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PPE ensembles for firefighters undertaking hazardous materials response activities —

Part 1: Gas-tight, vapour-protective ensembles for emergency response teams ("type 1")

Équipement de protection personnelle pour pompiers entreprenant des activités de réponse de produits dangereux —

Partie 1: Ensembles hermétiques au gaz et à la vapeur pour équipes d'urgence («type 1»)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Personal protective clothing equipment*, Subcommittee SC 14, *Firefighter's personal equipment*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this document is to provide minimum design and performance requirements for personal protective equipment, excluding respiratory protective devices (RPD), designed for protection against chemicals, including gases, vapours, liquids, and particulates during hazardous materials response by the emergency response teams of the fire services. This specific document addresses the highest form of protection for hazardous materials responses involving chemical gases, vapours, liquids, and particulates. Annex B provides a recommendation for selection of personal protective equipment for hazardous materials response.

Hazardous materials response involves significant potential dangers to the emergency responder. Accordingly, a risk assessment is undertaken to determine if the personal protective equipment covered by this standard is suitable for its intended use and the expected exposure. A risk assessment includes what additional personal protective equipment is necessary.

Emergency responders need to be trained in the selection, use, care and maintenance of the personal protective equipment covered by this document, including an understanding of its limitations.

PPE ensembles for firefighters undertaking hazardous materials response activities —

Part 1:
Gas-tight, vapour-protective ensembles for emergency response teams ("type 1")

1 Scope

This document establishes minimum design and performance requirements for personal protective ensembles to be worn during hazardous materials responses involving chemical gas, vapour, liquid, and particulate hazards. This document provides optional criteria to address protection during terrorism involving chemical and biological agents. This document provides optional criteria to address the ability of ensembles to retain their integrity during escape in the event of chemical flash fire. This document does not establish minimum criteria for protection against radiological hazards, flammable, or explosive atmospheres. This document does not pertain to clothing providing the high level of heat and flame protection that is required for fighting fires. This document does not address respiratory protection.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4674-1, *Rubber- or plastics-coated fabrics — Determination of tear resistance — Part 1: Constant rate of tear methods*

ISO 7854, *Rubber- or plastics-coated fabrics — Determination of resistance to damage by flexing*

ISO 10874:2009, *Resilient, textile and laminate floor coverings — Classification*

ISO 12947-1, *Textiles — Determination of the abrasion resistance of fabrics by the Martindale method — Part 1: Martindale abrasion testing apparatus*

ISO 12947-2, *Textiles — Determination of the abrasion resistance of fabrics by the Martindale method — Part 2: Determination of specimen breakdown*

ISO 13688, *Protective clothing — General requirements*

ISO 13996, *Protective clothing — Mechanical properties — Determination of resistance to puncture*

ISO 13997, *Protective clothing — Mechanical properties — Determination of resistance to cutting by sharp objects*

ISO 16602:2007/Amd1:2012, *Protective clothing for protection against chemicals — Classification, labelling and performance requirements*

ISO 16604, *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-X 174 bacteriophage*

ISO 17491-1, *Protective clothing — Test methods for clothing providing protection against chemicals — Part 1: Determination of resistance to outward leakage of gases (internal pressure test)*

ISO 17491-2, *Protective clothing — Test methods for clothing providing protection against chemicals — Part 2: Determination of resistance to inward leakage of aerosols and gases (inward leakage test)*

ISO 20345:2011, *Personal protective equipment — Safety footwear*

ISO 23388, *Protective gloves against mechanical risks*

EN 13274-4, *Respiratory protective devices — Methods of test — Part 4: Flame tests*

EN 15090:2012, *Footwear for firefighters*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

NOTE A graphical hierarchy of terms is provided in Annex G.

3.1
abrasion rub
one revolution of the outer drives of the Martindale abrasion tester

Note 1 to entry: See ISO 12947-1.

[SOURCE: ISO/TR 19591:2018, 3.2, modified — Note 1 to entry added.]

3.2
biological agents
biological materials capable of causing an acute disease or long term damage to the human body

[SOURCE: ISO/TR 19591:2018, 3.20]

3.3
bootee
sock-like extension of the *chemical protective suit* (3.7)

[SOURCE: ISO/TR 19591:2018, 3.24, modified — Note 1 to entry deleted.]

3.4
chemical flash fire
ignition of a flammable vapour or gas that produces an outward expanding flame front, as those vapours or gases burn

Note 1 to entry: This burning and expanding flame front (fire ball) will release both thermal and kinetic energy to the environment.

[SOURCE: ISO/TR 19591:2018, 3.35]

3.5
chemical protection layer
layer or layers included in the composite that provide resistance to ingress by chemicals and to provide gas-tight integrity for the purpose of providing protection from chemical hazards

[SOURCE: ISO/TR 19591:2018, 3.36, modified — The phrase "penetration resistance against" was replaced by "resistance to ingress by".]

3.6
chemical protective clothing
combined assembly of garments worn to provide protection to the skin against exposure to or contact with chemicals

[SOURCE: ISO/TR 19591:2018, 3.37]

3.7
chemical protective suit
clothing worn to protect against chemicals that covers the whole, or greater part of the body

Note 1 to entry: A chemical protective suit can comprise of garments combined together to provide protection to the body. A suit can also have various types of additional protection such as hood or helmet, boots and *gloves* (3.16), joined with it.

[SOURCE: ISO/TR 19591:2018, 3.39]

3.8
chemical terrorism agents
liquid, solid, gaseous and vapour chemicals capable of inflicting lethal or incapacitating injuries, generally on a civilian population as a result of a terrorist attack

[SOURCE: ISO/TR 19591:2018, 3.41, modified — The word "casualties" was replaced by "injuries".]

3.9
closure
device to open and close openings for doffing and donning of protective clothing

3.10
closure system
method of fastening openings in the garment including combinations of more than one method of achieving a secure *closure* (3.9)

EXAMPLE A slide fastener covered by an over flap fastened down with a touch and close fastener.

Note 1 to entry: This term does not cover *seams* (3.21).

[SOURCE: ISO/TR 19591:2018, 3.49]

3.11
component
part or sub-assembly of a protective item

[SOURCE: ISO/TR 19591:2018, 3.61, modified — Deleted "necessary for it to meet its respective requirements".]

3.12
emergency response team
firefighters and other first responders that are trained and equipped to respond to incidents involving the release of hazardous materials

[SOURCE: ISO/TR 19591:2018, 3.93, modified — The phrase "accidental release" was replace by "release".]

3.13
exhaust valve
component (3.11) of a *chemical protective suit* (3.7) that prevents over pressurization of the suit

[SOURCE: ISO/TR 19591:2018, 3.97]

3.14
footwear
component (3.11) of the protective ensemble designed to provide protection to the foot, ankle, and possibly the lower leg

[SOURCE: ISO/TR 19591:2018, 3.119, modified — The word "possibly" was added.]

3.15
gas-tight, vapour-protective ensemble
multiple items of clothing and equipment which when used together provide a high degree of protection for emergency responders from the adverse exposures to the inherent risks of hazardous materials and that demonstrate gas-tight integrity

Note 1 to entry: The elements of the gas-tight, vapour-protective ensemble include the *chemical protective suit* (3.7), *gloves* (3.16), and *footwear* (3.14).

Note 2 to entry: The gas-tight, vapour-protective ensemble can either be of limited use or re-usable construction, see 3.18 and 3.20.

Note 3 to entry: When referring to an “ensemble”, in the latter part of this document, gas-tight, vapour-protective ensemble is meant.

[SOURCE: ISO/TR 19591:2018, 3.131, modified — The notes 2 and 3 to entry were added.]

3.15.1
type 1a ensemble
gas-tight ensemble with a breathable gas supply that is independent of the ambient atmosphere

EXAMPLE An ensemble with RPD, type SCBA (self-contained breathing apparatus) worn inside.

3.15.2
type 1b ensemble
gas-tight ensemble with a breathable gas supply worn outside

EXAMPLE An ensemble with RPD, type SCBA (self-contained breathing apparatus) worn outside.

3.16
glove
personal protective equipment (PPE) which protects the hand or part of the hand against hazards

Note 1 to entry: It can additionally cover part of the forearm and arm.

[SOURCE: ISO/TR 19591:2018, 3.133]

3.17
lifeline
attached rope the purpose of which is to help to retrieve and pull someone back to safety

Note 1 to entry: This item should not be considered to be a fall-protection device.

3.18
limited-use chemical protective suit
chemical protective suit (3.7) for limited duration of use, i.e., to be worn until hygienic cleaning becomes necessary or chemical contamination has occurred and disposal is required

Note 1 to entry: This includes protective suits for single use and for limited re-use according to the information provided by the manufacturer.

[SOURCE: ISO/TR 19591:2018, 3.179, modified — The word "clothing" was replaced by "suit" in both the term and the definition.]

3.19
permeation
process by which a chemical moves through a material on a molecular level

Note 1 to entry: Permeation involves:

— sorption of the molecules of the chemical into the contacted (outside) surface of a material;

— diffusion of the sorbed molecules in the material, and;

— desorption of the molecules from the opposite (inner) side of the material.

[SOURCE: ISO/TR 19591:2018, 3.230]

3.20
re-usable chemical protective suit
chemical protective suit (3.7) that is constructed from materials allowing the clothing to be cleaned after repeated chemical exposures such that it remains suitable for continued use

[SOURCE: ISO/TR 19591:2018, 3.261, modified — The word "clothing" was replaced by "suit" in both the term and the definition.]

3.21
seam
permanent junction between two or more pieces of material created by sewing, welding or other method

Note 1 to entry: Seams include the permanent joining of suit material to suit material and suit material to other materials of construction such as integral *visor* (3.22) materials (visor seams), *bootees* (3.4) if they are different from the suit material and also permanently attached *gloves* (3.16) and boots.

[SOURCE: ISO/TR 19591:2018, 3.267, modified — Note 1 to entry was added.]

3.22
visor
portion of the *chemical protective suit* (3.7) that permits the user to see out of the ensemble

[SOURCE: ISO/TR 19591:2018, 3.327]

4 Ensemble requirements

4.1 General requirements

4.1.1 Minimum ensemble configuration

The gas-tight, vapour-protective ensemble shall consist of a chemical protective suit incorporating hood, gloves, footwear and RPD (respiratory protective device).

4.1.2 Hood visor

For type 1a ensembles, the suit hood shall be provided with a visor that is designed to allow the wearer to see out of the ensemble.

4.1.3 Respiratory protective device

For type 1b ensemble, any part of the respiratory protective device that forms the primary barrier between the outside environment and the wearer, for example the RPD respiratory interface materials

and hoseline and the seams and/or joins associated with, are considered part of the ensemble and shall be subjected to testing as applicable for chemical protection.

NOTE RPD ISO standards are under development to provide the adequate chemical testing. This document will be updated, amended or revised to reflect or refer to this information.

4.1.4 Designation of ensemble use

The manufacturer shall designate the ensemble as single use, limited use or re-usable.

4.1.5 Integration of ensemble

Other than outer gloves and separate boots, ensembles shall be designed so that all separate components are securely attached and provided as a single and integrated unit. The use of additional covers or outer garments, layers or components shall not be allowed to fulfil the mandatory requirements of this document.

4.1.6 Attachment of lifeline and other equipment

Pass-throughs providing breathing air into chemical protective suits shall withstand a pull force of at least 1 000 N. The force shall be at least 1 000 N for life-lines, 250 N for equipment attachment points, 150 N for exhalation valves and 100 N for boots and gloves.

Testing shall be in accordance with ISO 16602:2007/Amd1:2012, Annex B.

4.1.7 Optional requirements for integrity for escape from chemical flash fire

As an option, the ensemble may be tested for integrity for escape from chemical flash fire. The ensemble shall fulfil the following requirements when tested, according to NFPA 1991:2016, Clause 8.25, ensemble flash test.

The ensemble shall not exhibit any afterflame times longer than 2 s.

After the flash fire exposure the ensemble shall be tested in accordance with ISO 17491-1, Method 1, the ensemble shall not have a pressure drop of more than 40 %. Remove any other items of PPE which are not required to meet the basic requirements of this document before the leak tightness test. The visor shall pass the requirement of 6.2.3.

NOTE Ensembles meeting these requirements are intended to offer the wearer limited protection for escape only in situations that can result in chemical flash fires. This requirement does not imply any protection for any fire-fighting activities but offers minimum protection from the thermal effects of a chemical flash fire with no loss of suit gastight integrity.

4.2 Ensemble requirements pertaining to chemical protective suits

4.2.1 Additional or other PPE

The ensemble itself shall meet all mandatory chemical and physical requirements of this document, with the exception of gloves 4.3.1, and footwear 4.4.2. Any other optionally wearable covers shall not be allowed to provide or negatively impact the mandatory chemical and physical requirements of this document, but may provide additional protection based on other optional requirements.

4.2.2 Protective covers for exhaust valves

Protective covers shall be provided to protect the exhaust valves from direct chemical splashes to the diaphragm and interior of the exhaust valve(s). These protective covers shall be made of either the chemical protective suit material or another material meeting the minimum chemical permeation resistance requirements of this document. The covers shall allow access to the valves for removal and inspection.

4.2.3 Suit design

Type 1a ensembles shall allow wearing of a compressed breathable gas RPD inside the suit. Type 1a ensembles shall allow the wearing of head protection if required inside the suit.

4.2.4 Whole suit performance

Chemical protective suits used in ensembles shall fulfil the whole suit performance requirements for the appropriate "type 1" gas-tight chemical protective suits specified in ISO 16602/Amd1:2012.

4.2.5 Practical performance test

The practical performance test specified in Annex A shall be carried out and the ensemble shall permit the test subjects to carry out all tasks without damage to the suit material or to the integrity of the ensemble. It shall also pass the requirements of the assessment described in A.6.

4.3 Ensemble requirements pertaining to gloves

4.3.1 Outer gloves

It shall be permitted to use an outer glove designed to be worn over the ensemble gloves where additional gloves are needed to meet the glove mechanical requirements in this document.

4.3.2 Removal and replacement of gloves

When designed for removal and replacement, gloves attached to the chemical protective suit shall be exchangeable within 30 min per pair.

This shall be evaluated as part of the practical performance using the manufacturer's instructions.

4.4 Ensemble requirements pertaining to footwear

4.4.1 Bootees

The ensemble shall be permitted to be configured with bootees.

4.4.2 Separate boots

The footwear portion of the ensemble shall be permitted to be constructed using a separate boot designed to be worn over the ensemble footwear or chemical protective suit bootees where additional footwear is needed to meet the footwear mechanical requirements in this document.

4.4.3 Footwear splash flap

When designed to be worn with separate boots, the chemical protective suit shall be equipped with a flap that prevent liquids running off the suit into the boot.

5 Requirements for suit materials

5.1 General requirements

5.1.1 Suit material layers

Any optionally wearable layers, such as other PPE as described in 4.2.1, shall not be allowed to provide or contribute to the mandatory chemical and physical properties when testing to this document.

5.1.2 Materials for testing of permeation resistance

The chemical protection layer(s) shall be tested for permeation resistance. Any additional layers that may complicate or interfere with the permeation test shall be allowed to be removed.

5.1.3 Materials for testing of physical properties

The chemical protection layer shall be the sole component for testing purposes for puncture resistance, abrasion resistance, flex cracking resistance, and resistance to flame testing as long as the requirement of 5.1.1 is fulfilled.

The intention of 5.1.1 and 5.1.3 is that cover garments or outer layers shall not be used to fulfil the requirements of this document if they are detachable and optionally wearable.

5.2 Permeation resistance

Chemical protective suit materials shall be tested for permeation resistance as specified in ISO 16602:2007/Amd1:2012, 6.5, after preconditioning as specified in Annex F for each chemical listed in Table 1.

The selection of the chemicals from Table 1 shall be made by the manufacturer or applicant for the respective requirements described below.

All materials of construction of the whole ensemble shall be tested against the same set of at least 14 selected chemicals from Table 1 and shall achieve a result of Class 3 or higher.

For the remaining maximum 2 selected chemicals from Table 1, all materials of construction of the whole ensemble shall achieve Class 1 or higher. If Class 1 is not achieved for either of these two chemicals from Table 1 and for any material or component part tested from the whole ensemble, the instructions for use shall identify that this gas-tight chemical protective suit is not suitable for use for this chemical under continuous exposure.

Table 1 — Chemicals for permeation tests

Name	CAS number	Physical state
Acetone (2-propanone)	67-64-1	liquid
Acetonitrile (cyanomethane, methyl cyanide)	75-05-8	liquid
Ammonia, anhydrous (99,99 %)	7664-41-7	gas
Carbon disulphide	75-15-0	liquid
Chlorine (99,5 %)	7782-50-5	gas
Dichloromethane (methylene chloride)	75-09-2	liquid
Diethylamine	109-89-7	liquid
Ethyl acetate	141-78-6	liquid
n-Hexane	110-54-3	liquid
Hydrogen chloride (99,0 %) (hydrochloric acid)	7647-01-0	gas
Methanol (methyl alcohol, carbinol)	67-56-1	liquid
Sodium hydroxide (30 % by mass), ρ = 1,33 kg/l	1310-73-2	liquid
Sulphuric acid (96 % by mass), ρ = 1,83 kg/l to 1,84 kg/l	7664-93-9	liquid
Sulphuric acid (18 % by mass)		liquid
Tetrahydrofuran (THF, 1,4-epoxybutane)	109-99-9	liquid
Toluene (toluol)	108-88-3	liquid

5.3 Suit material physical properties

Chemical protective suit materials shall meet the physical property requirements as specified in Table 2 for testing conducted in accordance with ISO 16602:2007/Amd1:2012, 6.10 to 6.15.

Table 2 — Minimum physical property classes for limited use and re-usable chemical protective suits

Suit material physical property	Limited use chemical protective suits	Re-usable chemical protective suits
Tensile strength, ISO 16602:2007/Amd1:2012, 6.10	Class 4	Class 6
Tear resistance, ISO 16602:2007/Amd1:2012, 6.11	Class 3	Class 3
Puncture resistance, ISO 16602:2007/Amd1:2012, 6.12	Class 2	Class 3
Abrasion resistance ISO 16602:2007/Amd1:2012, 6.14	Class 4	Class 6
Flex cracking resistance, ISO 16602:2007/Amd1:2012, 6.15 using ISO 7854, Method B	Class 1	Class 4
Flex cracking at low temperatures (−30 °C), ISO 16602:2007/Amd1:2012, 6.15 using ISO 7854, Method B.	Class 2	Class 2

5.4 Suit material flame resistance

5.4.1 Requirements

The test for resistance to ignition specified in 5.4 is intended to evaluate only that a material is not of a highly flammable nature. A material which passes this ignition evaluation may not offer sufficient protection against heat and flame.

NOTE Conformity with this clause in no way implies that the ensemble is suitable for in fire situations or in close proximity to naked flames. The test method called up in this section is only sufficient to show that the ensemble does not, in itself, present a fire hazard in the event of unforeseen accidental exposure to an ignition source. Many type 1A ensembles are manufactured from combustible materials and will burn in a fire.

If resistance to heat and flame is required the chemical protective clothing should be tested and marked according to the appropriate International Standard (e.g. ISO 14116 or ISO 11612).

The chemical protective clothing material shall not form droplets and shall prove to be "self-extinguishing", i.e. it shall not be of a highly flammable nature and when tested shall not continue to burn for more than 5 s after removal from the flame.

To determine the pass/fail criteria performance after exposure to flame in either 5.4.2 or 5.4.3, the leak tightness of each of the test specimens of a material sample shall be determined before and after flame exposure.

For each test specimen, the test area of the specimen prior and after to flame exposure shall be clamped in the rectangular test pot apparatus, designed according to the specifications given in ISO 16602:2007/Amd1:2012 Annex G, with the rectangular dimensions appropriate to hold the test specimen and the pressure in the test pot shall then be reduced by 1 kPa (10 mbar). The increase of pressure after 1 min shall be measured and recorded.

The difference in the change of pressure in 1 min between a specimen prior to flame exposure and the same specimen after flame exposure shall be calculated. The maximum resultant value of the difference in the change of pressure in 1 min between new and exposed shall be determined for the set of specimens.

5.4.2 Limited-use suits

Limited-use chemical protective suit materials shall be tested in accordance with EN 13274-4, Method 3 modified as follows. Three specimens having the minimum dimensions 50 mm by 105 mm shall be tested. The specimens shall be passed through the flame as described in EN 13274-4, Method 3 with the outer side of the clothing material exposed to the flame. The test specimen shall be mounted in such a way, so that the 105 mm edge is perpendicular to the direction of travel of the specimen above the flame and the path length of the specimen above the flame is 50 mm.

5.4.3 Re-usable suits

Re-usable chemical protective suit materials shall be tested in accordance with EN 13274-4, Method 3 modified as follows. Three specimens having the minimum dimensions 50 mm by 105 mm shall be tested. The specimens shall not be passed through the flame but stopped and held still in the flame for 5 s.

6 Requirements for suit components and assemblies

6.1 Seams

6.1.1 Seam strength

Seams used in the construction of chemical protective suits shall meet the Class 5 requirement for seam strength as specified in ISO 16602:2007/Amd1:2012, 7.5.2.

6.1.2 Seam permeation resistance

Chemical protective suit seams shall meet the permeation requirements of 5.2.

6.2 Visors

6.2.1 Visor materials for testing

Any part of the respiratory protective device that forms the primary barrier between the outside environment and the wearer shall be tested. Therefore either the suit visor (type 1a) and seams or the visor of the RPD respiratory interface (type 1b), are considered part of the chemical protective suit and are therefore subject to testing according to the requirements specified in 6.2.2 to 6.2.4 and 6.2.5 if required by 6.2.4.

6.2.2 Visor physical performance

Visor materials shall meet the requirements for field of vision, impact resistance, and resistance to ignition as specified in ISO 16602:2007/Amd1:2012, 7.6.3, 7.6.4 and 7.6.5.

6.2.3 Distortion of vision

The loss of sight shall not exceed two tenths on an optometric chart when reading letters on the chart at a distance of 5 m. Test according to Annex D.

6.2.4 Visor permeation resistance

Visor materials shall meet Class 3 requirements for permeation resistance as specified in ISO 16602:2007/Amd1:2012, 7.6.2, for each chemical listed in Table 1.

6.2.5 Chemical degradation of visor

This test shall only be carried out with those test chemicals for which the test according to 6.2.4 has led to any indication of harm to the optical properties. When tested as specified below the visor shall pass for each chemical tested.

A test piece of visor material with the dimensions 200 mm × 200 mm shall be used (if the actual visor has dimensions smaller than these a visor with the dimensions used on the chemical protective suit shall be tested). The test piece shall be placed on a level surface leaning against a support. The visor shall rest against the support at an angle of (65 ± 5)° to surface. (If a flexible visor is used the support shall have the prescribed angle to the surface and allow the visor to be clamped to it so that the surface of the visor is kept flat). 100 ml of the test chemical shall be poured onto the test piece. The chemical shall be poured along the top edge of the test piece moving from one side to the other using half the amount of chemical and the rest going back thus covering the test piece twice. This operation should take (10 ± 3) s.

5 min after having applied the chemical, residues of it shall be removed and the distortion of vision according to 6.2.3 shall be assessed holding the visor at the same distance as the suit in front of the test person's eyes.

For gaseous chemicals the test piece shall be placed in a suitable vessel containing the pure gas and left there for 30 min. The inside of the visor which is mounted inside the chemical protective suit should be covered so that this side is not exposed to the gas. Alternatively this may be arranged by a frame or other arrangement in the vessel.

6.3 Gloves

6.3.1 Attached gloves

Gloves shall be attached to the chemical protective suit such that ensemble meets the leak tightness performance requirement specified in ISO 16602:2007/Amd1:2012, 5.4.

6.3.2 Assembly strength between gloves and suit sleeve

The join between the gloves and the sleeves of the chemical protective suit shall not exhibit a strength of less than 100 N when tested in accordance with ISO 16602:2007/Amd1:2012, 7.9.

6.3.3 Glove material permeation resistance

Chemical protective suit glove materials shall meet the permeation requirements specified in 5.2. If more than one pair of gloves is fitted to, or supplied with, the suit then only those glove layers that are fitted to the suit in a leak-tight manner according to 6.3.1 shall be tested.

6.3.4 Glove material physical properties

Gloves used with chemical protective suits shall be tested for physical properties as described below and conducted in accordance with ISO 23388.

The result of each test shall be reported. If Class 1 is not achieved for each property then an additional outer glove meeting Class 1 for all mechanical properties shall be provided.

The minimum class shall be met either by a single glove design or by a combination of different gloves combined.

NOTE The test methods and requirements list in this subclause are identical to ISO 23388, but described in more detail in this document.

6.3.4.1 Cut resistance

When tested in accordance with ISO 13997, the glove's cut resistance shall be classified against the levels listed in Table 3 using the weight needed to cut through the material with 20 mm of blade travel. Testing shall be performed with all layers in place for each area of the glove that is evaluated.

Table 3 — Classification for cut resistance

Level	Cut resistance N
A	≥2
B	≥5
C	≥10
D	≥15
E	≥22
F	≥30

6.3.4.2 Puncture resistance

When tested in accordance with ISO 13996, the glove's resistance against puncture shall be classified against the levels listed in Table 4 using the puncture force. Testing shall be performed with all layers in place for each area of the glove that is evaluated. No level of performance shall be reported for uncoated textile knits since such gloves do not protect against puncture.

Table 4 — Classification for puncture resistance

Level	Puncture resistance N
1	≥20
2	≥60
3	≥100
4	≥150

6.3.4.3 Abrasion resistance

When tested in accordance with ISO 12947-1, the glove's abrasion resistance shall be classified against the levels listed in Table 5 using the number of abrasion rubs to failure. For the purpose of this document, the pressure on the specimen shall be (9 ± 0,2) kPa and an abradant meeting the requirements in ISO 23388 shall be used. The end point at which the glove material is determined to fail shall be at the number of abrasion rubs just before the film or coating has a hole abraded through it. Testing shall be performed with all layers in place for each area of the glove that is evaluated. For woven and knit fabrics, the end point shall be when a hole is worn through the glove material(s).

Table 5 — Classification for abrasion resistance

Level	Abrasion rubs to fail
1	≥100
2	≥500
3	≥2 000
4	≥8 000

6.3.4.4 Tear resistance

When tested in accordance with ISO 4674-1, as modified in ISO 23388, the glove's tear resistance shall be classified against the levels listed in Table 6 using the tear force. Each separable layer of the glove shall be tested.

Table 6 — Classification for tear resistance

Level	Tear resistance N
1	≥10
2	≥25
3	≥50
4	≥75

6.4 Footwear

Footwear of a chemical protective ensemble is either:

— a gas tight attached chemical resistant safety boot with safety toe cap and puncture resistant sole, or

— the combination of a bootee (sock like extension to the suit leg) with a separately worn safety boot worn over the bootee, or

— a firefighter boot worn inside the suit where the material includes a reinforced tread to prevent abrasion, puncture, cut or tear of the suit material's sole.

NOTE Wearing a firefighter boot inside the suit can introduce the risk of cut or puncture of the ensemble from the inside.

6.4.1 Requirements for ensembles incorporating bootees and separate boots

When the footwear component of the ensemble is configured with bootees and separate boots, the material used in the construction of the bootees shall meet all of the requirements for suit materials in Clause 5 with the exception of resistance to flame. Separate boots shall meet the requirements specified for separate boots in Table 7.

NOTE When configuring ensembles using this foot protection method, it is essential that any footwear for separate boots is selected after a thorough assessment of the footwear construction. Certain footwear materials and components can be present internally which could cause abrasion wear of the bootees to be accelerated.

6.4.2 Requirements for ensembles using attached boots

When the footwear component of the ensemble is configured with attached boots, the boots shall meet all of the requirements for attached boots in Table 7.

Table 7 — Boot requirements

ISO 20345:2011	Clause/Subclause	Separate Boots	Attached Boots
Classification and designs	4, Table 1	Class I or Class II	Class II
Classification and designs	4, Figure 3	B, C or D	C or D
Basic requirements	5.1	All mandatory requirements from 20345 according to the classification	All mandatory requirements from 20345 according to the classification

6.4.3 Additional requirements

Both separate boots and attached boots shall meet the additional specific performance requirements from Table 8.

NOTE The boot sole shall not be known to degrade, to the extent that slip resistance might be significantly impaired, after exposure to any of the chemicals in table.

Table 8 — Additional requirements for boots

Requirement	Standard/Clause	Separate Boots	Attached Boots
Penetration resistance	ISO 20345:2011, 6.1	X	X
Flame resistance	6.4.4	X	X
Permeation resistance	ISO 16602:2007/Amd1:2012, 6.5	[a]	X

X Denotes that the requirement shall be met.

[a] Denotes that there is no requirement, as bootees shall be tested.

6.4.4 Resistance to flame

When tested in accordance with EN 15090:2012 7.3 with a modified exposure time of 5 s, no sample shall flame for more than 2 s (afterflame time) nor glow for more than 2 s (after-glow time). After testing, the footwear shall conform to EN 15090:2013, B.2.3.

6.4.5 Permeation resistance

6.4.5.1 Sampling and conditioning

Each material specimen to be tested shall have a minimum cross-sectional dimension of the same diameter as the flange of the permeation cell. Three test pieces (thinnest point, generally upper) from the footwear shall be tested. In the case of irregular design and/or multiple construction, at least three specimens shall be tested from each different design or multiple combination.

NOTE If it is not possible to obtain a large enough test piece from the footwear, then a sample of the material from which the component has been manufactured can be used instead and this is noted in the test report.

The sample shall be conditioned for at least 24 h at a temperature of (23 ± 2) °C.

6.4.5.2 Requirements

The footwear shall meet the permeation requirements of 5.2.

6.5 Closures

6.5.1 Closure physical performance

Closures shall be tested for strength in the same way seams are tested and shall meet the Class 4 requirement for seam strength as specified in ISO 16602:2007/Amd1:2012, 7.5.2.

The full closure assembly as it is made on the chemical protective garment shall be tested. It may be necessary to increase the length of the specimen (as specified in ISO 13935-2) to accommodate the full width of the closure assembly and allow it to be clamped in the surrounding suit material in the tensile testing machine. If the test house deems it is not possible to take samples from complete chemical protective suit it shall be allowed to test separately produced samples made by the manufacturer using the same construction technique as for the suits.

6.5.2 Closure system permeation resistance

Closure systems shall be tested for permeation resistance for the chemicals specified in 5.2 and shall not exhibit a normalized permeation breakthrough time of less than 5 min when tested as described in Annex C. The basic requirement of this clause is for the main closure component (usually a zipper) to be tested for resistance to permeation. In many cases the closure system includes one or two outer protective flaps or similar. The existence of such flaps does not take away this requirement. In order to avoid too high permeation breakthrough times which may result when clamping a zipper covered by a flap in a permeation test cell, the main closure component (e.g. zipper) itself shall be tested for permeation resistance without any such flaps, covers, etc.

7 Optional requirements for protection against chemical terrorism and biological agents under non-military circumstances

NOTE This document includes optional requirement for CBRN protection. These requirements can change in the future.

7.1 Additional ensemble requirement

Ensembles intended for protection against chemical terrorism and biological agents, ensembles shall show an inward leakage of not more than 0,05 % when testing according to Method 1 of ISO 17491-2 or 0,02 % when testing according to Method 2 of ISO 17491-2.

7.2 Additional ensemble material requirements

7.2.1 Chemical terrorism agent permeation resistance

All of those items that were subject to the non-CBRN permeation test in 5.2 except for the zipper shall be tested for permeation resistance against the chemical agents listed in Table 9 in accordance with Annex E Each ensemble material shall meet the minimum permeation performance criterion established separated for each chemical in accordance with Table 9.

Table 9 — Chemical terrorism agents for optional evaluation of chemical protective suit materials

Chemical agent	Minimum performance criteria
Distilled sulfur mustard (HD), bis (2-chloroethyl) sulfide	Cumulative permeation over 1 h is ≤4,0 µg/cm^2 or no breakthrough
Sarin (GB), isopropyl methanefluorophosphonate	Cumulative permeation over 1 h is ≤1,25 µg/cm^2 or no breakthrough
Dimethyl sulfate	Cumulative permeation over 1 h is ≤6,0 µg/cm^2
Acrolein	Cumulative permeation over 1 h is ≤6,0 µg/cm^2
Acrylonitrile	Cumulative permeation over 1 h is ≤6,0 µg/cm^2

7.2.2 Biological agent penetration resistance

Ensembles intended for protection against chemical terrorism and biological agents, the clothing, visor, glove, footwear upper, suit seams, and visor seams shall be tested for viral penetration resistance in accordance with ISO 16604 and shall permit no viral penetration at a test pressure of 20 kPa.

8 Labelling

The ensemble shall include a label that is permanently attached to the chemical protective clothing portion of the ensemble in a conspicuous location. The label shall include the following information in at

least 1,5 mm high letters. The label shall also fulfil applicable labelling requirements of ISO 16602/Amd1: 2012 and ISO 13688. In addition it shall meet the following requirements:

a) the name, trade mark or other means of identifying the manufacturer or its authorized representative;

b) the manufacturer's type number, identification, or model number for the chemical protective suit;

c) a list of any additional separable components or parts, including but not limited to, RPDs, outer garments, outer gloves, and separate boots, which shall be worn for compliance with this document;

d) the number and date of this document;

e) the year of manufacture and a lot or trace number;

f) the size range as defined in ISO 13688;

g) the following pictograms to indicate chemical protection (ISO 7000-2414) and to indicate that the instructions for use shall be read (ISO 7000-1641):

h) the letters CBRN, immediately above or below the chemical protection pictogram [see g)] shall be used to indicate compliance with Clause 7;

i) the following pictogram (ISO 7000-1051) for suits that are not re-usable:

9 Instructions for use and information supplied by the manufacturer

The manufacturer shall provide instructions with every garment that meet the requirements specified in ISO 16602:2007/Amd1:2012, Clause 9 and ISO 13688. In addition it shall meet the following requirements:

a) A list of any additional separable components or parts, including but not limited to, RPDs, outer garments, outer gloves, and separate boots, which shall be worn for compliance with this document.

b) The identification of the principal materials used in the construction of the chemical protective suit, visor, gloves, and footwear. This information is of importance in the use, care and maintenance of the ensemble.

c) The manufacturer shall provide information on the electrical insulative/antistatic/electrostatic dissipative properties of the ensemble.

d) The instructions for use, care, maintenance and storage shall be provided. For re-usable garments this shall also provide instructions on cleaning, decontamination and retirement from use guidelines.

e) Based on 5.2, if Class 3 is not achieved for either of these two chemicals from Table 1 and for any material or component parts tested from the whole ensemble, the instructions for use shall identify those chemicals as not meeting Class 3.

Annex A
(normative)

Practical performance test

A.1 General requirements

For the test, persons shall be selected who are familiar with using such or similar equipment and whose medical history is known to be satisfactory. The subjects shall be medically examined and confirmed fit to undertake the test procedures. The necessity of a medical examination before, or supervision during the tests shall be at the testing officers discretion.

Prior to testing the test devices shall be stored at room temperature of (20 ± 3) °C for at least 16 h.

For re-usable suits two sample suits shall be tested, each being tested by two test subjects. For limited-use suits two test subjects shall each test two new samples suits (four suits in total).

Prior to the tests there is an examination that the device is in good working order and that it can be used without hazard. If more than one size of the ensemble is manufactured the subjects are asked to select the appropriate size.

After fitting the ensemble, each test subject is asked "Does the ensemble fit?" If the answer is "Yes" continue the test. If the answer is “No”, report the fact and either replace the suit or the test subject and start over. If the suit doesn’t fit any test subject within the given size range the sizing table shall be reported as incorrect and the suit test shall be reported as failure.

A.2 Work simulation tests

Work simulation tests shall be carried out within a period of between 15 min and 45 min.

a) Walking on the level with a ceiling height of (1,3 ± 0,2) m for a total distance of 50 m.

b) Crawling on a smooth surface on the level with a ceiling height of ($0{,}70\ ^{+0{,}05}_{-0}$) m for a total distance of 10 m. If a suit passes on a slightly lower ceiling, then it shall be deemed to have passed.

   The surface shall be no smoother than a seamless Class 41 resilient floor covering according to ISO 10874:2009, Clause 3 e.g. conforming to

   1) ISO 16905 or EN 1817(for smooth homogeneous rubber), or
   2) ISO 10582 or EN 651 (for PVC with a foam layer), or
   3) ISO 26986 (for expanded PVC floor coverings) and be laid according to the flooring manufacturer’s instructions.

   If a suit passes on a rougher flooring surface, then it shall be deemed to have passed on a floor as specified above. If a suit doesn't pass on a rougher, surface then the test shall be repeated on a floor as specified above.

c) Laying out a flat fire hose ($15\ ^{+5}_{-1}$) m in length and recoiling the same.

d) Reading off a measuring device (height of letters 20 mm), e.g. an electronic device with a display.

e) Simulate cordoning off an area of 10 m × 20 m with a single rope (nominal length of 65 m and a nominal diameter of 1 cm), using 12 displaceable posts, one for every 5 m, clip the single rope on each post.

NOTE This can be done either in a big room or outside. If the room is small, it can be done by several rounds cordoning off a smaller area.

f) Performing a mechanical task:

The object of this exercise is to verify that the wearing of a gas-tight suit does not impair the wearer's ability to carry out a simple mechanical task to the extent that the task becomes impossible.

The test subject shall be familiar with the test apparatus and shall be capable of completing the exercise easily when not wearing a gas-tight suit.

The apparatus shall consist of a short (approximately 1 m) length of nominal 5,08 cm (2") (DN 50) internal diameter steel pipe mounted horizontally above a bench in an orientation parallel to the front edge of the bench. The bench surface shall be (1 ± 0,1) m above floor level. The pipe shall be fixed to the bench by means of fixing brackets such that the centre-line of the pipe is (0,10 ± 0,01) m above the bench and (0,25 ± 0,025) m behind the vertical plane of the edge of the bench.

The pipe shall be terminated in a flange-fitting that can accommodate 4 M16 bolts. The holes in the flange shall not be threaded. The orientation of the holes shall be such that a line between any two circumferentially adjacent holes shall be either vertical or horizontal.

A nominal 5,08 cm (2") (DN 50) internal diameter globe valve shall be bolted to the flanged end of the pipe by means of 4 M16 bolts and 4 plain (i.e. non-thread locking) nuts. The shaft of the valve shall be vertical and pointing upwards. The bolts shall be inserted from the pipe side of the flange and tightened to a torque of (10 ± 1) Nm.

A self-adhesive sealing gasket shall be positioned between the pipe flange and the valve with the self-adhesive side towards the valve.

The exercise shall commence with the subject turning the wheel of the valve from fully-open to fully-shut or vice versa. The subject shall then unfasten the 4 nuts using a pair of suitably-sized combination spanners.

NOTE A combination spanner is a non-adjustable spanner with 12-toothed ring spanner at one end and an open parallel-faced spanner at the other end.

Next, the subject shall remove the valve from the pipe and remove the self-adhesive sealing washer from the valve. The subject shall then replace the self-adhesive sealing washer, refit the valve to the pipe in the original orientation, and fasten the 4 bolts using the two spanners until the bolts are at approximately the original torque or tighter.

If the user is unable to carry out any of these tasks or reports severe restrictions to movement the ensemble shall fail the test.

A.3 Work simulation test at low temperature

All tests shall be carried out in a cold chamber at (–15 ± 3) °C. The test temperature shall be recorded. Work simulation tests at low temperature shall be carried out within a period of between 15 min and 45 min. The following activities shall be done:

a) Walking on the level at a regular rate of 5 km/h for 5 min.

b) Crawling on a surface on the level keeping all of the ensemble below a height of $(0{,}70\ ^{+0{,}05}_{-0})$ m for a total distance of 10 m. The surface shall as specified in A.2 b).

A.4 Detachable gloves

When designed for removal and replacement, gloves attached to the chemical protective suit shall be exchangeable within 30 min per pair. This shall be tested by one of the test subjects using the instructions for use.

A.5 Information to be recorded

During the practical performance tests the chemical protective suit shall be subjectively assessed by the wearer. Each of the following shall be recorded and rated with a score between 1 and 5, where a score of 1 signifies the poorest performance rating, and a score of 5 signifies the best performance rating.

a) comfort of any harness fitted;

b) security and usability of fastenings and couplings;

c) accessibility and suitability of controls, warning devices and pressure gauge (if fitted);

d) clarity of vision from the face piece and/or visor;

e) peripheral vision in case of chemical protective suits and clothing fitted with visor;

f) clothing comfort (information if the user felt distress by local cooling from air flow);

g) ease of speech transmission and reception;

h) that it is possible to see without impediments through the visor when the head is moved in all directions (up, down, to the left and to the right);

i) any other comments volunteered by the wearer;

j) accessibility of pass-through (if fitted);

k) impediment caused by the external air or ventilation supply.

In addition to points a) to j) the number and body dimensions (including the size of the suit) and any other comments volunteered by the test subject shall be recorded but not scored.

A.6 Assessment

The suit shall be deemed to have passed the practical performance test if

— the activities detailed in A.2 and A.3 can be carried out by the test subjects within the allocated time, and

— the test subjects reports that the features assessed in A.5 b) (secure fastenings and couplings), c) (accessible controls and pressure gauges) and d) (acceptable clarity of visor) are acceptable.

If either of these requirements is not met with the first two test subjects, then that section of the test shall be repeated by another test subject. If the new test subject encounters the problem reported by testing the first suit pair, then the suit shall be deemed to have failed.

If the average score for items a) to g) of A.5 is ≥3, and not more than one individual score is rated at 1 then the suit passes the test.

Notwithstanding the above, the following are obvious reasons for concluding that a protective clothing product is unacceptable and not fit for use:

a) The person-defined suit size based on the subject's size does not fit in a way that a safe use is not possible.

b) It does not stay closed or it will not stay in place.

c) It compromises any vital function e.g. breathing.

d) Simple tasks to be performed wearing it are impossible.

e) The subject refuses to continue this assessment due to pain.

f) It prevents the wearing of other essential PPE.

Annex B
(informative)

Guidelines for selection of personal protective equipment for hazardous materials response

B.1 Risk assessment

B.1.1 Recommended process

A risk and hazard assessment should be conducted for identifying chemical hazards in the response environment and determining the risk of exposure for ranking protection needs. The recommended steps of this process include:

a) Define the response environment and associated tasks to be evaluated. The area that encompasses the range of hazards that may be encountered should be defined. Specific work tasks should be defined as those activities that involve unique hazards and are accomplished by trained and competent members of the emergency response team.

b) Identify the hazards associated with each work task. General hazard categories include physical, environmental, chemical, biological, thermal, electrical hazards, radiation, person-position, and person-equipment hazards and any possible intelligence relating to who is involved or how the incident occurred.

c) Determine each affected body area or body system. For each hazard, determine which portion of the body can be affected by the hazard. General body areas and body systems typically affected by workplace hazards, include:

   1) head;
   2) eyes and face;
   3) hands;
   4) arms;
   5) feet;
   6) legs;
   7) trunk or torso;
   8) entire body;
   9) respiratory system (included for completeness of the assessment);
   10) hearing (included for completeness of assessment).

d) Estimate the likelihood of wearer exposure to identified hazards. For every identified hazard affecting a specific portion of the body (or the whole body), indicate the likelihood of exposure.

e) Estimate the possible consequences of exposure to identified hazards. For every identified hazard affecting a specific portion of the body (or the whole body), indicate the consequences of exposure.

B.1.2 Identification of hazards

There are several types of hazards to which emergency response team personnel can be exposed. To identify chemical hazards, consider the following aspects of the work place.

a) Potential or actual chemical hazards:

- Identify specific chemicals involved in the response.
- For overlapping tasks, identify the chemicals and their effects.
- Note the temperature of chemicals in which contact will take place.

b) Physical properties of chemicals:

- Identify as a solid, liquid, or gas.
- List the material's vapour pressure and specific gravity (SG).
- If a mixture is present, determine the properties of the most hazardous components.

c) Chemical contact periods:

- Determine if contact with the chemical(s) will be as solids, liquids, vapours, or gas.
- Note how long the chemical protective clothing will be in direct contact with the chemicals (seconds, minutes, hours, days [reuse?]).
- Determine if the contact is routine, intermittent, or infrequent/unplanned.
- Note if the chemical protective clothing is simply for splash protection, and if the wearer can change quickly.

d) Type of potential contact:

- Determine the type of chemical contact expected under emergency conditions (e.g. pressurized spray accident).
- Note the physical hazards that will impact the integrity of the clothing to keep chemicals out (tearing, cut, puncture, or abrasion risks).

If possible, use information from the chemical supplier to identify chemical hazards.

Consider other hazards that are present in the workplace. These include:

e) other physical hazards (e.g. flying debris, slippery surfaces);

f) environmental hazards (e.g. extremes of cold or heat, noise, lighting);

g) biological hazards (e.g. airborne or liquid-borne pathogens);

h) thermal hazards (e.g. contact with hot surfaces, radiant heat);

i) electrical hazards;

j) radiation hazards.

There are also hazards that occur depending on where the person is placed. For example, if a person is working near water, they will need a personal flotation device to prevent risk of drowning, especially if the person is encumbered with clothing and equipment. Similarly, if the work is carried out on an elevated platform, fall protection will be needed.

The protective clothing and equipment itself create hazards. Some examples include:

— creation of particles or static electricity that can damage sensitive environments;

— allergic or other skin reactions from non-biocompatible materials;

— retention of contamination for continued exposure;

— reduced mobility and hand function, or impaired communications and vision for diminished productivity or propensity to accidents;

— lack of ankle or back support increasing the opportunity for strains and sprains;

— heat stress from use in warm environments.

In identifying risks, it becomes important to note which parts of the body will be affected by the hazard if exposure occurs. Exposures can be isolated to a single area, such as the hand in the case of the splash, or extend to the entire body as in exposure to a gas.

B.1.3 Estimating the likelihood of exposure

While chemicals are present, it does not mean that exposure will occur. In some functions, exposure is part of the response activity, for example, using an adsorbent to soak up spilled chemical and then shoveling the contaminated adsorbent into a drum. In other cases, exposure might not occur unless there is a serious accident. Deciding on the likelihood of exposure will come from the prior analysis conducted in characterizing the workplace and the type of chemicals present. For example, chemicals present as gases or particulates may be more likely exposures than chemicals in a liquid form.

B.1.4 Determination of risk

A completed hazard assessment will provide a list of hazards, which parts of the worker body may be affected, how likely exposure will occur, and the probable consequences of exposure. The determination of risk permits decisions on which hazards necessitate the greatest risk and thus indicate those hazards to be considered important for selecting chemical protective clothing.

B.1.5 Operational selection

Once the operational risk assessment has been completed, the need to ensure the compatibility of protection from the exposure hazard and the protective clothing selection is critical. This process should consider the most vulnerable component of the protective clothing and the most hazardous chemical. It should also consider the duration of the incident, particularly the allocated tasks in relation to the recommended time of exposure with components of your particular PPE.

B.2 Selection of gas-tight, vapour-protective ensembles

Gas-tight, vapour-protective ensembles ("type 1") should be used under the following conditions:

— The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either

  — measured (or potential for) high concentration of atmospheric vapours, gases, or particulates, or

  — site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapours, gases, or particulates of materials that are harmful to skin or capable of being absorbed through intact skin.

— Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible.

— Operations shall be conducted in confined, poorly ventilated areas until the absence of conditions requiring this level of protection is determined.

The materials used in the construction of the ensemble shall be compatible with the substances involved.