puncture resistance class, or significant visible degradation.

3.3.14 Resistance to penetration of infectious agents

Garment materials shall pass ISO 16604:2004 procedure A, or procedure B if the samples require support, substituting MS2 bacteriophage for the Phi-X174 bacteriophage.

3.3.15 Clothing B3a protection against gases and vapours

Garments shall be preconditioned by storage at the manufacturer's stated minimum temperature (-10°C, -20°C or –30°C) for not less than four hours, followed by 24 hours at (20±2)°C and (65±5)% relative humidity.

Garments as part of a compatible ensemble shall meet the requirements of BS 8467:2006 clause 5.4.3a when tested using any method listed there except option A3 from EN 943-1:2002.

Note: Option A3 is excluded because particle protection aspects are already addressed in 3.3.9 above.

Note also: The methods described here are applicable to protection against both TIC/TIM and CBR gases/vapours.

3.3.16 Clothing B3a resistance of materials and seams to permeation by TIC gas/vapours (optional)

Note: Exposure to these substances in concentrations that would be hazardous to operators by dermal exposure is considered to be extremely unlikely in USAR scenarios. The requirement is included as an option for consideration.

When tested against at least the gases/vapours listed in Table 3.8, materials and seams of the garment shall achieve at least class 4 of EN 14325:2004 clause 4.11. If class 6 is not reached for any chemical, the manufacturer shall state the maximum breakthrough time for that substance.

Table 3.8 Gas/vapour chemicals to be used for clothing materials testing		
Common name (minimum purity)	**Synonym**	**Chemical Abstracts Service (CAS) number**
Ammonia, anhydrous, (99.99 %)	-	[7664-41-7]
1,3-Butadiene, inhibited, (99.0 %)	bivinyl, vinylethylene, biethylene, divinyl	[106-99-0]
Chlorine, (99.5 %)	-	[7782-50-5]
Ethylene Oxide, (99.7 %)	oxirane, 1,2-epoxyethane	[75-21-8]
Hydrogen Chloride, (99.0 %)	hydrochloric acid	[7647-01-0]
Methyl Chloride, (99.5 %)	chloromethane, monochlormethane	[74-87- 3]

3.3.17 TIC gas/vapour degradation resistance (optional)

Note: Exposure to these substances in concentrations that would be likely to damage garment materials is considered to be extremely unlikely in USAR scenarios. The requirement is included as an option for consideration.

Separate samples of garment materials shall be chemically preconditioned by 60 minutes continuous contact exposure to each of the gases/vapours listed in Table 3.8. The samples shall then be tested according to EN 14325:2004, clause 4.10, in comparison with unexposed samples. There shall be no change to the measured puncture resistance class, or significant visible degradation.

3.3.18 Resistance of materials and seams to permeation by classical chemical warfare agents

When tested against substances listed in Table 3.9 materials and seams of the garment shall meet the requirements of BS 8467:2006 clause 5.3.3b.

Note: In BS 8467 clause 5.3.3.b refers to Annex E, which calls for $10g/m^2$ in $1\mu l$ drops.

Table 3.9 CBRN chemicals to be used for clothing testing		
Common name	**Synonym**	**Chemical Abstracts Service (CAS) number**
GB	Sarin, isopropyl methylphosphonofluoridate/methylfluorophosphonate	[107-44-8]
GD	Soman, pinacolyl methylphonofluoridate/methylfluorophosphonate	[96-64-0]
VX	O-ethyl-S-2-diisopropylaminoethyl methyl phosponothioate	[50782-69-9]
HD	Mustard, bis(2-chloroethyl) sulphide	[505-60-2]

3.4 New clothing test methods needed

3.4.1 General introduction

The new test methods detailed at 3.4.2 to 3.4.5 are given where there are none in existing standards which can be used to completely assess the new performance requirements given in this specification.

As noted in Section 1.3, these new test methods are given as suggestions only, and have not been practically evaluated. They describe the principles involved, and are not fully defined and ready to be used “as written”. Where possible, these new test methods use, or give as examples, test methods from existing standards. If alternative test methods are available to assess the performance requirements and they are considered appropriate, they can be used where necessary.

3.4.2 Test method for practical performance testing at ambient temperature

3.4.2.1 GENERAL

Practical performance testing is essential to assess aspects of garment performance which cannot be determined by other forms of testing. In addition, this testing is used as preconditioning of the garments before assessment of protective capabilities, so simulate a consistent level of wear and tear, to confirm durability of the measured protection.

3.4.2.2 TEST CONDITIONS

Testing shall take place at (23±5)$^{\circ}$C and (45±15)% relative humidity. The actual test conditions shall be reported.

3.4.2.3 TEST SUBJECTS

For the test, persons shall be selected who are familiar with the use of this or similar protective equipment and whose medical history is known to be satisfactory. Before performing tests involving human subjects, account shall be taken of any national or local regulations concerning medical history, examination, monitoring or supervision of the test subject.

3.4.2.4 TEST PROCEDURE

The following procedure shall be undertaken by each test subject.

a) The subject shall read the manufacturer's instructions, and select the appropriate size of garment accordingly.
b) The subject shall don the garment (and any identified accessory equipment to be used at the same time, including sampling lines which may be required for tests conducted immediately subsequent to the practical performance tests) according to the instructions.
c) The seven-movement sequence from EN 14605:2005 clause 4.3.4.1 shall be carried out.
d) Exercise c) of EN 943-1:2002 clause 6.2.1 shall be carried out, but with a duration 5 minutes instead of 10, filling and emptying the basket 7 to 10 times.
e) Items c) and d) above shall be repeated a further two times.

The subject shall rest for (3±2) minutes between repetitions.

3.4.2.5 ASPECTS TO BE ADDRESSED DURING PRACTICAL PERFORMANCE TESTING

Points to be addressed during practical performance testing include:

- design, sizing, comfort, adequacy of padding to knees/elbows
- marking, information, and user instructions
- mechanical robustness, security of fastenings
- subject withdrawal related to clothing
- donning/disrobing/doffing procedures

- ergonomic aspects according to EN 340:2003 Annex C.

3.4.3 Test method for practical performance at low temperature

3.4.3.1 GENERAL

In addition to the purposes of ambient temperature practical performance testing, these tests dynamically assess the resistance of garment materials to mechanical damage caused by low temperatures.

3.4.3.2 TEST CONDITIONS

Testing shall take place at the lowest temperature claimed by the manufacturer for operation, from the options of –10°C, -20°C or -30°C. The test temperature shall be maintained within 1°C during tests.

3.4.3.3 TEST SUBJECTS

3.4.2.3 shall apply. In addition, particular attention shall be given to the medical screening for fitness to work at reduced temperatures, and any need for additional monitoring of subject condition during tests.

3.4.3.4 TEST PROCEDURE

3.4.2.4 shall apply.

3.4.3.5 ASPECTS TO BE ADDRESSED DURING PRACTICAL PERFORMANCE TESTING

3.4.2.5 shall apply, together with:

- cold-induced damage to the garment.

3.4.4 Test method for protection against high levels of airborne particles

The method described in EN 13982-2:2002 shall be used, with the following modifications. There shall be three separate sampling points:

a) Within the hood of the garment.

b) In the upper right chest region of the garment.

c) In the right leg of the garment at knee level.

The sampling probe used shall be as described in EN 13982-2:2002 clause 5.5. When sampling any one position, an equivalent volume of clean air shall be returned to the garment through the nearest alternative sampling line.

3.4.5 Method for protection against gases using SF6

The method of 3.4.4 shall be used, substituting SF_6 for salt aerosol as the test agent (see EN 943-1:2002 Annex A for description of SF_6 methodology).

Note: The SF_6 test is more searching than a particle test. If gas is kept out, particles will not penetrate either. The converse is not true.

There may be some garment materials which are effective against CWAs but will not work against SF_6. In this case, live agent or surrogate (MS) tests could be used instead of SF_6. However, performance against gases/vapours other than CWAs would still need to be assessed.

SECTION 4

Hearing protection

4.1 General introduction

Under the *Control of Noise at Work Regulations 2005* there are two indicators of the risk to hearing; the daily overall noise exposure and the instantaneous peak level exposure. There are lower and upper action values and limit values for both these quantities.

For the daily noise exposure 80dB(A), 85dB(A), and 87dB(A) are the lower, upper and limit values respectively. These values are the overall daily noise exposure calculated as the equivalent steady level if all the sound occurred over 8 hours.

For the instantaneous peak level 135dB(C), 137dB(C) and 140dB(C) are the lower, upper and limit values respectively. These are instantaneous values and apply regardless of how often or how long the exposure occurs.

Hearing protection is required to be provided to anyone whose noise exposure is likely to exceed the lower action value but they are not required to use this hearing protection until there is a risk of exceeding the upper exposure action value.

Hearing protection should be sufficient to reduce the noise exposure below the upper exposure action values. If this is impossible the limit values apply.

You may also find EN 458:2004 “Hearing protectors - Recommendations for selection, use, care and maintenance - Guidance document” useful.

4.2 General scope

Hearing protectors are available in two basic types, muffs and plugs. Both attenuate the passage of sound through the ear canal and so attenuate the sound level at the ear. Muffs may be more suitable if helmet mounted, while plugs are more suitable where muffs cannot be worn with other head mounted personal protective equipment (PPE).

Hearing protectors provide protection but also impair hearing. Over or unnecessary protection should be avoided.

Some protectors are designed to provide a flat response, and deliberately reduce the attenuation of high frequencies to improve clarity of sound heard with the protector worn. Sound restoration protectors contain electronics that enhances the frequencies important for clarity at lower levels. These types of protector will reduce hearing impairment effects.

It is important to note that although the specification for hearing is basically the same for Scenarios 2 and 3 any chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including chemical, biological, radiological substances.

4.2.1 Types of hearing protection

4.2.1.1 SOUND RESTORATION HEARING PROTECTION

Sound restoration protectors mitigate some of the risks associated with the hearing impairment. Sound restoration protectors use microphones on the outside of the protector and speakers inside to reproduce the outside sound at the ear. As the outside level increases the gain of the sound restoration system decreases. This allows the wearer to hear clearly the sounds around them when it is quiet but to be protected against high levels, even sudden blast noise, up to the full attenuation of the protector. Sound restoration hearing protectors should be specified to EN 352-4:2001 (muffs) or EN 352-7:2002 (plugs). For urban search and rescue (USAR) applications, battery type, life and ease of replacement will also be important.

4.2.1.2 INCORPORATION OF COMMUNICATIONS EQUIPMENT

Sound restoration protectors can also incorporate communications equipment (communications equipment is an option, section 4.3.3). Muffs designed for essential communication should be specified to EN 352-6:2002 and will allow the user to select the level they require for clear communication. A similar standard for plugs (prEN 352-9) is in preparation. For USAR applications, battery type, life and ease of replacement will also be important.

Where hearing protectors incorporate communications equipment any CE marking and hearing protection performance should apply to the whole unit, and not to the hearing protector without communications equipment.

4.2.1.3 HEARING PROTECTION FOR EXPLOSIVE ATMOSPHERES

Sound restoration protectors will give the best audibility where sound levels are varying and should be the preferred choice. As sound restoration protectors contain electronics they may not be suitable for explosive atmospheres. Therefore protectors without electronics have also been specified with regard to both hearing impairment and attenuation.

4.2.1.4 MUFFS OR PLUGS?

Muffs are easier to fit than plugs and there is a wider range of protectors with both sound restoration and communication facilities. Muff attenuation may be reduced when other head worn clothing or personal protective equipment is used, and if not worn correctly. Using a purpose built combination of muffs with the other PPE ensures the best fit.

Plugs can usually be used with other head worn clothing and personal protective equipment without loss of attenuation. Plugs are available with both sound restoration and communication facilities but there is possibly a smaller range than for muffs.

Plugs can be difficult to fit correctly. Plugs moulded to the users ears usually provide the easiest and best fit. These custom moulded types are the ones most commonly available with sound restoration and communication facilities. If custom moulded plugs are not used a variety of plugs should be available to enable users to find the one giving the best fit. Users require training in fitting plugs to obtain the specified attenuation.

4.2.1.5 RELATIONSHIP BETWEEN THIS AND PREVIOUS USAR HEARING PROTECTION SPECIFICATION

Previous USAR guidance had recommended using hearing protection with a signal number rating (SNR) value of at least 30dB. A 30dB SNR value is usual for protectors designed for use in noisy heavy industry (see Table 4.1). SNR values usually extend only to about 35dB and such protectors are designed for the most extreme environments. In some cases such heavy-duty protectors will over protect users, and provide an unnecessary hearing impairment.

In addition, previous guidance had suggested the H value should be at least 30dB. The H value is an indication of the protection provided to high frequency sound. High frequencies are easily attenuated and even lightweight protectors will meet this requirement. However there is little advantage in high attenuation of high frequencies as it muffles sounds for the users of hearing protection giving a loss of clarity especially to speech. In addition apart from compressed air discharges such high frequencies are not a significant component of machine noise.

Table 4.1 Indication of protector factors

A- weighted noise level dB	**Select a protector with an SNR of….**
85 - 90	20 or less
90 - 95	20 - 30
95 - 100	25 - 35
100 - 105	30 or more

4.3 Performance requirements for C1a hearing protection

4.3.1 General introduction

C1a hearing protection is a plug with sound restoration and, if desired, communications.

> **Note :** Sound restoration hearing protectors have H, M and L criterion levels specified (these are not to be confused with the H, M and L attenuation values). These criterion levels are the outside level at which the level at the ear first reaches 85dB(A) when the sound restoration is set to full volume in high, medium and low frequency noise.

4.3.2 Performance

The earplug shall be specified to EN 352-7:2002 “Hearing protectors - Safety requirements and testing - Part 7: Level-dependent ear-plugs”.

Sound restoration protectors shall have H, M and L criterion values not lower than 115dB(A), 105dB(A), and 90dB(A) respectively. In the passive mode (sound restoration off) they shall have an SNR value of at least 30dB.

> **Note:** This will ensure they provide sufficient attenuation for those working in steady noise such as that from most hand held power tools when the sound restoration is at full volume. The sound restoration feature will ensure that the protector does not overprotect those using the protector at lower levels. The SNR value ensures a minimum protection against high level blast noise when the passive attenuation dominates.

The battery life shall be at least 300 hours.

4.3.3 Communications (optional)

At this time (December 2008) there is only a draft standard for the specification of ear plugs with audio communication. This draft standard is prEN 352-9 “Hearing protectors - Safety requirements and testing - Part 9: Ear-plugs with electrical audio input”. Plugs purchased with audio communication should be specified to this standard once it is published

The battery life shall be at least 300 hours.

SECTION 5

Respiratory protective equipment

5.1 General introduction

A range of types of respiratory protective equipment (RPE) is described, which is intended to provide protection against either airborne contaminants (solid particles, micro-organisms, mists, fumes, gases and vapours), or oxygen deficiency, or both. This range has been based on types of equipment which are currently on the market, but the performance does not exclude innovative designs from being developed for urban search and rescue (USAR) activities. Final selection of appropriate devices for deployment will balance choice of design with the necessary protection in likely use environments.

The terms RPE (respiratory protective equipment) and respiratory protective device (RPD) are used interchangeably in this document.

5.2 General scope

Section 5 specifies minimum performance requirements for three forms of RPD including both filtration types (respirators) and supplied breathable gas types (breathing apparatus - BA). The specifications are based upon the current EN or BS RPD product standards with additions where these are deemed necessary. Escape apparatus and diving apparatus are not included within the specification.

Laboratory and practical performance tests are included for the assessment of compliance with the requirements. Unless otherwise specified in this document, prior conditioning of samples tested shall be according to the referenced standards.

The selection of the most suitable type of RPE to be deployed will depend upon an on-site risk assessment of the incident.

5.2.1 Type D3a RPE

SELF-CONTAINED OPEN-CIRCUIT COMPRESSED AIR BREATHING APPARATUS WITH FULL FACE MASK

This apparatus comprises valved pressure vessel(s) and typically body harness, lung governed demand valve, pressure indicator(s), warning device(s), connecting hoses and tubes and full face mask. It may include a pressure reducer, pressure reducer relief valve, supplementary air supply, second medium pressure connector, ambient air bypass device or other components and parts. The apparatus functions by enabling the wearer to breathe compressed air on demand. The exhaled air from the wearer then passes without re-circulation to the ambient atmosphere.

Additional requirements over and above current EN standards are included to cope with high dust levels and chemical, biological and radiological hazards.

Equipment of this type has a nominal protection factor of 10000. No information is yet available on which to base an assigned protection factor (APF). See Section 11.5 which explains how simulated work place factors can be used instead of APF.

5.2.2 Type D3d RPE

POWER ASSISTED FILTERING DEVICE INCORPORATING A FULL FACE MASK OR HOOD

This device typically consists of:

a) one or more filters through which all the air supplied to the facepiece passes

b) a power operated turbo unit which supplies filtered ambient air to the facepiece directly or by means of a breathing hose. The energy supply for the turbo unit may be carried on the person

c) a full face mask or hood

d) one or more exhalation valves or other outlets through which exhaled air and air in excess of the wearer’s demand is discharged.

Additional requirements over and above current EN standards are included to cope with high dust levels and chemical, biological, radiological (CBR) hazards.

Equipment of this type has a nominal protection factor of 2000. No information is yet available on which to base an APF. See section 11.5 which explains how simulated work place factors can be used instead of APF.

5.2.3 Type D3e RPE

FULL FACE MASK RESPIRATOR

This device consists of a full face mask with one or more exhalation valves. One or more filters connect to the face-piece through which all the incoming air passes.

Additional requirements over and above current EN standards are included to cope with high dust levels and CBR hazards.

Equipment of this type has a nominal protection factor of 2,000. No information is yet available on which to base an APF. See section 11.5 which explains how simulated work place factors can be used instead of APF.

5.2.4 Filters for Type D3 respirators

Particle filters or particle filtering components of combined gas/vapour/particle filters for use with D3 respirator variants shall achieve P3 performance when tested according to EN 143:2000 or the relevant device standard referenced below for the RPE variants.

Gas/vapour filters for use with D3 devices shall achieve an accumulated dose of substance penetrating the filter/device not exceeding the EREG concentration in a period of two hours. Testing shall be carried out at a saturated challenge concentration (23±2°C, 70±5% RH) or 1000ppm, whichever is lower.

Note: BS 8468-2 Table 4 lists the substances and challenge concentrations it requires for filter tests. We are asking for many more substances to be tested than 8468, and have taken a view on the maximum concentrations that are likely to be present in an ambient temperature USAR environment. In comparison with BS 8468 we are calling for tests at lower concentration for ammonia and sulphur dioxide, and we do not test at all against cyclohexane, formaldehyde, nitrogen dioxide or phosphine.

The chemicals listed in Appendix 1 shall be used. Flow rate through the filters shall be 30l/min for filters used on negative pressure devices, or at manufacturer's minimum design flow (MMDF) for powered systems (divided by the number of filters per device in each case).

Note: These tests are primarily for classification of the gas/vapour capacity of the filters, and not as an estimation of their service life in use. EN 14387 calls for testing at 30l/min, whereas BS 8468 calls for testing at 64l/min (a NIOSH value) rather than 30l/min. If desired, 64l/min can be used to make the test more stringent.

Note: If filters cannot practically achieve this requirement, procedures and time schedules for filter change should be described by the manufacturer.

5.3 Performance requirements for respiratory protective equipment type D3a

5.3.1 General

This device shall comply with BS 8468-1:2006 and the requirements of 5.3.2 to 5.3.8. It shall not be used in atmospheres containing dust levels greater than 400mg/m^3, which was the maximum level agreed in phase 1 of this work (Vaughan *et al*, 2007a and 2007b).

Note: *BS 8468-1:2006 covers Positive pressure self contained open circuit BA. Maximum allowed inward leakage is 0.01% (PF 10000) with materials resistance to HD vapour and liquid, and GB vapour.*

5.3.2 Face mask visor

5.3.2.1 VISOR IMPACT

After being subjected to any pre-conditioning requirements, the apparatus shall continue to function and provide respiratory protection after an impact on the face-piece visor and associated components in accordance with:

- EN 166:2001 clause 7.2.2 "Protection against high-speed particles" - medium energy impact; and
- EN 166:2001 clause 7.3.4 "Protection against high speed particles at extremes of temperature" – medium energy impact.

In addition, visibility through the visor after each impact test shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

Note: this performance requirement is intended to give a facepiece visor that is strong enough to continue providing full respiratory protection after a 6 Joule impact from a projectile at –5°C and +55°C. After such an impact, in addition to continued respiratory protection, the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This requirement is the same as that for currently available EN 136 masks.

This performance requirement uses tests from existing standards. These are given in 5.6.4.

5.3.2.2 FACE MASK VISOR CHEMICAL RESISTANCE

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the visibility through the visor shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the face mask visor shall meet the impact performance requirements for respiratory protection and visibility as given in 5.3.2.1.

Note: this performance requirement is intended to give a face mask visor whose impact resistance and visor visibility are not compromised by exposure to chemicals. As for “Face mask visor impact”, after exposure to a chemical the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This performance requirement needs new test methods. Options for these new test methods are suggested in 5.6.2.

5.3.2.3 FACE MASK VISOR ABRASION RESISTANCE

After the visor is subjected to the abrasion test the visibility through the visor shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

Note: this performance requirement is intended to give a face mask visor whose visor visibility is not compromised by cleaning large quantities of abrasive dust from the visor when working in a high dust level. As for “Face mask visor impact”, after abrasion the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This performance requirement needs new test methods. Options for these new test methods are suggested in 5.6.12.

5.3.3 Faceblank

The faceblank shall be tested in accordance with EN 14325:2004, clause 4.11 and shall, as a minimum, meet the requirement for class 4 as defined in that clause.

This performance requirement will need new test methods based on modifying those in existing standards. These are given in 5.6.3.

5.3.4 Dust induced malfunction of valves and connections

The apparatus shall continue to meet the breathing resistance requirements of EN 137:2006 during exposure to an atmosphere containing 400mg/m^3 of dust and shall remain leak tight afterwards.

Testing in accordance with 5.6.5.

5.3.5 Performance of demand valve at high dust levels

The apparatus shall continue to meet the breathing resistance requirements of EN 137:2006 during exposure to an atmosphere containing 400mg/m^3 of dust and shall remain leak tight afterwards.

Testing in accordance with 5.6.6.

5.3.6 Performance of warning system at high dust levels

The apparatus shall continue to meet the audible warning requirements of EN 137:2006 during and after exposure to an atmosphere containing 400mg/m^3 of dust.

Testing in accordance with 5.6.7.

5.3.7 High level liquid penetration resistance

The complete apparatus shall continue to provide respiratory protection and remain leak tight during and after exposure to a water jet.

Testing in accordance with 5.6.8.

5.3.8 High level chemical resistance

The complete apparatus shall continue to provide respiratory protection during and after exposure to a given chemical.

Note: There is no specific clause in BS 8468 covering degradation by chemical exposure – it is geared towards CWAs only, whereas our remit is much broader. BS 8468 concentrates on protection against CWAs: if severe degradation occurred during BS 8468 tests, it is likely that the equipment would fail the protection tests in BS 8468.

After exposure the facemask visor shall meet the requirements of 5.3.2 for visor impact.

Testing in accordance with 5.6.13.

5.4 Performance requirements for respiratory protective equipment type D3d

5.4.1 General

This device shall comply with draft BS 8468-4 and the requirements of 5.4.2 to 5.4.9. It shall not be used in atmospheres containing dust levels greater than 400mg/m^3.

5.4.2 Facepiece visor

5.4.2.1 VISOR IMPACT

After being subjected to any pre-conditioning requirements, the apparatus shall continue to function and provide respiratory protection after an impact on the facepiece visor and associated components in accordance with:

- EN 166:2001 clause 7.2.2 “Protection against high-speed particles” - medium energy impact; and
- EN 166:2001 clause 7.3.4 “Protection against high speed particles at extremes of temperature” – medium energy impact.

In addition, visibility through the visor after each impact test shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

> **Note:** this performance requirement is intended to give a face-piece visor that is strong enough to continue providing full respiratory protection after a 6 Joule impact from a projectile at –5°C and +55°C. After such an impact, in addition to continued respiratory protection, the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.
>
> This requirement is the same as that for currently available EN 136 masks.

This performance requirement uses tests from existing standards. These are given in clause 5.6.4.

5.4.2.2 FACEPIECE VISOR CHEMICAL RESISTANCE

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the visibility through the visor shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the face-piece visor shall meet the impact performance requirements for respiratory protection and visibility as given in 5.4.2.1.

Note: this performance requirement is intended to give a face-piece visor whose impact resistance and visor visibility are not compromised by exposure to chemicals. As for "Face-piece visor impact", after exposure to a chemical the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This performance requirement needs new test methods. Options for these new test methods are suggested in 5.6.2.

5.4.2.3 FACEPIECE VISOR ABRASION RESISTANCE

After the visor is subjected to the abrasion test the visibility through the visor shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

Note: this performance requirement is intended to give a face-piece visor whose visor visibility is not compromised by cleaning large quantities of abrasive dust from the visor when working in a high dust level. As for "Face-piece visor impact", after abrasion the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This performance requirement needs new test methods. Options for these new test methods are suggested in 5.6.12.

5.4.3 Faceblank or hood material

The mask faceblank or hood material shall be tested in accordance with EN 14325:2004, clause 4.11 and shall, as a minimum, meet the requirement for class 4 as defined in that clause.

This performance requirement will need new test methods based on modifying those in existing standards. These are given in 5.6.3.

5.4.4 Strength of connections

The connection(s) between the filter(s) and the turbo unit and between the power source (battery) and the turbo unit shall withstand an axial pull of 250N for 10 second. The connection(s) shall not fail and there shall be no significant damage to any of the components.

Testing in accordance with 5.6.10.

5.4.5 Robustness of the breathing hose

The breathing hose shall be sufficiently robust to withstand a 5 Joule impact and shall remain leak tight.

The breathing hose shall meet the requirements of EN 12942:1998, clause 6.10.2 but with an applied force of 250N.

Testing in accordance with 5.6.11.

5.4.6 Dust induced malfunction of filters, valves and connections

5.4.6.1 MASK BASED DEVICES

The apparatus shall continue to meet the breathing resistance requirements of EN 12942:1998 during exposure to an atmosphere containing 400mg/m^3 of dust and shall remain leak tight afterwards. Dust concentration inside the mask shall not exceed an average of 0.2mg/m^3 during the test. Warning devices shall still continue to function.

> **Note:** The in-face-piece concentration limit set here represents protection to at least the specified NPF for this device against a challenge of 400mg/m^3.

Testing in accordance with 5.6.5.

5.4.6.2 HOOD BASED DEVICES

The apparatus shall continue to meet the breathing resistance requirements of EN 12941:1998 during exposure to an atmosphere containing 400mg/m^3 of dust. Dust concentration inside the hood shall not exceed an average of 0.8mg/m^3 during the test. Warning devices shall still continue to function.

> **Note:** The in-face-piece concentration limit set here represents protection to at least the specified NPF for this device against a challenge of 400mg/m^3.

Testing in accordance with 5.6.5.

5.4.7 Dust clogging of filters at high dust levels

The apparatus shall continue to meet the requirements of EN 12942:1998 clause 6.8 (masks) or EN 12941:1998 clause 6.8 (hoods) when exposed to an atmosphere of 400mg/m^3.

Testing in accordance with EN 12942:1998 clause 7.9 (masks), or EN 12941:1998 clause 7.8 (hoods).

5.4.8 High level liquid penetration resistance

The complete apparatus shall continue to provide respiratory protection during and after exposure to a water jet. Masks shall remain leak tight.

Testing in accordance with 5.6.8.

5.4.9 High level chemical resistance

The complete apparatus shall continue to provide respiratory protection during and after exposure to a given chemical.

After exposure the facemask visor shall meet the requirements of 5.4.2 for visor impact.

Testing in accordance with 5.6.13.

5.5 Performance requirements for respiratory type D3e

5.5.1 General

This device shall comply with BS 8468-2:2006 and the requirements of 5.5.2 to 5.5.7. It shall not be used in atmospheres containing dust levels greater than 400mg/m^3.

5.5.2 Face mask visor

5.5.2.1 VISOR IMPACT

After being subjected to any pre-conditioning requirements, the apparatus shall continue to function and provide respiratory protection after an impact on the facepiece visor and associated components in accordance with:

- EN 166:2001 clause 7.2.2 “Protection against high-speed particles” - medium energy impact; and
- EN 166:2001 clause 7.3.4 “Protection against high speed particles at extremes of temperature” – medium energy impact.

In addition, visibility through the visor after each impact test shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

Note: this performance requirement is intended to give a face-piece visor that is strong enough to continue providing full respiratory protection after a 6 Joule impact from a projectile at –5°C and +55°C. After such an impact, in addition to continued respiratory protection, the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This requirement is the same as that for currently available EN 136 masks.

This performance requirement uses tests from existing standards. These are given in 5.6.4.

5.5.2.2 FACE MASK VISOR CHEMICAL RESISTANCE

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the visibility through the visor shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

After being subjected to any pre-conditioning requirements, and after exposure to a given chemical, the face mask visor shall meet the impact performance requirements for respiratory protection and visibility as given in 5.5.2.1.

Note: this performance requirement is intended to give a face mask visor whose impact resistance and visor visibility are not compromised by exposure to chemicals. As for “Face mask visor impact”, after exposure to a chemical the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This performance requirement needs new test methods. Options for these new test methods are suggested in 5.6.2.

5.5.2.3 FACE MASK VISOR ABRASION RESISTANCE

After the visor is subjected to the abrasion test the visibility through the visor shall be such as to enable a sign with characters 100mm high to be read from a distance of 6m in accordance with EN 403:2004 clause 6.17.2.

Note: this performance requirement is intended to give a face mask visor whose visor visibility is not compromised by cleaning large quantities of abrasive dust from the visor when working in a high dust level. As for “Face mask visor impact”, after abrasion the vision through the visor is intended, at worst, to be sufficient for the wearer to be able to move safely out of the hazardous area.

This performance requirement needs new test methods. Options for these new test methods are suggested in 5.6.12.

5.5.3 Faceblank

The faceblank shall be tested in accordance with EN 14325:2004, clause 4.11 and shall, as a minimum, meet the requirement for class 4 as defined in that clause.

This performance requirement will need new test methods based on modifying those in existing standards. These are given in 5.6.3.

5.5.4 Dust induced malfunction of filters, valves and connections

The apparatus shall continue to meet the breathing resistance requirements of the Standards referenced in 5.5.1 during exposure to an atmosphere containing 400mg/m^3 of dust and shall remain leak tight afterwards.

Testing in accordance with 5.6.5.

5.5.5 Dust clogging of filters at high dust levels

Covered by EN 143:2000.

The apparatus shall continue to meet the breathing resistance requirements of the relevant standards listed in 5.5.1 during and after exposure to a given chemical, and shall remain leak tight after exposure.

This performance requirement will need new test methods based on modifying those in existing standards. These are given in 5.6.2.

5.5.6 High level liquid penetration resistance

The complete apparatus shall continue to provide respiratory protection and remain leak tight during and after exposure to a water jet.

Testing in accordance with 5.6.8.

5.5.7 High level chemical resistance

The complete apparatus shall continue to provide respiratory protection during and after exposure to a given chemical.

After exposure the facemask visor shall meet the requirements of 5.5.2 for visor impact.

Testing in accordance with 5.6.13.

5.6 New respiratory protective equipment test methods needed

5.6.1 General

All the new test methods in this section are given where there are none in existing standards which can be used to completely assess the new performance requirements given in this specification.

As noted in section 1.3, these new test methods are given as suggestions only, and have not been practically evaluated. They describe the principles involved, and are not fully defined and ready to be used "as written". Where possible, these new test methods use, or give as examples, test methods from existing standards.

5.6.2 Face-piece visor chemical resistance test

5.6.2.1 CHEMICALS USED FOR TESTING

The chemicals and volumes used for testing should be representative of the range to be encountered when the PPE is in use.

Table 5.1 is a good example of a basic list of chemicals for such testing (as given in EN 14458:2004 clause 5.2.16).

Chemicals from the list in Appendix 1 can be used for this test where it is considered appropriate. The volume of liquid used for the tests should be appropriate to the likely worst case exposure during use – for typical CWAs, only a few microlitres may be appropriate.

Table 5.1 - List of chemicals for resistance testing of visor assemblies		
Chemical	**Concentration weight %**	**Temperature of chemical °C (± 2°C)**
Sulphuric acid	30 (aqueous)	20
Sodium hydroxide	10 (aqueous)	20
p-Xylene	Undiluted	20
Butan-1-ol	Undiluted	20
n-Heptane	Undiluted	20

Note: these chemicals are, in tabled order, representative of an acid, a base, a cyclic organic solvent, an aliphatic organic solvent and organic solvents found in transport fuels.

Details of the chemicals used for any test should be given in the information provided by the manufacturer with the PPE.

5.6.2.2 TEST METHOD

EN 14458:2004 clause 6.10 contains a suitable sequence for applying the chemicals to the visor. This text can be adapted for a face mask visor as follows:

“Test chemicals shall be at a temperature of (20±2) °C. The chemical shall be applied with the visor assembly mounted in the in-use position, oriented as though being worn by a standing subject.

100 ml (or the appropriate amount, see 5.6.2.1) of the test chemical shall be poured onto the visor and any exposed parts of the means of fixing. The chemical shall be poured along the upper exposed edges of the visor assembly, moving from one side to the other using half the amount of chemical, and the rest going back, thus covering the assembly twice. This operation shall take (10± 3) seconds.

Five minutes after having applied the chemical, residues shall be removed (using any appropriate method such as rinsing in clean water and drying). The device shall then be subjected to examination and testing as required.”

5.6.3 Faceblank or hood material chemical resistance test

EN 14325:2004 clause 4.11 calls on either:

- the test method in EN 374-3:2003; or

- test methods A or B in EN ISO 6529:2001.

These methods need to be modified from their use for clothing materials to their use for faceblank/hood materials. Procedures similar to those used for glove or footwear materials may be appropriate.

Table 5.1 is a good example of a basic list of chemicals for such testing.

Chemicals from the list in Appendix 1 can be used for this test where it is considered appropriate.

Note: There is no specific clause in BS 8468 covering degradation by chemical exposure – it is geared towards CWAs only, whereas our remit is much broader. BS 8468 concentrates on protection against CWAs: if severe degradation occurred during BS 8468 tests, it is likely that the equipment would fail the protection tests.

5.6.4 Facepiece visor impact test

EN 166:2001 clauses 7.2.2 and 7.3.4 both invoke the test method in EN 168:2001 clause 9.

EN 403:2004 clause 6.17.2 invokes the test method in EN 403:2004 clause 7.5.

5.6.5 Test method for dust induced malfunction of (filters), valves and connections

Based on 13274-8:2002 Dolomite dust clogging with a suitable means of measuring in-facepiece dust concentration.

5.6.6 Test method for performance of demand valve at high dust levels

Based on 13274-8:2002 Dolomite dust clogging.

5.6.7 Test method for performance of warning system at high dust levels

Based on 13274-8:2002 Dolomite dust clogging.

5.6.8 Test method for liquid penetration of (filters), valves and connections

Based on spray test described in EN 468:1994.

5.6.9 Test method for gas/vapour induced malfunction of (filters), valves and connections

One suitable approach is given in clause 14 “Test for protection against gases and fine dust particles” of EN 168:2001, where ammonia is used as the chemical vapour. (This method is called on by the performance requirement in clause 7.2.6 “Protection against gases and fine dust particles” of EN 166:2001.)

This method would need to be modified to use different chemical vapours. The chemical vapours used for testing should be representative of the range to be encountered when the PPE is in use.

Table 5.1 is a good example of a basic list of chemicals for such testing (as given in EN 14458:2004 clause 5.2.16).

Details of the chemicals used for any test should be given in the information provided by the manufacturer with the PPE.

5.6.10 Strength of connections

Mount the turbo unit on a dummy torso using additional restraining straps if required to ensure that the load is applied to the turbo unit/filter connection as directly as possible, then apply an axial load of 250N for 10 seconds to the filter.

Repeat the test for each additional filter and the power source (battery).

> **Note:** It may be necessary to use a dummy power source to enable the test force to be applied.

5.6.11 Robustness of the breathing hose

Based on EN 397:1995 clause 6.7.

5.6.12 Facepiece visor abrasion test

There are two suggested approaches to this test method.

5.6.12.1 OPTION 1 – ABRASION BY FALLING MATERIAL

One method used in existing standards is to subject the visor material to falling abrasive material and measure the effect on visibility through the visor.

An example of this approach is found in the test method described in clause 15 “Test for resistance to surface damage by fine particles” of EN 168:2001, where sand is used as the abrasive material. This method is called on by the performance requirement in clause 7.3.1 “Resistance to surface damage by fine particles” of EN 166:2001.

While this approach is repeatable as a test method, it is not viewed by experts as a “good” test method. The falling sand only imparts minimal impact and friction on the visor surface, and this does not replicate the pressures and forces which may be applied when wiping a dirty visor to clean it.

5.6.12.2 OPTION 2 – ABRASION BY CONTROLLED WIPING WITH ABRASIVE MATERIAL

An alternative is to wipe the visor in a controlled manner with a defined abrasive material, and measure the effect on visibility through the visor. For a reliable test method the stroke, application force, duration and location of the wiping action should be defined. A fixed type of abrasive material should also be defined.

An example of this type of test is the Taber abrasion test, applied to planar samples of visor material in Annex A of EN 14458:2004.

5.6.12.3 TEST FOR HIGH LEVEL CHEMICAL RESISTANCE

Base on test methods described in 5.6.2.2 and 5.6.3 using the chemicals listed in Appendix 1.

Filters will have to be tested in accordance with the manufacturer’s guidance on filter performance.

Note: BS8468 does not address this. What we are considering here is not filter penetration by the challenge agent, it is damage to the filter e.g. destruction of the body of the canister by gross exposure to the chemical.

SECTION 6
Footwear

6.1 General introduction

This section describes the minimum performance specification for footwear providing protection to the feet below the ankle, and possibly to the lower leg. The performance requirements may be met by a single item of footwear, or by combinations of different footwear layers designed to be worn simultaneously.

In this work we have assumed that any high dust or chemical, biological, radiological (CBR) barrier performance needed for the feet is provided by integral or attached accessory socks on the clothing. Footwear described here requires only to protect the wearer and the sock from mechanical and thermal damage, and to have basic resistance to chemicals including CBR.

If the footwear does provide the chemical barrier then it would have be tested with the PPE clothing for chemical permeation and full ensemble testing.

Note: See also the comment in section 3.1 on the exclusion of footwear type E3b from this specification.

Requirements in this section are based where possible on existing standards covering safety footwear, and footwear protecting against chainsaws, chemicals, electrical or firefighting hazards.

6.2 General scope

Type E1a footwear provides levels of mechanical strength consistent with intended urban search and rescue (USAR) applications. It provides limited protection to the wearer from impact, crushing, rough surfaces and abrasions, non-hazardous airborne and settled dusts, heat and flame, water and a small number of liquid chemicals. These properties apply as a minimum to all USAR activities. For Scenario 3 activities, the footwear must also be resistant to a wide range of CBR substances.

It is important to note that for E1a although the specification is basically the same for Scenarios 2 and 3 the chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including CBR substances.

Footwear can only provide limited protection against impacts and compression. In particular, for practicality of use, only the toe region of the footwear is specifically designed to provide significant levels of protection to the wearer against such mechanical hazards. While some limited protection is also specified below against hazards such as electricity, chain saws or molten metal splash, there may be operational situations where additional specific protection will be required against such hazards.

6.3 Performance requirements for E1a footwear

6.3.1 Introduction

In addition to the general and type-specific requirements set our below, the usability, performance and protection of footwear depends strongly on comfort and compatibility with both the user and the other items of the protective ensemble. Practical performance testing of the footwear as part of a protective ensemble is essential. Relevant practical performance tests are called up in other sections of this specification (some of which are referenced under distinct footwear requirements), and for complete ensembles in section 11. Such practical performance testing shall include assessment of the marking, information and user instructions provided by the manufacturer (required by EN ISO 20345:2004 clauses 7 and 8).

6.3.2 Footwear general basic requirements

Footwear shall meet the requirements of EN ISO 20345:2004 clause 5.

Where footwear may be used in a flammable/explosive atmosphere, they shall have no exposed light alloys which may on frictional impact give rise to incendive sparks.

6.3.3 Footwear general additional mechanical requirements

Footwear or its component parts shall meet the requirements in Table 6.1, where applicable.

> **Note:** Establishment of applicability will be assisted by reference to Table 14 of EN ISO 20345:2004.

Table 6.1 Additional mechanical requirements for footwear E1a		
Requirement	**Clause (EN ISO 20345:2004 unless otherwise stated)**	**EN ISO 20345 symbol**
Penetration resistance	6.2.1	P
Energy absorbing seat	6.2.4	E
Ankle protection	6.2.7	AN
Resistance to chainsaw cutting, Level 2	EN ISO 17249:2004, 5.2, 5.3, 5.4	-

6.3.4 Footwear general heat and flame protection

Footwear materials or material assemblages shall achieve at least the performance levels given in Table 6.2, when tested as specified in the relevant standard, subject to any variations given in Table 6.2.

Table 6.2 Heat and flame requirements for footwear			
Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Flame resistance	EN 15090:2006	6.3.3	-
Contact heat insulation of sole	EN 15090:2006, 6.3.1	HI_1	Test at 150°C
Heat resistance of sole	EN 15090:2006, 6.3.1	HI_1	Test at 150°C
Radiant heat protection	EN 15090:2006, 6.3.2	RHTI >40s	-
Resistance to molten metal	BS 4676:2005	Table 2	Tested as Annex A, but with (200±30) cm^3 of metal.

6.3.5 Footwear general cold performance

6.3.5.1 COLD CONTACT PROTECTION

Materials of the sole assembly shall meet the requirements of EN ISO 20345:2004 clause 6.2.3.2.

6.3.5.2 RESISTANCE TO COLD CONDITIONS

The complete footwear shall be subjected to practical performance tests according to 3.4.3 at the lowest operating temperature claimed by the manufacturer, as part of the garment ensemble.

Note: Low temperature garment tests are conducted at -10°C, -20°C or –30 °C.

No failure or degradation of materials, seams or closures shall be observed for the footwear, and no test subject shall report the footwear to be unusable or withdraw from the test as a result of problems with the footwear.

Note: Visual assessment for damage may be conducted according to the guidance in EN 15090:2006 Annex B, clause B.2.

6.3.6 Footwear general visibility and conspicuity (optional)

Where affixed to the footwear, retroflective material shall encircle the leg of the footwear and as a minimum meet the following requirements of EN 471:2003:

a) clause 4.2.2 - minimum width 50mm,

b) clause 6.1 - coefficient of reflection level 2,

c) clause 6.2 – retroreflective performance after test exposure (wear effects)

6.3.7 Footwear general slip resistance

6.3.7.1 SOLE PROPERTIES

Footwear soles shall conform to the requirements of EN ISO 20345:2004 clauses 6.4.1, 6.4.2 and 6.4.3.

6.3.7.2 FOOTWEAR SLIP RESISTANCE PERFORMANCE

Footwear shall achieve a coefficient of friction of at least 0.36 when tested according to 6.4.2.

6.3.8 Footwear general electrical properties

6.3.8.1 ELECTRICALLY INSULATING FOOTWEAR

Footwear shall meet at least the requirements for Class 0 insulation of EN ISO 20345:2004 clause 6.2.2.3.

6.3.8.2 ANTISTATIC FOOTWEAR

Footwear shall meet the requirements of EN ISO 20345:2004 clause 6.2.2.2.

6.3.9 Footwear protection against solid particles

Footwear shall be considered to protect against solid particles if it satisfies the requirements of 6.3.10 applicable to the footwear design (see EN ISO 20345:2004 Tables 2 and 14).

6.3.10 Footwear protection against liquids

Footwear shall meet the requirements in Table 6.3 applicable to the footwear design (see EN ISO 20345:2004 Tables 2 and 14).

Table 6.3 Footwear protection against liquids

Requirement	Reference, Clause	Comments
Leakproofness	EN ISO 20345:2004, 5.3.3	-
Water penetration and absorption	EN ISO 20345:2004, 6.3.1	-
Water resistance	EN ISO 20345:2004, 6.3.1	-
Liquid penetration resistance	This specification, 3.5.3	Test as part of the garment ensemble

6.3.11 Footwear chemical permeation resistance

Footwear shall achieve at least level 3 permeation resistance of EN 13832-3:2006 when tested using the liquid chemicals given in Table 5.1.

6.3.12 Footwear chemical degradation resistance

Footwear shall meet the requirements of EN 13832-3:2006 clause 6.2.2 when tested using the liquid chemicals given in Table 5.1.

The outsole shall also meet the requirements of EN ISO 20345:2004 clause 5.8.7 for fuel oil.

6.4 Footwear test methods needed

6.4.1 General introduction

All the new test methods in this section are given where there are none in existing standards which can be used to completely assess the new performance requirements given in this specification.

As noted in section 1.3, these new test methods are given as suggestions only, and have not been practically evaluated. They describe the principles involved, and are not fully defined and ready to be used “as written”. Where possible, these new test methods use, or give as examples, test methods from existing standards. If alternative test methods are available to assess the performance requirements and they are considered appropriate, they can be used where necessary.

6.4.2 Test method for slip resistance of complete footwear

The method of DIN 51130:2004 shall be used to assess the performance of the footwear, but using representative flooring surfaces (e.g. steel and smooth concrete with defined surface roughness properties) with water as the contaminant. The tangent of the angle of the ramp at which slip occurs gives the coefficient of friction.

SECTION 7
Gloves

7.1 General introduction

This section describes the minimum performance specification for gloves providing protection to the hands from the wrists. The requirements for the different types of performance may be met by a single glove, or by combinations of different gloves worn simultaneously. For practical reasons, the outermost glove of two or more gloves worn at the same time will be required to provide the majority of the mechanical and physical protection to the wearer, and also to chemical/biological resistant gloves/layers worn underneath.

In this work we have assumed that any high dust or chemical, biological, radiological (CBR) barrier performance needed for the hands is provided by integral or attached accessory glove on the clothing. Gloves described here require only to protect the wearer and the inner glove(s) from mechanical and thermal damage, and to have basic resistance to chemicals.

7.2 General scope

Type F1a gloves essentially only specify mechanical, physical and thermal protection to the hands, and do not protect against water, or toxic or harmful solid, liquid or gaseous chemicals.

Protection to the hands against contaminants will be limited by the quality and integrity of the interface between the cuff of the glove and the sleeve of the garment. For this reason, critical protective performance of gloves shall be assessed in conjunction with garments as an ensemble, as described in Sections 3 and 11.

It is important to note that for F1a although the specification is basically the same for Scenarios 2 and 3 the chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including CBR substances.

7.3 Performance requirements for F1a gloves

7.3.1 General introduction

Gloves specified here essentially only provide mechanical, physical and thermal protection to the hands, and do not protect against water, or toxic or harmful solid, liquid or gaseous chemicals. Requirements in this clause are likely to be required for the majority of urban search and rescue (USAR) glove applications. It is assumed that high dust and CBR barrier performance will be provided by a separate glove component of the clothing worn beneath this glove. The requirements of this clause shall therefore be met by the outermost glove layer or layers used for protection. Unless otherwise specified, gloves shall conform to applicable general requirements of EN 420:2003 concerning:

- innocuousness
- design and construction
- comfort and efficiency
- size designation
- marking, and
- information supplied by the manufacturer.

Where appropriate, design of gloves shall also take the following aspects into consideration:

- EN 510:1993 – where there is a risk of entanglement.
- ISO 11611:2007 Clause 4, where there is a risk of exposure to molten spatter.
- where gloves may be used in a flammable/explosive atmosphere, they shall have no exposed light alloys which may on frictional impact give rise to incendive sparks.

These aspects shall be assessed by visual inspection and by means of practical performance testing (as part of a clothing ensemble). Basic ergonomic performance during practical performance testing shall be assessed in accordance with guidance in EN 340:2003 Annex C.

7.3.2 Gloves general – Sampling, conditioning and pretreatment

Numbers of samples, pre-treatment and conditioning of samples, shall be as described in the standards referenced, unless specified differently in this document.

7.3.3 Glove dexterity

Single gloves and combinations of gloves worn together to provide protection (including any glove component of clothing) shall be assessed for finger dexterity according to EN 420:2003 clause 5.2. Gloves and intended combinations shall achieve at least level 1 performance.

Note 1: Higher levels of performance in this test are always desirable.

Note 2: Section 11 of this standard describes means of conducting more comprehensive assessments of dexterity, applied to complete ensembles.

7.3.4 Glove F1a resistance to minor impacts

The glove shall be designed and constructed to provide resistance to minor knocks and abrasions to the hand, particularly the palm and knuckles. The position and performance of this protection shall be deemed adequate during practical performance testing according to 3.4.2 and 3.4.3.

7.3.5 Glove F1a mechanical strength

Materials from which gloves are made shall meet at least the performance levels given in Table 7.1, when tested as specified in the relevant standard, subject to any variations given in Table 7.1.

Table 7.1 Mechanical performance requirements for glove materials

Property	Standard reference	Minimum performance level	Variations from referenced standard
Abrasion	EN 659:2003, 3.3	3	-
Blade cut	EN 659:2003, 3.4	2	-
Tear	EN 659:2003, 3.5	3	-
Puncture	EN 659:2003, 3.6	3	-

Seams shall achieve at least a strength of 350N when tested according to ISO 13935-2:1999.

7.3.6 Glove F1a protection against vibration (optional)

Note: The ability of gloves to provide effective protection against vibration is at best considered to be doubtful. This requirement has been included as an option for situations where an adequate risk assessment has determined that vibration risks (e.g. arising from power tool use) can be mitigated by the use of this type of equipment.

Gloves shall optionally conform to the anti-vibration requirements of EN 10819:1996.

7.3.7 Glove F1a heat and flame resistance

7.3.7.1 MATERIALS HEAT RESISTANCE

Glove materials, or material assemblages for multi-layered construction, shall achieve at least the performance levels given in Table 7.2, when tested as specified in the relevant standard, subject to any variations given in Table 7.2.

Table 7.2 Glove materials heat resistance

Property	Standard reference	Minimum performance level	Variations from referenced standard
Contact heat resistance	EN 407:2004, 5.2	Threshold time >15s	Test at 250°C
Molten spatter resistance	EN 12477:2001, 5.8	Level 2 (15 drops)	-
Heat shrinkage	EN 659:2003, 3.12	<5% shrinkage	-

7.3.7.2 FLAME RESISTANCE

Glove materials, or material assemblages for multi-layered construction, shall achieve the performance levels given in Table 7.3, when tested as specified in the relevant standard, subject to any variations given in Table 7.3. For gloves of multi-layer construction, samples of the complete assemblage shall be tested.

Table 7.3 Flame resistance

Property	Standard reference	Minimum performance level	Variations from referenced standard
Materials flame resistance	EN 407:2004, 5.1	4	3 second exposure only.
Seam flame resistance	EN 407:2004, 5.1	Seams to remain intact	3 second exposure only.

7.3.8 Glove F1a cold resistance

Note: Requirements in this clause may be met with the addition of thermal insulative/protective layers or liners, to the glove. Manufacturer's instructions should make clear when to use such layers.

7.3.8.1 COLD CONTACT PROTECTION

Materials of the glove shall achieve at least level 2 of EN 511:2006 clause 4.6, when tested as described in clause 5.6 of that standard.

7.3.8.2 Resistance to cold conditions

The complete glove shall be subjected to practical performance tests according to 3.4.3 at the lowest operating temperature claimed by the manufacturer.

Note: Low temperature garment tests are conducted at -10°C, -20°C or –30 °C. For compatibility, gloves to be used in such an ensemble should be similarly tested.

No failure or degradation of materials, seams or closures shall be observed, and no test subject shall report the glove to be unusable or withdraw from the test as a result of problems with the glove.

7.3.8.3 PROTECTION AGAINST COLD CONDITIONS

Protection against cold conditions shall be assessed as given in Table 7.4. Where the glove includes removable thermal layer(s), performance shall be reported for the glove with and without the layer(s) present, where indicated in Table 7.4.

Table 7.4 Glove protection against cold conditions

Property	Standard reference	Minimum performance level	Variations from referenced standard
Convective cold	EN 511:2006, 4.5	Level 2	For each glove configuration
Air permeability	EN 342:2004, 4.3	Class 3	For each glove configuration

Based on the information in Annex B of EN 511:2006, the manufacturer shall provide advice on the limitations to use of the glove in cold conditions.

7.3.9 Glove F1a electrical properties

7.3.9.1 RESISTANCE TO LIVE ELECTRICAL CONTACT

Note: The requirement below minimises the possibility of electrical shock by short term, accidental contact with live electric conductors at low voltages, up to approximately 100V DC. It may not prevent injury or electrocution by longer contacts or higher voltages.

See also the note in 3.3.8.1.

Glove materials shall meet the requirements of ISO 11611:2007, clause 6.10 (>10^5 ohms).

7.3.9.2 ANTISTATIC PROPERTIES

Glove materials shall satisfy the following requirements in Table 7.5 for vertical and surface resistance.

Table 7.5 Electrostatic properties of materials

Property	Standard reference	Minimum performance level	Variations from referenced standard
Surface resistivity	EN 1149-1:2006	<10^{11} ohms	-
Vertical resistance	EN 1149-2:1997	<10^8 ohms	-

7.3.10 Glove F1a chemical degradation resistance

Separate samples of glove materials shall be chemically preconditioned by 60 minutes continuous contact exposure to at least each of the chemicals listed in Table 5.1. (Additional tests against the chemicals listed in Table 3.7 may optionally be carried out). The samples shall then be tested according to EN 14325:2004, clause 4.10, in comparison with unexposed samples (7.3.5 may generate data for unexposed samples which can be used here). There shall be no change to the measured puncture resistance class, or significant visible degradation.

SECTION 8

Elbow and knee protection

8.1 General introduction

Kneeling and crawling will expose workers to possible discomfort and immediate injuries, or their garments to possible damage, from rough and hard surfaces, small stones and sharps, or hot/cold surfaces. This section describes specific additional protection to these vulnerable areas, intended to reduce the possibilities of such injury/damage during urban search and rescue operations.

8.2 General scope

A single type of elbow/knee protective performance (G1a) is described. This provides protection against minor impacts and abrasion, compression, puncture and contact with moderately hot/cold surfaces. It resists electrical conduction, build-up of electrostatic charge and flame, and has basic chemical resistance.

The principal requirements of EN 14404:2004 (covering knee protectors) are adapted and extended within section 8 of this specification to apply to elbow protectors. Aspects of performance not covered in EN 14404:2004 are adapted from footwear standards.

Two relevant forms of knee protector are defined in EN 14404:2004:

a) Pads which are independent of other clothing and fasten around the limb (EN 14404:2004 Type 1).

b) Pads which are inserted in pockets on garments or are permanently attached to the garment (EN 14404:2004 Type 2).

Either of these forms may be provided.

Where protectors are inserted into pockets in the garment and are entirely covered by garment material, the following clauses need not be tested:

- clause 8.3.7 Resistance to flame
- clause 8.3.8 Resistance to molten droplets
- clause 8.3.9.2 Antistatic properties
- clause 8.3.11 Resistance to water penetration
- clause 8.3.12 Resistance to chemical degradation.

It is important to note that for G1a although the specification is basically the same for Scenarios 2 and 3 the chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including chemical, biological, radiological substances.

8.3 Performance requirements for G1a elbow and knee protectors

8.3.1 General requirements

Unless otherwise specified, elbow/knee protectors shall conform to applicable general requirements of EN 14404:2004 concerning:

- innocuousness
- design and construction
- comfort and efficiency
- size designation
- marking, and
- information supplied by the manufacturer.

Where pads may be used in a flammable/explosive atmosphere, they shall have no exposed light alloys which may on frictional impact give rise to incendive sparks.

These aspects shall be assessed according to Table 1 of EN 14404: 2004, by visual inspection and by means of practical performance testing (as part of a clothing ensemble). Basic ergonomic performance during practical performance testing shall be assessed in accordance with the guidance in EN 340:2003 Annex C.

8.3.2 Elbow/knee protectors – sampling, conditioning and pretreatment

Numbers of samples, pre-treatment and conditioning of samples, shall be as described in the standards referenced, unless specified differently in this document.

8.3.3 Elbow and knee protection G1a dimensions

8.3.3.1 KNEE PROTECTORS

Dimensions of knee protectors shall conform to the requirements of clause 5.2.4 of EN 14404:2004, Type 1 or Type 2 as appropriate.

8.3.3.2 ELBOW PROTECTORS

Dimensions of elbow protectors shall conform to the requirements of DD CEN/TS 15256:2005 clause 5.4.2.

Note: These dimensions are for elbow protectors for ice hockey players other than goalkeepers. No other suitable specification could be identified, but the combination of necessary mobility and required anatomical protection are probably comparable with urban search and rescue.

8.3.4 Elbow and knee protection G1a mechanical properties

Elbow and knee protectors shall meet at least the performance levels given in Table 8.1, when tested as specified in the relevant standard, subject to any variations given in Table 8.1.

Table 8.1 Mechanical properties of elbow/knee protectors

Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Penetration resistance	EN 14404:2004, 5.2.5	2	-
Force distribution	EN 14404:2004, 5.2.6	<30N	For elbow protectors, substitute a suitable test elbow for the “Kandy” knee in EN 14404:2004, 6.6.1
Peak transmitted force	EN 14404:2004, 5.2.7	2	-

8.3.5 Elbow and knee protection G1a restraint

8.3.5.1 GENERAL RESTRAINT

The requirements of EN 14404:2004 clause 5.2.8.1 shall apply to both knee and elbow protectors.

8.3.5.2 RESTRAINT BY STRAPS

The requirements of EN 14404:2004 clause 5.2.8.2 shall apply to both knee and elbow protectors. (Reference to “knee” and “leg” shall also apply to “elbow” and “arm”, as appropriate.)

The requirements of EN 14404:2004 clause 5.4.2 shall be met by restraint straps.

The performance requirements of EN 14404:2004 clause 6.10.1 shall be met, substituting the exercise procedure at 8.4.2.

8.3.5.3 RESTRAINT BY POCKETS OR ATTACHMENT TO GARMENT

The requirements of EN 14404:2004 clause 5.2.8.3 shall apply to both knee and elbow protectors. (Reference to “knee” and “trouser” shall also apply to “elbow” and “sleeve”, as appropriate.)

The performance requirements of EN 14404:2004 clause 6.10.2 shall be met, substituting the exercise procedure at 8.4.2. (Reference to “knee” and “trouser” shall also apply to “elbow” and “sleeve”, as appropriate.)

8.3.6 Elbow/knee protectors G1a resistance to hot contact

Elbow/knee protectors shall achieve a threshold time of >15 s when tested according to EN 407:2004 clause 5.2 at 250°C.

8.3.7 Elbow/knee protectors G1a resistance to flame

Elbow/knee protectors shall achieve level 2 when tested according to EN 407:2004 clause 5.1.

8.3.8 Elbow/knee protectors G1a resistance to molten droplets

Elbow/knee protectors shall achieve level 2 when tested according to EN 407:2004 clause 5.5. There shall be no melting of the internal surface of the protector, and no ignition if the droplets adhere to the outside.

8.3.9 Elbow/knee protectors G1a electrical properties

8.3.9.1 RESISTANCE TO LIVE ELECTRICAL CONTACT

The elbow/knee protector shall meet the requirements of EN ISO 20345:2004 clause 6.2.2.3 for at least level 00.

8.3.9.2 ANTISTATIC PROPERTIES

The elbow/knee protector shall meet the requirements of EN ISO 20345:2004 clause 6.2.2.2.

8.3.10 Elbow/knee protectors G1a resistance to hot contact

Elbow/knee protectors shall meet the requirements of EN ISO 20345:2004 clause 6.4.4.

8.3.11 Elbow/knee protectors G1a resistance to water penetration

Elbow/knee protectors shall meet the requirements of EN 14404:2004 clause 5.3.

8.3.12 Elbow/knee protectors G1a chemical degradation resistance

Separate samples of elbow/knee protector pad materials shall be chemically preconditioned by 60 minutes continuous contact exposure to each of the chemicals listed in Table 5.1. The samples shall then be tested according to EN 14404:2004 clause 5.2.5, in comparison with unexposed samples (8.3.4 may generate data for unexposed samples which can be used here). The requirement for penetration resistance shall still be met.

Straps similarly exposed shall remain elastic. The force required to stretch the strap by 4cm shall not differ from the value measured at 8.3.5.2 by more than 20 per cent, and shall not exceed 11N.

8.4 New elbow and knee protection test methods needed

8.4.1 General introduction

All the new test methods in this section are given where there are none in existing standards which can be used to completely assess the new performance requirements given in this specification.

As noted in Section 1.3, these new test methods are given as suggestions only, and have not been practically evaluated. They describe the principles involved, and are not fully defined and ready to be used “as written”. Where possible, these new test methods use, or give as examples, test methods from existing standards.

8.4.2 Test method for ergonomic wearer trials

This test shall be conducted while wearing at least the garment, footwear and gloves which are intended to be used with the knee/elbow protectors.

A subject who is medically fit and with no knee or elbow injuries, and of an appropriate size, shall put on knee and elbow protectors. The subject shall adjust the straps or other fixings according to the manufacturer’s instructions. The subject shall walk around for (15±1) min and during this time get down on knees and elbows and stand up ten times. The subject shall also shuffle forwards for (10±1) m on their knees and elbows on a smooth concrete surface at about the tenth minute during the test. The subject shall not adjust or reposition the knee or elbow protectors during the test, and on one occasion shall remain on knees/elbows for (5±0.5) min.

SECTION 9
Eye and face protection

9.1 Note

No separate requirements are given here for eye/face protection for urban search and rescue applications (USAR) in the operational scenarios being considered. These areas of the wearer are covered by the full face respiratory protective device. Requirements contained in Section 5 of this specification document address the mechanical strength and vision requirements of these face-pieces.

There may be specific operational activities (e.g. chainsaw use and hot cutting) where additional eye/face protection is necessary. Available occupational equipment will need to be utilised, after assessment of adequacy, suitability and compatibility with the rest of the USAR ensemble.

SECTION 10
Fall arrest

10.1 General introduction

This section specifies the requirements, test methods, marking, and information supplied by the manufacturer, for full body harnesses.

10.2 General scope

A full body harness provides support primarily for fall arrest purposes, as part of a fall arrest system. The harness may comprise straps, fittings, buckles or other elements, suitably arranged and assembled to support the whole body of a person and to restrain during a fall, after fall arrest, or during rope supported access work.

A single type (I1a) of harness performance is described for all urban search and rescue applications.

It is important to note that for I1a although the specification is basically the same for Scenarios 2 and 3 the chemical degradation tests for Scenario 3 are likely to include a wider range of chemicals, including chemical, biological, radiological substances.

10.3 Performance requirements for I1a fall arrest

10.3.1 General introduction

The principal performance requirements for fall arrest harness are contained in EN 361:2002. A number of further requirements address the specific hazards of the USAR environment.

Unless otherwise specified, fall arrest harness shall conform to applicable general requirements of EN 361:2002 concerning:

- design and ergonomics
- materials and construction
- marking
- information supplied by the manufacturer.

Where harnesses may be used in a flammable/explosive atmosphere, they shall have no exposed light alloys which may on frictional impact give rise to incendive sparks.

Where necessary, these aspects shall be assessed by visual inspection and by means of practical performance testing. Basic ergonomic performance during practical performance testing shall be assessed in accordance with the guidance in EN 340:2003 Annex C.

10.3.2 Fall arrest general I1a sampling, conditioning and pretreatment

Numbers of samples, pre-treatment and conditioning of samples, shall be as described in the standards referenced, unless specified differently in this document.

10.3.3 Fall arrest I1a static strength

The requirements of EN 361:2002 clause 4.3 shall be met.

10.3.4 Fall arrest I1a dynamic performance

The requirements of EN 361:2002 clause 4.4 shall be met.

10.3.5 Fall arrest I1a additional elements

The requirements of EN 361:2002 clause 4.5 shall be met.

10.3.6 Fall arrest I1a resistance to flame

Harness materials shall achieve the performance levels given in Table 10.1, when tested as specified in the relevant standard, subject to any variations given in Table 10.1.

Table 10.1 Flame resistance			
Property	**Standard reference**	**Minimum performance level**	**Variations from referenced standard**
Materials flame resistance	EN 469:2005, 6.1	EN 469:2005, 6.1	Only outer face tested
Seams and fastenings	EN 469:2005, 6.1	EN 469:2005, 6.1	Only outer face tested.
Hardware	EN 469:2005, 6.1	EN 469:2005, 6.1. After testing, the main closure system shall operate once.	6.1.6 replaced by: If hardware is used on the protective clothing, this shall be tested as attached to the garment material, by applying the flame to the outer surface of the hardware item. Hardware of the main closure system shall be tested in the configuration in which it is present in the donned garment.

10.3.7 Fall arrest I1a resistance to low temperature

The requirements of 10.3.3, 10.3.4 and 10.3.5 shall be met after conditioning the harness (pre-fitted on the dummy torso if appropriate) at the lowest temperature stated by the manufacturer of the garment with which the harness is intended to be used (-10°C, -20°C or -30°C). Conditioning shall be for at least four hours at this temperature, and testing shall take place within five minutes of removing the harness/torso from the conditioning environment.

10.3.8 Fall arrest I1a chemical degradation resistance

The mean tensile strength of test-pieces (prepared as specified in 10.4.2) shall be measured using the procedure at 10.4.3. Three samples shall be tested as received, and three after exposure using the procedure at 10.4.4, for each of the chemicals given in Table 5.1. Mean tensile strength of the test-pieces shall not decrease by more than 10 per cent after exposure, and elongation at break shall not increase by more than 5 per cent.

10.4 New fall arrest test methods needed

10.4.1 General introduction

All the new test methods in this section are given where there are none in existing standards which can be used to completely assess the new performance requirements given in this specification.

As noted in Section 1.3, these new test methods are given as suggestions only, and have not been practically evaluated. They describe the principles involved, and are not fully defined and ready to be used “as written”. Where possible, these new test methods use, or give as examples, test methods from existing standards.

10.4.2 Manufacture of test-piece for chemical degradation testing

Test-pieces shall be representative of the materials and seams/connections used in the construction of the harness. The form of the test-piece shall be linear, with an overall length of 600mm between terminations suitable for connection to the testing machine. The test-piece shall be formed from two lengths of strap, joined in the centre by a typical seam construction. Separate test-pieces shall be provided for each material/joining construction used in the harness.

10.4.3 Test method for assessing chemical degradation

Test-pieces shall be tested to failure on a static testing machine in accordance with EN 364:1992 clause 4.1. Tensile force at breakage and elongation at break shall be measured.

10.4.4 Method for exposure of test-piece to chemicals

Appropriate safety procedures shall be applied to control the health and safety risks to operators during this chemical conditioning. These will vary according to the chemical substance being used.

The central seamed portion of the test-piece shall be placed in a shallow chemically resistant dish, and 1 ml of the test chemical shall be pipetted onto the centre of the seamed area. The exposed test-piece shall be allowed to stand for (300±10) second before being removed by suitable means (e.g. blotting, rinsing in clean distilled water if appropriate). The test-piece shall be conditioned at (23±5)$^{\circ}$C and (45±15)% relative humidity for at least 12 hours before testing.

SECTION 11

PPE Ensembles

11.1 General introduction

Note: Text 11.1 and 11.2 is largely based on the introductory sections of BS 8469:2007, adapted to be more specific to urban search and rescue applications.

The potentially severely adverse environments in which urban search and rescue (USAR) teams can be called upon to operate, present considerable challenges in protecting the operator. The personal protective equipment (PPE) provided by employers offers a high degree of technical performance thereby helping to minimize the risk of injuries.

Almost by definition, any item of PPE introduces a barrier between part or parts of the body and the external environment. Whilst this barrier is essential for protecting the body, it has long been recognised that this can have unwanted side-effects on the wearer in terms of imposing additional physical workload, hindering movement, impairing sensory perception or in some cases causing considerable discomfort. Such side-effects can reduce the efficiency of task performance and/or encourage the user not to wear the PPE correctly thereby impairing the level of protection afforded.

This problem has been recognised in legislation. The EC Directive on personal protective equipment enacted in the UK by *The Personal Protective Equipment Regulations 2002* places duties on PPE manufacturers to take account of ergonomic requirements, whilst the associated EC Directive on the use by workers of personal protective equipment at the workplace enacted in the UK by *The Personal Protective Equipment at Work Regulations 1992* (as amended) places similar duties on employers providing PPE for use.

To facilitate compliance with such legislation, European technical product standards for individual items of PPE, large numbers of which are called up in this specification, are gradually introducing tests for ergonomic characteristics. However, such standards are for testing individual products and seldom include the assessment of interactions with other items of PPE except in isolated cases (e.g. helmet-mounted ear-muffs conforming to EN 352-3) where they are an essential element of their use.

This specification includes additional forms of test exercises aimed at assessing the performance, compatibility and usability of single or small numbers of combined items. However, in use, it is the complete ensemble that operators will be required to wear to carry out their work. There is no substitute for a thorough dedicated assessment of the complete ensemble. Such ensemble tests are not intended to be used in place of methods for assessing the performance of individual items of PPE, either contained in their product standards or in this specification. Complete ensembles should be tested so that the compatibility of the numerous individual items can be evaluated and any adverse interactions between the individual items can be identified.

11.2 Aspects to be addressed

Specific aspects of ensembles which can be investigated using this type of methodology include:

- restriction of movement
- physiological burden
- donning, disrobing and doffing procedures
- communications
- comfort and operational efficiency.

Particularly problematic with regard to PPE interfacing and compatibility problems are the head region, and where other items of PPE must be used in conjunction with garments for body protection.

11.3 Suggested methodology

British Standard BS 8469:2007 specifies requirements and test methods for the objective and subjective evaluation of the ergonomic and thermal impact of PPE ensembles, including gloves, footwear, clothing, helmets and respiratory protective equipment (RPE), on wearers. It specifies requirements for testing by either assessing the performance of a PPE ensemble against a benchmark condition (i.e. benchmark testing) or assessing the performance of two or more PPE ensembles against each other (i.e. comparative testing). The standard incorporates practical performance testing as well as laboratory-based testing.

The results of the testing in this standard can assist employers who use PPE to demonstrate compliance with the EC Directive on personal protective equipment at the workplace, enacted in the UK by *The Personal Protective Equipment at Work Regulations 2002*.

The general approach and the testing methodology included in BS 8469:2007 incorporate practical experience gained during a major contemporary assessment of firefighters' PPE ensembles, including those intended for non-fire activities. The principles and test methods outlined are likely to be applicable to PPE ensembles utilised in other circumstances, e.g. USAR.

11.4 Procedures for use

PPE manufacturers are required to provide clear and sufficient instructions on how to use their equipment correctly and safely, including donning and doffing. Where, as anticipated in the case of USAR ensembles, items of PPE are sourced from a number of manufacturers for simultaneous use, the responsibility for developing suitable donning and disrobing/doffing procedures falls on the organisation requiring the combination. Development of suitable processes and procedures for use of ensembles will require expert evaluation and development, and probably input from the manufacturers of individual items.

Aspects such as ability to remove contaminated ensembles cleanly (i.e. disrobing), without contaminating the wearer, dressing assistants or others who may subsequently come into contact with the equipment, will definitely require separate dedicated study. Qualitative and quantitative approaches to this evaluation are possible.

Qualitative – observation and assessment by experienced practitioners from emergency services, nuclear industry or military spheres.

Quantitative – existing protocols have been developed to track and measure cross-contamination during use/disrobing using tracer materials.

While development and evaluation of these procedures is outside the scope of this specification, they may have an iterative effect on the materials, design, construction or interfacing of the PPE involved, which may require re-evaluation of the protection or function of the components according to the requirements of this specification.

11.5 Measurement of ensemble protection

11.5.1 Introduction

Sections 3, 5, 6 and 7 of this report indicate that the various separate components of the ensemble which comprise the barrier layer between the wearer and their contaminated environment must be tested together so that the ensemble respiratory and skin protection can be measured and the suitability of the ensemble for the intended work tasks assessed. This section outlines the procedures which will be needed to carry out this form of assessment. Although the PPE in sections 2, 4, 8 and 10 do not form part of this barrier, the inclusion of some or all of these items in ensembles for testing may be necessary to ensure that they do not adversely affect the performance of the PPE which does form the barrier layer. (Of course, when assessing the ergonomic or physiological aspects a full ensemble is likely to be needed for most tests.)

When assessed as described below, the protective performance of the ensemble is in effect being measured using a simulated workplace protection factor protocol. The duration of the test and activities carried out as test exercises should be sufficiently close to operational use to be considered as representative of the performance of the ensemble in a real deployment. As a result, the measured levels of protection may be taken as representative of likely workplace protection, and will supersede any generally accepted or assigned protection factors for individual items of equipment, such as assigned protection factors (APFs) for respiratory protection equipment (RPE).

We have defined the required skin protection factor for Scenario 3 as 1000, and the required respiratory protection factor for Scenario 3 as 10000. Ensemble items making up the barrier to exposure of the body which satisfy the total inward leakage (TIL) requirements in this document can be assumed to provide at least a SWPF of 1000. Respiratory protection meeting the requirements in this document can be assumed to provide at least a SWPF of 10000.

11.5.2 PPE items to be included in the assessment

All components of the ensemble which provide part of the barrier to ingress of contaminant shall be included in this assessment. These shall be worn as instructed by the manufacturer taking particular care over the interfacing of the separate components together. Typically, this will include:

- clothing
- gloves
- respiratory protective equipment.

Depending on design, it may also include any separate components required to complete the barrier layer, such as:

- separate hood
- separate bootees/socks/boots.

Where use of additional items of PPE is mandatory (e.g. mechanically robust boots covering integral socks on a garment) these shall also be worn during testing. Other items which may possibly affect protective performance may be included at the discretion of the test house, taking a precautionary approach.

Individual sections of the report detail the pre-conditioning required before undertaking assessment of protective performance – this will normally include either ambient or cold temperature practical performance tests immediately prior to protection measurement.

11.5.3 Measurement approaches for ensemble protection

11.5.3.1 ASSESSMENT USING PARTICLE TRACER

This test method for ensemble integrity is based on measuring the ingress of a standardised salt particle aerosol into the clothing or respiratory zone of the protective ensemble. Ensembles passing this test can be expected to protect the body and respiratory system against airborne particles to the required levels, but they may not achieve the same levels of performance against gases and vapours. When considered alongside performance data for garment materials and filters against specific chemicals, overall performance of the ensemble can be predicted.

The method uses that same generation system, test chamber and principles as described in EN 136 and EN 13982-2. Refer to these standards for detail of probes, probe locations, sampling flow rates and sampling times. Measurements of salt concentration drawn from inside the PPE are compared with that drawn from the challenge in the chamber, while the wearer carries out a series of test exercises.

Sampling probes for assessing protection to the body shall be as described in EN 13982-2 and located:

a) within the hood of the garment
b) in the upper right chest region of the garment
c) in the right leg of the garment at knee level.

(Where the hood forms an integral part of the respiratory protective device (i.e. is part of a powered hood-type respirator), the garment hood probe may be omitted.) Additional probe locations may be used if desired, but note that this will prolong the test period.

Sampling probes for the breathing zone of RPE shall be as described in EN 136 for masks, or EN 12941 for hoods.

When sampling from within the garment, an equivalent volume of clean air shall be fed into the garment through the nearest alternative probe position to that being sampled. No such make-up air is required when sampling from within RPE.

11.5.3.2 EXERCISE AND SAMPLING SEQUENCE

Test subjects shall carry out a pre-determined sequence of test exercises, such as that outlined in Table 11.1. Those listed here are drawn from the suite of practical performance test exercises detailed in EN 13274-2 and in EN 943-1. (The exact exercises included in the sequence may be varied to reflect differing operational activities and functions, but must be agreed between the test house, and the customer.)

For each exercise, samples shall be drawn sequentially from each of the clothing/RPE probes in the order – Knee; Chest; Hood; RPE, taking care where necessary to supply make-up air and to allow sufficient time for the sample concentration to stabilise after switching. Following stabilisation, the salt concentration at each sampling point shall be averaged over a period of 100s before moving on to the next exercise or sampling point.

Note that this type of test sequence is more physically demanding and protracted than “standard” PPE tests. Subject safety and well-being will need to be monitored more stringently as a result. Building in rest periods may allow subjects to partially recover from exertion, but also prolongs the overall test duration.

Table 11.1 Example exercise sequence for measurement of ensemble performance

Exercise	**Duration (approx) (min)**	**Origin**
Walk on level treadmill, 6 km/hr.	12	EN 13274-2 Table 1, No.2
Fill, lift and tip a basket of chippings at a rate of twice per minute.	12	EN 13274-2 Table 1, No.14
Three vertical pulls per minute on a work machine each lifting 25kg.	12	EN 13274-2 Table 1, No.15
Carrying and stacking 20 sandbags, each 12kg, from one end of the test chamber to the other, one at a time.	12	EN 13274-2 Table 1, No.16
Subject using a gas sampling hand pump.	12	EN 943-1, A.9.2, m.

Additional or alternative exercises of similar duration may be used where these are considered to be a more accurate representation of the urban search and rescue work-rates and procedures. Such activities may be identified and agreed in consultation with end-users.

11.5.3.3 DATA TREATMENT

PROTECTION TO THE BODY
For assessment of particle protection to the body, for each subject, sampling position and test exercise there will be a separate measurement of inward leakage (based on the exercise protocol above there would be six subjects x 3 probe positions x five exercises = 90 separate measurements). Calculate:

> **TIL_E** = the arithmetic mean of results for a single exercise, across all subjects and sampling positions.
>
> **TIL_A** = the arithmetic mean of all results across all exercises, subjects and sampling positions.

Compare values of TIL_E and TIL_A with the requirements in Table 3.6.

PROTECTION TO THE RESPIRATORY SYSTEM
For assessment of respiratory protection, for each subject and test exercise there will be a separate measurement of inward leakage. None of these values shall exceed 0.01 per cent. This corresponds to a respiratory protection factor of 10000.

11.5.4 Alternative or complementary approaches to assessment of ensemble protection

11.5.4.1 ASSESSMENT USING GAS TRACER

This test method for ensemble integrity is most appropriate for gas-impermeable ensembles. Ensembles passing this test can be expected to protect the body against gases, vapours and particles to the required levels, but for filter-based devices there is no direct assessment of filter performance against either gases or particles. (SF_6 gas is not removed by filters, so testing is carried out with clean air supplied to the filter inlet. Consequently, this test assesses only inward leakage and not filter performance as well.) For gas filtering devices, the assumption is that there is no ingress of contaminant through the filter until breakthrough occurs, so the measured leakage of SF_6 is representative of the protection. When considered alongside performance data for garment materials and filters against specific challenges, overall performance of the ensemble can be predicted.

The same principles and procedures as described in 11.5.3.1 to 11.5.3.2 can be applied, using SF_6 gas for the challenge agent, with a suitable detection and measurement system as described in EN 943-1 Annex A4 and EN 136.

11.5.4.2 TESTING WITH SIMULANT

The usual CWA simulant is methyl salicylate. This may be used with either human test subjects (Man In Simulant Test – MIST) or an animated manikin to assess either gas tight or selectively gas permeable ensemble integrity. Appropriate test methods are listed and referenced in BS 8467 Annex C. These methods do not directly assess protection of the body or respiratory system against particles, but when considered alongside performance data for garment materials and filters against specific challenges, overall performance of the ensemble can be predicted.

11.5.4.3 LIVE AGENT TESTS

Specifically targeted at CWA protection assessment, these tests are conducted on animated manikins using live agent in liquid or vapour form, and are referenced in BS 8467. Integrity of protection to the body can be assessed, and quantification of respiratory protection is possible with breathing manikins. Again, protection of the body and respiratory system against particles is not assessed by this approach. When considered alongside performance data for garment materials and filters against other specific challenges, overall performance of the ensemble can be predicted.

11.5.5 Choice of ensemble assessment method

Given that it is impractical to fully assess an ensemble against the complete range of possible chemicals and phases described in Annex 1, pragmatic approaches to establishing confidence in likely performance are required. The choice of which one or more of the above procedures to adopt to gain this confidence will in part be determined by the design characteristics of the ensemble components – gas tight or permeable; filtering device or breathing apparatus. Table 11.2 summarises the applicability of the different methods and the necessary supporting evidence for confident application of ensembles.

Table 11.2 Summary of ensemble test inferences

Test	Pass confirms	Applicability	Additional information needed for confidence
Salt	Integrity of particle protection to body. Particle protection to respiratory system.	Gas tight ensembles, breathing apparatus - pass will infer gas tightness as well. Gas permeable ensembles, filtering devices - particle protection.	Materials tests against specific chemicals. Filter tests against specific chemicals. Gas/vapour integrity test for ensemble.
SF6	Integrity of gas and particle protection to body. Absence of respiratory leakage.	Gas and particle protection to the body for all forms of ensemble. Gas and particle protection of BA. No leakage into filtering RPE.	Materials tests against specific chemicals. Filter tests against specific chemicals.
MIST	Integrity of ensemble and protection against CWA surrogate.	Gas tight and gas permeable ensembles; any RPE. Infers performance against CWAs.	Materials tests against specific chemicals. Filter tests against specific chemicals. Assessment of particle protection.

Table 11.2 Summary of ensemble test inferences			
Mannikin in simulant	Integrity of ensemble and protection against CWA surrogate.	Gas tight and gas permeable ensembles; any RPE. Infers performance against CWAs.	Materials tests against other chemicals. Filter tests against other chemicals. Assessment of particle protection.
Live agent	Integrity of ensemble and protection against specific CWA.	Gas and particle protection to the body for gas tight ensembles. CWA gas protection to the body for gas permeable ensembles. CWA protection for any RPE. Gas and particle protection of BA. No leakage into filtering RPE.	Materials tests against other chemicals. Filter tests against other chemicals. Assessment of particle protection to body for gas permeable ensembles. Particle protection of filters.

Clearly, none of these tests alone can provide complete confidence in the global performance of the ensemble.

SECTION 12
Summary

In this report a stand-alone performance based specification for personal protective equipment (PPE) ensembles for urban search and rescue (USAR) Scenario 3, high dust and chemical, biological, radiological (CBR), has been developed. Previous Health and Safety Laboratory' (HSL) work on the specification of USAR PPE has formed the basis for this work. The specification will assist manufacturers, certification bodies and procurement authorities in producing and sourcing appropriate PPE for these applications. Wherever possible, the specifications relate to existing PPE standards and test methods for commercial off-the-shelf (COTS) equipment.

The key feature of the specification is that a skin protection factor of 1,000 and a respiratory protection factor of 10000 are required from a PPE ensemble if it is to be considered suitable for high dust and CBR Scenario 3. Specifications for individual items of PPE are followed by specifications for ensembles of the PPE.

The specifications for individual items of PPE ensure that each individual item is capable of the performance required to form part of such an ensemble. There are two main reasons for this:

1. to allow procurers and manufacturers/suppliers to assess the suitability of COTS equipment for inclusion in ensembles; and
2. to allow procurers and manufacturers/suppliers to screen new equipment designs for their suitability for inclusion in ensembles without running full ensemble tests.

Having created a specification that can be used to establish that individual items are capable of the performance required to form part of an ensemble, the specification then gives performance requirements for the ensemble. These requirements cover not only protection, but also the suitability of the ensemble for likely USAR work tasks. The ensemble specification uses principles and reasoning from BS 8469:2007 "Personal protective equipment for fire-fighters – Assessment of ergonomic performance and compatibility – Requirements and test methods", adapted to be more specific to USAR applications. Input on the best choice of simulated work tasks that will replicate USAR operations will be needed from USAR teams and others.

An important advantage of ensemble testing using human subjects and representative exercises is that it can be used to generate simulated workplace protection factors (SWPFs). In a SWPF test, the measured levels of protection may be taken as representative of likely workplace protection, and so will supersede any generally accepted or assigned protection factors for individual items of equipment (such as assigned protection factors (APFs) for respiratory protective equipment (RPE)). A SWPF needs the duration of the test and activities carried out as test exercises to be sufficiently close to operational use to be considered as representative of the performance of the ensemble in a real deployment. The ensemble tests of barrier performance in this specification will form such a SWPF test.

As an example, in this specification one RPE option is a full face mask respirator (negative pressure). This has an assigned protection factor (APF) of only 40 if used with particle filters alone, and 20 if gas/vapour filters are fitted. It is likely that such a device, if fitted and used correctly, can achieve a SWPF greater than 10000 for both filter types. Without any SWPF tests, selection should use the APF, making the device unsuitable for USAR work. The SWPF data resulting from ensemble testing is likely to demonstrate that the device is suitable for USAR work. This shows the potential importance of the ensemble testing, and the resulting SWPFs, for USAR PPE selection.

Selection and procurement of ensembles can be a complex, time-consuming and expensive process. There are two main approaches:

1. allow manufacturers/suppliers to submit suitable individual items so that potential users/procurers can assess all the combinations of these considered appropriate; and
2. follow a turnkey approach where a single manufacturer/supplier (or consortium) submits a full PPE ensemble to be assessed by the user/procurer.

There may be rules or legal liability issues which affect the choice of approach. If there is a choice between the two approaches the turnkey approach is likely to be most cost-effective for a potentially complex ensemble such as USAR high dust and CBR Scenario 3 The turnkey approach can also have advantages when the provision of consumable items, spares, maintenance, training and product support are considered as there is one clear manufacturer/supplier responsible.

Recommendations

HSL recommends that the specification in this report is used as part of the process for selection and procurement of USAR PPE for Scenario 3, high dust and CBR applications. Where there are options requiring input from USAR teams or others, it is recommended that a wide and full consultation is conducted so that the best information can be gathered. It is also recommended that the assumptions on USAR operations that have been used to inform the specification are regularly reviewed.

SECTION 13

References

Vaughan, N, Bee, C, Bolsover, J, Clayton, M, Crook, B, Ferguson, I, Webb, D, (2007a) Urban search and rescue PPE – Final report Volume 1: Explanation. HSL Internal report PE/07/04/1

Vaughan, N, Bee, C, Bolsover, J, Clayton, M, Crook, B, Ferguson, I, Webb, D, (2007b) Urban search and rescue PPE – Final report Volume 2: Specification. HSL Internal report PE/07/04/2

Webb, D, Vaughan, N and Bolsover, J (2008) FRS USAR PPE for high dust and/or CBR hazards. HSL Internal Report PE/08/07A

Note that this reference is taken to include information in Webb, D, Vaughan, N and Bolsover, J (2008) FRS USAR PPE for high dust and/or CBR hazards – Supporting information. HSL Internal Report PE/08/07B

HSE EREGS, June 2003, P Ridgway HSE.

SECTION 14

Appendix 1 - List of representative chemical, biological and radiological materials

ASTM F1001 (shaded area) and European Standard EN 943-2

List of liquid test chemicals		
Common name	**Synonym**	**Chemical Abstract Registry Service (CAS) number**
Acetone	2-propanone, dimethyl ketone	[67-64-1]
Acetonitrile	cyanomethane, methyl cyanide	[75-05-8]
Carbon Disulfide	carbon bisulfide	[75-15-0]
Dichloromethane	methylene chloride/dichloride	[75-09-2]
Diethylamine	N,N-diethylamine	[109-89-7]
Dimethylformamide	DMF	[68-12-2]
Ethyl Acetate	ethyl ethanoate, acetic ester, acetic ether	[141-78-6]
n-Hexane	-	[110-54-3]
Methanol	methyl alcohol, carbinol, wood alcohol	[67-56-1]
Nitrobenzene	oil of mirbane	[98-95-3]
Sodium Hydroxide (50 % w/w)	caustic soda, lye	[1310-73-2]
Sulfuric Acid (93.1 % sp gr 1.84, 66° Be8)	electrolyte acid, hydrogen sulfate	[7664-93-9]

List of liquid test chemicals		
Tetrachloroethylene	perchloroethylene, carbon dichloride	[127-18-4]
Tetrahydrofuran	THF, 1,4-epoxybutane, diethylene oxide	[109-99-9]
Toluene	toluol, methyl benzene	[108-88-3]

List of gaseous test chemicals		
Common name (minimum purity)	**Synonym**	**Chemical Abstracts Service (CAS) number**
Ammonia, anhydrous, (99.99 %)	-	[7664-41-7]
1,3-Butadiene, inhibited, (99.0 %)	bivinyl, vinylethylene, biethylene, divinyl	[106-99-0]
Chlorine, (99.5 %)	-	[7782-50-5]
Ethylene Oxide, (99.7 %)	oxirane, 1,2-epoxyethane	[75-21-8]
Hydrogen Chloride, (99.0 %)	hydrochloric acid	[7647-01-0]
Methyl Chloride, (99.5 %)	chloromethane, monochlormethane	[74-87- 3]

Additional test chemical		
Hydro Fluoride Acid (80%)	hydrofluoric acid	[7664-39-3]

Additions to above list (to assess effective respiratory protection)		
Cyclohexane	hexamethylene	[110-82-7]
Sulphur Dioxide	sulfurous acid	[7446-09-5]
Hydrogen Sulphide	sulferetted hydrogen	[7783-06-4]

Chemical warfare agents		
GB	Sarin, isopropyl methylphosphonofluoridate/methylfluorophosphonate	[107-44-8]
GD	Soman, pinacolyl methylphonofluoridate/methylfluorophosphonate	[96-64-0]
VX	O-ethyl-S-2-diisopropylaminoethyl methyl phosponothioate	[50782-69-9]
HD	Mustard, bis(2-chloroethyl) sulphide	[505-60-2]

Additions to above list (To assess effective respiratory protection)	
Hydrogen Cyanide (HCN) [74-90-8], Cyanogen Chloride (CK) [506-7-4], Phosgene (CG, Carbonyl Chloride) [75-44-5]	Low boiling point materials
Chloropicrin (PS trichloronitromethane) [76-06-2] and dimethylmethylphosphonate (DMMP) [756-79-6]	High boiling point materials

Radiological and nuclear hazards
Alpha and beta particles

Biological Warfare Agents	
BG (*Bacillus subtilis var. niger*)	Simulant for the causative agent for anthrax
MS2 Bacteriophage	Simulant for smallpox and viral haemorrhagic fevers

The chemicals in this table have been selected to provide a test battery that is representative of the vast majority of chemicals that USAR teams might expect to encounter in CBR/TIC/TIM contaminated environments. It should be emphasized that this is not a generic list taken from another application but a test battery specifically designed to challenge the permeation resistance of chemical protective clothing.

Chemicals listed in the test battery are generally the smallest molecules of their type except where a smaller molecule would be gaseous at normal temperatures and pressures. In these cases the smallest liquid molecule has been chosen on the grounds that liquids are very much more concentrated than gases and that the permeation process is highly dependent on the challenge concentration.

Bacteria, viruses, prions and other biological pathogens are all orders of magnitude larger than the molecules of any of the chemicals listed in the test battery. It is generally accepted that if a chemical protective fabric gives permeation protection against aqueous solutions then it will be totally resistant to biohazards.

Solids are not listed included in the test battery because, with very few exceptions, solids do not permeate chemical barriers over the timescale in which chemical protective clothing is intended to be worn. There is also currently no reliable permeation test method for solids.

The breakthrough time of a chemical is in no way related to the degree of its toxicity. The test battery has been selected to test whether different types of chemical can permeate through a chemical protective suit, not on the basis of the harm a substance might do to the wearer should permeation occur. The absence of well-known poisons from this table should not therefore be interpreted as a deficiency in the test battery.

The choice of chemicals has been restricted to those substances that USAR clothing might reasonably be expected to provide protection against. Chemicals such as violently air sensitive reagents, unstable explosives and cryogenic liquids have not been considered since protection against these additional hazards is beyond the scope of this specification.

The battery consists of two groups of chemicals; worst case examples of chemicals that are known to permeate many chemical barriers and some of the most common hazardous chemicals that are likely to be encountered. Some of the chemicals in the test battery fall into both categories. Although additional permeation data for a given product will often be available from the PPE manufacturer, good performance (in excess of the requirements of this specification) against the chemicals listed here should normally be taken to infer that a garment offers good all-round permeation resistance against chemicals in general.

Substances which are considered to represent a class of chemicals are:

Acetone – smallest of the ketones – very common industrial solvent.

Acetonitrile – smallest organic nitrile molecule – representative of nitrile. monomers

Ammonia – common industrial refrigerant gas.

Carbondisulphide – smallest liquid organic sulphide. (thioformaldehyde trimerises….)

Chlorine – representative of the halogens - used extensively as a disinfecting agent for drinking and swimming-pool water treatment. (Fluorine is a smaller halogen molecule but this chemical is so violently reactive with such a wide range of materials that it is seldom encountered).

Dichloromethane – smallest liquid chloroalkane – representative of halogenated solvents – readily permeates many chemical barriers.

Ethyl acetate –most commonly encountered ester – used in large quantities as an industrially solvent.

n-Hexane – alkane – representative of lightest component of petroleum fuels.

Hydrogen chloride – representative of polar inorganic gases – common combustion product of some plastics and rubbers – given off by concentrated hydrochloric acid solutions used to clean and disinfect dairy equipment.

Methanol – smallest of the alcohol molecules

Sodium hydroxide solution – Representative of aqueous solutions and strong alkalis.

Sulphuric acid – representative of strong and oxidising mineral acids – common industrial acid.

Tetrahydrofuran – Smallest of the liquid ether molecules – readily permeates many chemical barriers.

Toluene – one of the smallest aromatic solvent molecules (benzene is slightly smaller but deemed too carcinogenic to be used for routine testing).

SECTION 15

Appendix 2 - Normative references

Standards listed under each personal protective equipment (PPE) type are referenced in the relevant section of the specification. In most instances, only certain clauses of the referenced standards are called up by the specification, and not the entire standard. In addition to the referenced standards, newly defined requirements and test methods may apply – see main text for details.

Where different variants of the same type of PPE call up the same standard (either explicitly by appearance of the standard number under more than one variant heading, or implicitly by the statement that this variant includes the references of another variant), the referenced clauses may differ in detail.

Standards may be revised or superceded at any time, so checks should be made of the referenced standards status when this report is used. However, even if a standard has been revised or superceded, the dated references to clauses in this report will remain technically consistent and valid.

HELMETS

A1b

EN 397:1997 Specification for Industrial safety helmets

EN 443:2008 Helmets for fire fighting in buildings and other structures

Note that previous HSL reports to DCLG on USAR PPE referred to the previous version of this standard EN 443:1997.

EN 1384:1997 Specification for Helmets for equestrian activities

EN 12492:2000 Mountaineering equipment - Helmets for mountaineers - Safety requirements and test methods

EN 14052:2005 High performance industrial helmets

EN 14572:2005 High Performance Helmets for Equestrian Activities

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CLOTHING

B3a

BS 8467:2006	Protective clothing. Personal protective ensembles for use against chemical, biological, radiological and nuclear (CBRN) agents. Categorization, performance requirements and test methods
EN 340:2003	Protective clothing: general requirements
EN 342:2004	Protective clothing. Ensembles and garments for protection against cold
EN 343:2003	Protective clothing. Protection against rain
EN 468:1994	Protective clothing for use against liquid chemicals. Test method. Determination of resistance to penetration by spray (Spray Test)
EN 469:2005	Protective clothing for firefighters. Performance requirements for protective clothing for firefighting
EN 471:2003	High-visibility warning clothing for professional use. Test methods and requirements
EN 510:1993	Specification for protective clothing for use where there is a risk of entanglement with moving parts
EN 511:2006	Protective gloves against cold
EN 943-1:2002	Protective clothing against liquid and gaseous chemicals, including liquid 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
EN 1149-1:2006	Protective clothing. Electrostatic properties. Test method for measurement of surface resistivity
EN 1149-2:1997	Protective clothing. Electrostatic properties. Test method for measurement of the electrical resistance through a material (vertical resistance)
EN 13982-1:2004	Protective clothing for use against solid particulates. Performance requirements for chemical protective clothing providing protection to the full body against airborne solid particulates (type 5 clothing)
EN 14325:2004	Protective clothing against chemicals. Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages
EN 31092:1993	Textiles. Determination of physiological properties. Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)

EN 50286:1999	Electrical insulating protective clothing for low-voltage installations
EN 60903:2003	Live working. Gloves of insulating material
EN ISO 4674-1:2003	Rubber or plastics-coated fabrics. Determination of tear resistance. Constant rate of tear methods
EN ISO 9073-4:1997	Textiles. Test methods for nonwovens. Determination of tear resistance
EN ISO 13937-2:2000	Textiles. Tear properties of fabrics. Determination of tear force of trouser-shaped test specimens (single tear method)
EN 14605:2005	Protective clothing against liquid chemicals. Performance requirements for clothing with liquid-tight (type 3) or spray-tight (type 4) connections, including items providing protection to parts of the body only (types PB [3] and PB [4])
ISO 11611:2007	Protective clothing for use in welding and allied processes
ISO 6942:2002	Protective clothing. Protection against heat and fire. Method of test: Evaluation of materials and material assemblies when exposed to a source of radiant heat
ISO 12127:1996	Textiles. Fabrics. Determination of mass per unit area using small samples
EN ISO 13934-1:1999	Textiles. Tensile properties of fabrics. Determination of maximum force and elongation at maximum force using the strip method.
ISO 13994:1998	Clothing for protection against liquid chemicals. Determination of the resistance of protective clothing materials to penetration by liquids under pressure
ISO 16603:2004	Clothing for protection against contact with blood and body fluids. Determination of the resistance of protective clothing materials to penetration by blood and body fluids. Test method using synthetic blood
ISO 16604:2004	Clothing for protection against contact with blood and body fluids. Determination of resistance of protective clothing materials to penetration by blood-borne pathogens. Test method using Phi-X174 Bacteriophage

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HEARING PROTECTION

C1a

EN 352-7:2002	Hearing protectors - Safety requirements and testing - Part 7: Level-dependent ear-plugs
prEN 352-9	In preparation - “Hearing protectors - Safety requirements and testing - Part 9: Ear-plugs with electrical audio input”
EN 458:2004	Hearing protectors - Recommendations for selection, use, care and maintenance - Guidance document

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RPE

D3a

BS 8468-1:2006	Respiratory protective devices for use against chemical, biological, radiological and nuclear (CBRN) agents - Part 1: Positive pressure, self-contained, open-circuit breathing apparatus – Specification
BS 8468-2:2006	Respiratory protective devices for use against chemical, biological, radiological and nuclear (CBRN) agents - Part 2: Negative pressure, air purifying devices with full face mask - Specification
EN 137:2006	Respiratory protective devices - Self-contained open-circuit compressed air breathing apparatus with full face mask - Requirements, testing, marking
EN 166:2001	Personal eye-protection - Specifications
EN 168:2001	Personal eye-protection - Non-optical test methods
EN 374-3:2003	Protective gloves against chemicals and micro-organisms - Part 3: Determination of resistance to permeation by chemicals
EN 403:2004	Respiratory protective devices for self-rescue - Filtering devices with hood for escape from fire - Requirements, testing, marking
EN 468:1994	Protective clothing - Protection against liquid chemicals - Test method: Determination of resistance to penetration by spray (Spray Test)
EN 943-2:2002	Protective clothing against liquid and gaseous chemicals, including liquid aerosols and solid particles - Part 2:Performance requirements for “gas-tight” (Type 1) chemical protective suits for emergency teams (ET)
EN 12021:1998	Respiratory protective devices - Compressed air for breathing apparatus

EN 13274-8:2002	Respiratory protective devices - Methods of test - Part 8: Determination of dolomite dust clogging
EN 14325:2004	Protective clothing against chemicals - Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages
EN 14458:2004	Personal eye-equipment - Faceshields and visors for use with firefighters' and high performance industrial safety helmets used by firefighters, ambulance and emergency services

EN ISO 6529:2001 Protective clothing - Protection against chemicals - Determination of resistance of protective clothing materials to permeation by liquids and gases (ISO 6529:2001)

D3d

BS 8468-4	In preparation Respiratory protective devices for use against chemical, biological, radiological and nuclear (CBRN) agents Part 4: Powered air-purifying respirators – Specification
EN 166:2001	Personal eye-protection - Specifications
EN 168:2001	Personal eye-protection - Non-optical test methods
EN 397:1995	Industrial safety helmets
EN 403:2004	Respiratory protective devices for self-rescue - Filtering devices with hood for escape from fire - Requirements, testing, marking
EN 468:1994	Protective clothing - Protection against liquid chemicals - Test method: Determination of resistance to penetration by spray (Spray Test)
EN 943-2:2002	Protective clothing against liquid and gaseous chemicals, including liquid aerosols and solid particles - Part 2:Performance requirements for “gas-tight” (Type 1) chemical protective suits for emergency teams (ET)
EN 12941:1998	Respiratory protective devices - Powered filtering devices incorporating a helmet or a hood - Requirements, testing, marking
EN 12942:1998	Respiratory protective devices - Power assisted filtering devices incorporating full face masks, half masks or quarter masks - Requirements, testing, marking
EN 13274-8:2002	Respiratory protective devices - Methods of test - Part 8: Determination of dolomite dust clogging

EN 14325:2004	Protective clothing against chemicals - Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages
EN 14387:2004	Respiratory protective devices - Gas filter(s) and combined filter(s) - Requirements, testing, marking
EN 14458:2004	Personal eye-equipment - Faceshields and visors for use with firefighters' and high performance industrial safety helmets used by firefighters, ambulance and emergency services

D3e

BS 8468-2:2006	Respiratory protective devices for use against chemical, biological, radiological and nuclear (CBRN) agents - Part 2: Negative pressure, air purifying devices with full face mask – Specification
EN 136:1998	Respiratory protective devices - Full face masks - Requirements, testing, marking
EN 143:2000	Respiratory protective devices - Particle filters - Requirements, testing, marking
EN 166:2001	Personal eye-protection - Specifications
EN 168:2001	Personal eye-protection - Non-optical test methods
EN 403:2004	Respiratory protective devices for self-rescue - Filtering devices with hood for escape from fire - Requirements, testing, marking
EN 468:1994	Protective clothing - Protection against liquid chemicals - Test method: Determination of resistance to penetration by spray (Spray Test)
EN 943-2:2002	Protective clothing against liquid and gaseous chemicals, including liquid aerosols and solid particles - Part 2:Performance requirements for “gas-tight” (Type 1) chemical protective suits for emergency teams (ET)
EN 13274-8:2002	Respiratory protective devices - Methods of test - Part 8: Determination of dolomite dust clogging
EN 14325:2004	Protective clothing against chemicals - Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages
EN 14387:2004	Respiratory protective devices - Gas filter(s) and combined filter(s) - Requirements, testing, marking
EN 14458:2004	Personal eye-equipment - Faceshields and visors for use with firefighters' and high performance industrial safety helmets used by firefighters, ambulance and emergency services

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FOOTWEAR

E1a

BS 4676:2005	Protective clothing. Footwear and gaiters for use in molten metal foundries. Requirements and test methods
DIN 51130: 2004	testing of floor coverings; determination of the anti-slip properties; workrooms and fields of activities with slip danger; walking method; ramp test
EN 471:2003	High-visibility warning clothing for professional use. Test methods and requirements
EN 14325:2004	Protective clothing against chemicals. Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages
EN 15090:2006	Footwear for firefighters
EN ISO 17249:2004	Safety footwear with resistance to chainsaw cutting
EN ISO 20345:2004	Personal protective equipment. Safety footwear

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GLOVES

F1a

EN 340:2003	Protective clothing: general requirements
EN 342:2004	Protective clothing. Ensembles and garments for protection against cold
EN 407:2004	Protective gloves against thermal risks (heat and/or fire)
EN 420:2003	Protective gloves. General requirements and test methods
EN 510:1993	Specification for protective clothing for use where there is a risk of entanglement with moving parts
EN 511:2006	Protective gloves against cold
EN 659:2003	Protective gloves for firefighters
EN1149-1:2006	Protective clothing. Electrostatic properties. Test method for measurement of surface resistivity
EN 1149-2:1997	Protective clothing. Electrostatic properties. Test method for measurement of the electrical resistance through a material (vertical resistance)

EN 10819:1996	Mechanical vibration and shock. Hand-arm vibration. Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand
EN 12477:2001	Protective gloves for welders
ISO 11611:2007	Protective clothing for use in welding and allied processes
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

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ELBOW AND KNEE

G1a

DD CEN/TS 15256:2005	Protective clothing. Hand, arm, leg, genital and neck protectors for use in ice hockey. Protectors for players other than goalkeepers. Requirements and test methods
EN 340:2003	Protective clothing: general requirements
EN 407:2004	Protective gloves against thermal risks (heat and/or fire)
EN 14404:2004	Personal protective equipment. Knee protectors for work in the kneeling position
EN ISO 20345:2004	Personal protective equipment. Safety footwear

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EYE AND FACE

Not applicable – see RPE

FALL ARREST

I1a

EN 340:2003	Protective clothing: general requirements
EN 361:2002	Personal protective equipment against falls from a height. Full body harnesses
EN 364:1992	Personal protective equipment against falls from a height. Test methods
EN 469:2005	Protective clothing for firefighters. Performance requirements for protective clothing for firefighting

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PPE ENSEMBLES

BS 8469:2007	Personal protective equipment for firefighters — Assessment of ergonomic performance and compatibility — Requirements and test methods
EN 136:1998	Respiratory protective devices - Full face masks - Requirements, testing, marking
EN 943-1:2002	Protective clothing against liquid and gaseous chemicals, including liquid 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 suitsEN 12941
EN 13274-2	Respiratory protective devices – Methods of test – Part 2: Practical performance tests
EN ISO 13982-2:2004	Protective clothing for use against solid particulates. Test method of determination of inward leakage of aerosols of fine particles into suits

SECTION 16

Appendix 3 - Glossary

APF	Assigned protection factor: for RPE. The level of protection that 95% of properly trained and supervised users of well maintained and correctly fitted RPE can expect to achieve or exceed in real use situations. APF is conventionally represented by the 5th percentile of valid workplace or simulated workplace protection factor measurements. The APF is the correct value to use when selecting RPE which is capable of providing adequate levels of protection. See also NPF, PF and WPF.
BA	Breathing apparatus. Respiratory protective equipment which supplies breathable gas to the wearer from a source independent of the surrounding atmosphere.
CAT	Cable Avoidance Tools.
CBRN	Chemical, Biological, Radiological or Nuclear. Substances considered to fall under this heading are detailed in Appendix 1.
COTS	Commercial off-the-shelf
CWA	Chemical warfare agent.
DCLG	Department of Communities and Local Government
EDBA	Extended duration breathing apparatus. This usually takes either the form of open-circuit BA with large air storage capacity, or closed circuit breathing apparatus.
EN	European Norm. European Standard generated by the European Standardisation Committee (CEN) e.g. EN 340:2003.
EREGs	Emergency Responder Exposure Guidelines (HSE)
Ensemble	The assemblage of specific PPE items intended and designed to be used together to provide complex protection to the wearer. The individual items must interface correctly and be compatible in terms of their capabilities and performance. Testing of ensembles against specific hazards may be achievable without having every item present. For example, when assessing barrier performance of an ensemble, the presence of earplugs worn inside the garment, or kneepads worn outside the garment will have no bearing on the gas/liquid/particle ingress into the garment, and may be omitted for this test. When assessing ergonomic or physiological performance or burden however, the complete ensemble must be used.

FFP3 Filtering facepiece respirator achieving class 3 performance against airborne particles.

FR Flame retardant. Materials demonstrated to have burning behaviour which does not spread flame, and self-extinguishes on removal from a source of ignition.

GTS Gas-tight-suit

IS equipment Intrinsically safe equipment. Electrical equipment designed and certified for safe use in flammable or explosive atmospheres.

ISO International Standards Organisation, or a prefix denoting the standards they generate, e.g. ISO 16603:2004.

MOU Memorandum of understanding.

NPF Nominal protection factor. The level of protection achieved in laboratory certification tests, assuming the maximum leakage permitted in the performance requirement applied. Being measured under ideal laboratory conditions, this level of protection is unlikely to be achieved in real-use situations, and should not be used in the selection of equipment. See also APF, PF and WPF.

NPV/HEPA Negative pressure ventilation combined with high efficiency particle air filters, used as a means to control or contain airborne dust.

ODPM Office of the Deputy Prime Minister (forerunner to CLG).

PAPR Powered air purifying respirator. A self-contained filtering device incorporating a battery powered fan unit which draws air through suitable filters and supplies this to a facepiece, which may be either a mask or hood.

PF Protection factor. A measure of the level of protection provided by an item of equipment (or ensemble) against a particular type or form of contaminant hazard (gas, particle or liquid). See also APF, NPF and WPF.

PPE Personal protective equipment. Items that are worn or carried to protect the wearer against one or more hazards to their health or safety.

PPT Practical performance test. Means of assessing the ergonomic, physiological and interfacial aspects of one or more items of equipment. Also used in this specification as a means of pre-stressing equipment and ensembles prior to barrier performance testing.

PPV	Positive pressure ventilation. Forced air movement used to remove airborne contaminants and/or introduce fresh air into an area or enclosed space.
PTSD	Post-traumatic stress disorder.
RPE	Respiratory protective equipment.
SNR	A reduction value measured in dB, describing the sound attenuation properties of hearing protection (determined from the octave-band sound attenuation data of a hearing protector – see EN ISO 4869-2:1995). The SNR value is used in calculations that will provide a reasonably accurate estimate of the effective A-weighted sound pressure level to aid in the selection and specification of hearing protectors.
STF	Slips, trips and falls.
SWPF	Simulated workplace protection factor. Level of protection achieved by experienced operatives when carrying out representative working activities but under controlled laboratory test conditions. Properly generated SWPF data can be acceptable for establishing the level of protection likely to be achieved in real working situations in place of published generic APF values for dome forms of equipment.
TIL	Inward leakage applies to PPE which provides a barrier between the wearer and a hazardous substance in the atmosphere as particle, vapour or gas. It is the amount of substance (or its test surrogate) passing through the barrier by a given route. Total Inward Leakage is a measurement which includes all the inward leakage from different paths that is experienced by the PPE wearer. It is the ratio (sometimes given as a percentage) between the substance concentration inside the PPE and the substance “challenge” concentration in the atmosphere outside the PPE.
USAR	Urban search and rescue.
WPF	Workplace protection factor. The level of protection provided by an item of PPE or ensemble, measured in real use conditions using appropriate methodology. With a sufficient body of WPF data, the assigned protection factor (APF) is taken as the fifth percentile of ranked WPF data. For technical or ethical reasons, it may be impractical to measure WPF in real use situations. Simulation of realistic working activity with a suitable tracer challenge agent is considered to be an acceptable substitute for real WPF data.

SECTION 17

Appendix 4 - ASTM F1001 chemicals: Emergency Response Exposure Guidelines (EREGs)

Substance	**CAS**	**EREG value**	**Comments**
1,3-Butadiene	106-99-0	100 ppm	Mutagenicity alert
Acetone	67-46-1	1500 ppm	
Acetonitrile	75-05-8	80 ppm	Skin notation
Ammonia	7664-41-7	50 ppm	
Carbon disulphide	75-15-0	50 ppm	Skin notation
Chlorine	7782-50-5	2 ppm	
Chloropicrin	76-06-2	0.3 ppm	
Cyanogen chloride	506-77-4	0.2 ppm	
Cyclohexane	110-82-7	300 ppm	Skin notation
Dichloromethane	75-09-2	250 ppm	Skin notation
Diethylamine	109-89-7	15 ppm	Corrosive
Dimethylformamide	68-12-2	50 ppm	Skin notation
Dimethylphosphonate	52-68-6	21 mg/m^3	Skin notation, mutagenicity alert,
Ethyl acetate	141-78-6	500 ppm	
Ethylene oxide	75-21-8	32 ppm	Mutagenicity alert
GB Sarin	107-44-8	0.01 mg/m^3	Skin notation
GD Soman	96-64-0	0.005 mg/m^3	Skin notation
HD sulphur mustard	505-60-2	0.1 mg/m^3	Skin notation, mutagenicity and carcinogenicity alert

Substance	CAS	EREG value	Comments
Hydrogen chloride	7647-01-0	5 ppm	
Hydrogen cyanide	74-90-8	6 ppm	Skin notation
Hydrogen fluoride	7664-39-3	3 ppm	Corrosive
Hydrogen sulphide	7783-06-4	10 ppm	
Methanol	67-56-1	800 ppm	Skin notation
Methyl chloride	74-87-3	150 ppm	Skin notation
n-Hexane	110-54-3	500 ppm	
Nitrobenzene	98-95-3	5 ppm	Skin notation
Phosgene (carbonyl chloride)	75-44-5	0.1 ppm	
Sodium hydroxide (50%)	1310-73-2	2 mg/m^3 (as NaOH)	Corrosive
Sulphur dioxide	7446-09-5	5 ppm	
Sulphuric acid (93%)	7664-93-9	1 mg/m^3	Corrosive
Tetrachloroethylene	127-18-4	150 ppm	
Tetrahydrofuran	109-99-9	200 ppm	Skin notation
Toluene	108-88-3	75 ppm	Skin notation
VX	50782-69-9	0.0003 mg/m^3	Skin notation

The Emergency Response Exposure Guideline (EREG) represents an airborne concentration that, according to available information, could be tolerated for a single 2 hour period without causing significant health effects or substantial discomfort, with no impairment in the ability to effectively carry out emergency procedures and would not cause serious longer term adverse health effects.

Genotoxic (mutagenic) chemicals have been flagged in the list. Additionally, one chemical with possible carcinogenicity concerns on single exposure has been flagged. For these chemicals there may be a conceptual possibility of a low, but unquantifiable, risk of genetic damage/carcinogenicity following exposure at or below the EREG. A skin notation has been assigned to chemicals that have the ability to be absorbed through the skin and make a significant contribution to the body burden, thus potentially contributing to systemic effects. Additionally, chemicals that are corrosive on contact with the skin have been flagged.