INTERNATIONAL STANDARD

# ISO 17491

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# Protective clothing — Protection against gaseous and liquid chemicals — Determination of resistance of protective clothing to penetration by liquids and gases

*Vêtements de protection — Protection contre les produits chimiques liquides et gazeux — Détermination de la résistance des vêtements de protection à la pénétration des liquides et des gaz*



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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 17491 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

## Introduction

Chemical protective clothing is worn in conjunction with appropriate respiratory protective devices, in order to isolate the body of the wearer from the environment. Several tests exist for determining the resistance of chemical protective clothing materials to either the permeation or penetration of gaseous or liquid chemicals. However, the effectiveness of the overall protective clothing item in preventing exposure from chemical hazards depends on the integrity of the clothing item's design in eliminating or reducing inward leakage of chemicals.

The selection of the appropriate integrity test method will depend on the application of the chemical protective clothing and the exposure hazards present. Usually, the integrity test method will be specified in the overall chemical protective clothing specification.

Evaluations of protective clothing material chemical resistance should be carried out by the appropriate test. ISO 6529 specifies methods for measuring the resistance of the protective clothing materials to permeation by either liquids or gases. ISO 13994 specifies a method for determinig the penetration resistance of protective clothing materials under conditions of continuous liquid contact and pressure, and can be applied to microporous materials, seams, and assemblages. ISO 6530 specifies a procedure for measuring the penetration resistance of protective clothing materials from the impact and runoff of liquids. General protective clothing requirements are specified in ISO 13688.

# Protective clothing — Protection against gaseous and liquid chemicals — Determination of resistance of protective clothing to penetration by liquids and gases

## 1 Scope

This International Standard specifies six different test methods for determining the resistance of complete protective clothing to inward leakage of either gaseous or liquid chemicals (protective clothing integrity). These test methods apply to either liquid or gaseous chemicals, or aerosols, and range in the level of severity.

The six integrity test methods specified by this International Standard are as follows:

a) **Method A** specifies a method for assessing the resistance of a gas-tight suit to outward leakage of air through, for example, essential openings, fastenings, seams, interface areas between items, pores and any imperfections in the materials of construction.

b) **Method B** specifies two different methods for determining the inward leakage of chemical protective suits in a gaseous (or aerosol) environment. The procedure is applicable to gas-tight suits and provides an evaluation of chemical protective suit integrity, paticularly leakage in the breathing zone, under dynamic conditions through the use of human subjects.



c) **Method C** specifies a method for determining the resistance of chemical protective clothing to penetration by jets of liquid chemicals. This procedure is applicable to clothing worn where there is a risk of exposure to a forceful projection of a liquid chemical and intended to be resistant to penetration under conditions which require total body surface cover but not gas-tight clothing.



d) **Method D** specifies a method for determining the resistance of chemical protective clothing to penetration by sprays of liquid chemicals. This procedure applies to protective clothing intended to be worn when there is a risk of exposure to slight splashes of a liquid chemical or to spray particles that coalesce and run off the surface of the garment and intended to be resistant to penetration under conditions which require total body surface cover but not gas-tight clothing.

e) **Method E** specifies an alternative method to method D for determining the resistance of chemical protective clothing to penetration by sprays of liquid chemicals. Method E differs from Method D in that it uses a static mannequin instead of a test subject, it also uses a different spray configuration and duration (1 h compared to 30 min for Method D) and is based on a qualitative determination of observed liquid on the absorbent coverall or interior of the chemical protective clothing.

f) **Method F** is a modification of Method D where the spray has been modified to light spray or mist by use of different nozzles and spray conditions and is intended for partial body protective clothing where the likelihood of splash exposure is low.

Methods C, D, E and F are not appropriate for evaluating the permeation or penetration of liquid chemicals through the material from which the clothing is made.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 13688, *Protective clothing — General requirements*

EN 136:1998, *Respiratory protective devices — Full face masks — Requirements, testing, marking*

EN 149:1991, *Respiratory protective devices — Filtering half masks to protect against particles — Requirements, testing, marking*

EN 12941:1998, *Respiratory protective devices — Powered filtering devices incorporating a helmet or a hood — Requirements, testing, marking*

## 3 Terms and definitions

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

**3.1**
**assemblage**
permanent fastening between two or more different garments, or between chemical protective clothing and accessories, obtained, for example by sewing, welding, vulcanizing, gluing



**3.2**
**calibrated stain**
fluorescent or visible stain, with a defined minimum area, generated by dropping a specified quantity of test agent onto an absorbent coverall

NOTE The calibrated stain is used to measure liquid penetration during spray and jet testing of chemical protective clothing.

**3.3**
**chemical protective clothing**
combined assembly of garments, worn to provide protection against exposure to or contact with chemicals

**3.4**
**chemical protective suit**
clothing worn to protect against chemicals that covers the whole, or greater part of the body

NOTE 1 A chemical protective suit may comprise of garments combined together to provide protection to the body.

NOTE 2 A suit may also have various types of additional protection such as hood or helmet, boots and gloves joined with it.

**3.5**
**connection**
assemblage or joint

**3.6**
**degradation**
deleterious change in one or more physical properties of a protective clothing material due to contact with chemicals

**3.7**
**garment**
individual component (of chemical protective clothing), the wearing of which provides protection against contact with chemicals to the part of the body that it covers

**3.8**
**gas-tight suit**
one-piece garment with hood, gloves and boots which, when worn with self-contained or air-line breathing apparatus provides the wearer a high degree of protection against harmful liquids, particles and gaseous or vapour contaminants

**3.9**
**joint**
non-permanent fastening between two different garments, or between chemical protective clothing and accessories

**3.10**
**penetration**
flow of a chemical through closures, porous materials, seams, and holes or other imperfections in a protective clothing material on a non-molecular level

**3.11**
**permeation**
process by which a chemical moves through a protective clothing material on a molecular level

NOTE Permeation involves

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

b) diffusion of the sorbed molecules in the material, and

c) desorption of the molecules from the opposite (inside) surface of the material.



**3.12**
**protective clothing material**
any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from a potential hazard



**3.13**
**undergarments**
clothing worn next to the body surface, beneath the other clothing

## 4 Method A — Internal pressure test

### 4.1 Principle

After the suit has been inflated to a defined pressure, the extent of the subsequent leakage of air is assessed by recording the pressure reached after a defined period. Two different sets of test pressures are provided. Method A1 uses an inflation pressure of 1 250 Pa and a test pressure of 1 000 Pa. Method A2 uses an initial pressure of 1 750 Pa, a dwell test pressure of 1 700 Pa, and a test pressure of 1 650 Pa. Method A1 is considered the minimum internal pressure test, but Method A2 provides a more rigorous determination of suit gas-tight integrity.

NOTE This test does not simulate penetration by gases in an inward direction. Although the danger to the wearer arises from leakage in an inward direction, this test method assesses the outward leakage of air after the gas-tight suit has been inflated so as to stretch the material of construction, thereby enabling the test method to be capable of detecting very small imperfections, e.g. holes, splits or tears.

### 4.2 Apparatus

**4.2.1 Source of compressed air**, supplying air within the temperature range of $(20 \pm 5)$ °C.

**4.2.2 Pressure-measuring device**, with the capability of measuring up to $(1\,750 \pm 30)$ Pa with a sensitivity (readability) of 50 Pa.

**4.2.3 Vent valve-closure components**, such components may be plugs or other means that are to be supplied for test purposes by the manufacturer.

**4.2.4 Stop clock** or **appropriate timing device**, capable of measuring to the nearest second.

## 4.3 Procedure

### 4.3.1 General

**4.3.1.1** Lay out the chemical protective suit including attached gloves and footwear, and full facemask if appropriate, on a suitable flat and clean surface away from any sources of heat and/or currents of air.

Select an area for testing that is away from direct sunlight, open doors, drafts, heating and air conditioning registers.

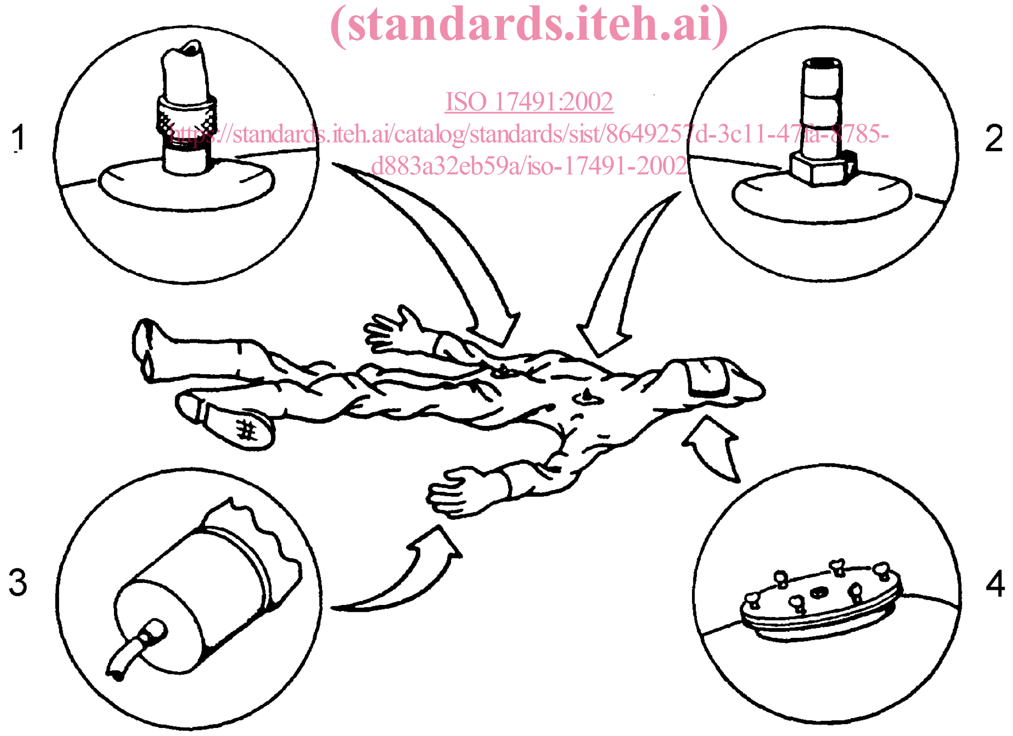
**4.3.1.2** Perform a visual inspection of the chemical protective suit. Check the chemical protective suit for seam integrity by visually examining the seams and gently pulling on the seams. Ensure that all air supply lines, fittings, visor or faceshield, zippers, and valves are secure and show no signs of deterioration.

**4.3.1.3** Remove any creases and folds in the suit as far as practicable.

**4.3.1.4** Leave the suit for a minimum of 1 h at (ambient temperature $\pm$ 3) °C.

**4.3.1.5** Make an inflation connection using on the techniques illustrated in Figure 1. Attach the pressure-measuring device (4.2.2) to the chemical protective suit or inflation system.






**Key**

1 Airline connector or inflation couple
2 Suit venting-valve adapter
3 Removable gloves
4 Face-plate seal

**Figure 1 — Typical examples of suit modification to permit inflation**

**4.3.1.6** Carefully blank off the valves and other openings on the chemical protective suit with appropriate means of closure supplied by the manufacturer.

**4.3.1.7** Choose either Method A1 or Method A2.

### 4.3.2 Method A1 — Minimum procedure

**4.3.2.1** Using compressed air (4.2.1), inflate the suit carefully to a pressure of $(1\,250 \pm 50)$ Pa.

**4.3.2.2** Maintain the pressure at $(1\,250 \pm 50)$ Pa for at least 1 min by addition of air, if necessary, and at the same time ensure that any creased areas are unfolded and that the suit is stretched as appropriate.

NOTE During this period, the temperature is stabilized and the pressure throughout the suit reaches equilibrium.

**4.3.2.3** After the period of at least 1 min has elapsed (see 4.3.2.1), adjust the pressure in the suit to $(1\,000 \pm 25)$ Pa.

**4.3.2.4** Allow a further 4 min to elapse. Note and record the ending pressure in the suit in pascals.

Pay careful attention to the cleanliness and the refitting of valves which have been obstructed or removed to carry out the test, to ensure that they function satisfactorily after the test.

**4.3.2.5** If the chemical protective suit shows a 20 % or more drop in pressure [(inflation pressure minus the ending pressure/inflation pressure) $\times$ 100], check for leaks by inflating the suit to $(1\,250 \pm 50)$ Pa and by brushing or wiping the entire chemical protective suit (including seams, closures, lens gaskets, glove-to-sleeve joints, etc.) with a mild soap and water solution. Observe the wiped areas of the chemical protective suit for the formation of soap bubbles, which are an indication of a leak. Repair all identified leaks in accordance with specific manufacturer instructions, if permitted.



Any commercially available, high sudsing soap solution such as children's bubble, has been found to offer satisfactory performance for this purpose.

**4.3.2.6** Retest the repaired chemical protective suit as specified in 4.3.1.1 to 4.3.1.6 and 4.3.2.1 to 4.3.2.4 (if it originally showed a 20 % or more drop in pressure, and was subsequently repaired).

### 4.3.3 Method A2 — Rigorous procedure

**4.3.3.1** Using compressed air, inflate the suit carefully to a pressure of $(1\,750 \pm 50)$ Pa.

**4.3.3.2** Maintain the pressure at $(1\,700 \pm 50)$ Pa for 10 min by addition of air, if necessary, and at the same time ensure that any creased areas are unfolded and that the suit is stretched as appropriate.

NOTE During this period, the temperature is stabilized and the pressure throughout the suit reaches equilibrium.

**4.3.3.3** After the period of 10 min has elapsed (see 4.3.3.2), adjust the pressure in the suit to $(1\,650 \pm 25)$ Pa.

**4.3.3.4** Allow a further 6 min to elapse. Note and record the ending pressure in the suit in pascals.

Pay careful attention to the cleanliness and the refitting of valves which have been obstructed or removed to carry out the test, to ensure that they function satisfactorily after the test.

**4.3.3.5** If the chemical protective suit shows unacceptable leakage as defined by the required performance, check for leaks by inflating the suit to $(1\,700 \pm 50)$ Pa and by brushing or wiping the entire chemical protective suit (including seams, closures, lens gaskets, glove-to-sleeve joints, etc.) with a mild soap and water solution. Observe the wiped areas of the chemical protective suit for the formation of soap bubbles, which are an indication of a leak. Repair all identified leaks in accordance with specific manufacturer instructions, if permitted.

Any commercially available, high sudsing soap solution such as children's bubble, has been found to offer satisfactory performance for this purpose.

**4.3.3.6** Retest the repaired chemical protective suit as specified in 4.3.1.1 to 4.3.1.6 and 4.3.3.1 to 4.3.3.4.

### 4.4 Test report

The test report shall include the following information.

a) a reference to this International Standard, i.e. ISO 17491;

b) the method used, i.e. Method A1 or Method A2;

c) the manufacturer/supplier and any identifying mark;

d) the pressure recorded in clause 4.3.2.4 or 4.3.3.4 and the test temperature;

e) any further qualifying remarks and observations;

f) the results of any retesting, after repair of the suit.

## 5 Method B — Aerosol and gaseous inward leakage test

### 5.1 Principle



The subject wearing the suit under test, walks on a treadmill over which there is an enclosure. Through this enclosure flows a constant concentration of the test agent, either sodium chloride (NaCl) using Method B1 or sulfur hexafluoride ($SF_6$) using Method B2.

NOTE Method B1 simulates an aerosol challenge while Method B2 simulates a gaseous challenge.



The air inside the suit is sampled to determine the test agent content. The sample is extracted through a probe placed inside the suit. Another probe measures the pressure inside the suit.

The airflow rate to the suit is adjusted and maintained at the manufacturer's minimum design flow rate. If the suit is not outfitted with an external continuous flow air supply, then the airflow rate into the suit shall be at the rate of sampling air that is withdrawn from the suit. For a typical arrangement, see Figures 2 and 3.

### 5.2 Test agents and test subjects

#### 5.2.1 Test agents

##### 5.2.1.1 Method B1 — Sodium chloride test agents

The mean sodium chloride concentration within the enclosure shall be as described in 8.16.3.2.2 of EN 136:1998.

##### 5.2.1.2 Method B2 — Sulfur hexafluoride test agents

This method employs sulfur hexafluoride as the test gas. The subject wearing the suit under test stands with his suited body surrounded by the $SF_6$ test atmosphere (see Figure 3). Accurate determinations of leakage shall be possible within the range for 0,001 % to approximately 20 % depending on the test challenge atmosphere. It is recommended to use a test atmosphere at 0,1 % $SF_6$ (by volume) since $SF_6$ can build up inside the suit.

$SF_6$ is not to be used for full suits utilizing filters as exhaust assemblies unless the suit exhaust assemblies are connected to an atmosphere free of the challenge agent during testing.