INTERNATIONAL STANDARD

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Protective clothing - Test methods for clothing providing protection against chemicals —

Part 5: Determination of resistance to penetration by a spray of liquid (manikin spray test)

Vêtements de protection - Méthodes d'essai pour les vêtements fournissant une protection contre les produits chimiques —

Partie 5: Détermination de la résistance à la pénétration par vaporisation de liquide (essai au brouillard à l'aide d'un mannequin)

Reference number
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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

ISO 17491 (all parts) cancels and replaces ISO 17491:2002, which has been technically revised.

ISO 17491 consists of the following parts, under the general title *Protective clothing — Test methods for clothing providing protection against chemicals*:

— *Part 1: Determination of resistance to outward leakage of gases (internal pressure test)*

— *Part 2: Determination of resistance to inward leakage of aerosols and gases (inward leakage test)*

— *Part 3: Determination of resistance to penetration by a jet of liquid (jet test)*

— *Part 4: Determination of resistance to penetration by a spray of liquid (spray test)*

— *Part 5: Determination of resistance to penetration by a spray of liquid (manikin spray test)*

Introduction

Chemical protective clothing is worn in conjunction with appropriate respiratory protective devices when required 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 are carried out by the appropriate test.

ISO 6529 specifies methods for measuring the resistance of the protective clothing materials, seams, and assemblages to permeation by either liquids or gases. ISO 13994 specifies a method for determining 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.

This International Standard specifies 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 integrity test methods specified by this International Standard are as follows:

— Part 1 specifies a method to be performed either at minimum test settings (method 1) or at more rigorous test settings (method 2), 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.

— Part 2 specifies two different methods for determining the inward leakage of chemical protective clothing in an aerosol environment (method 1) or gaseous environment (method 2). The procedure is applicable to gas-tight suits and non-gas-tight suits according to ISO 16602 and provides an evaluation of chemical protective suit integrity, particularly leakage in the breathing zone, under dynamic conditions through the use of human subjects.

— Part 3 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.

— Part 4 specifies a method to be performed either at minimum test settings (method A, low-level spray test) or at more rigorous test settings (method B, high-level spray test), 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.

— Part 5 specifies an alternative test method for determining the resistance to spray penetration. It uses a static manikin instead of a test subject; it also uses a different spray configuration and duration.

The methods specified in this International Standard are not appropriate for evaluating the permeation or penetration of liquid chemicals through the material from which the clothing is made.

Protective clothing - Test methods for clothing providing protection against chemicals —

Part 5:
Determination of resistance to penetration by a spray of liquid (manikin spray test)

1 Scope

This part of ISO 17491 specifies an alternative test method to the one described in ISO 17491-4.

The method for determining the resistance to chemical spray penetration differs from the method in ISO 17491-4 in that it uses a static manikin instead of a test subject. It also uses a different spray configuration and duration.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13688, *Protective clothing — General requirements*

ISO/TR 11610, *Protective clothing — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 11610 and the following apply.

3.1
absorbent overall
overall made from an absorbent material, worn under the test suit and intended for collecting liquid penetration during spray and jet testing of chemical protective clothing

4 Principle

The chemical protective clothing is placed on a manikin that is already dressed in an absorbent overall covering the portions of the manikin form that are of interest. Water, treated to achieve a surface tension of $(30 \pm 5) \times 10^{-3} \mathrm{N/m}$, is sprayed at the chemical protective clothing from five nozzles positioned in a specific configuration with respect to the specimen.

The specimen is exposed to the liquid spray for a period of 15 min in each of four specimen orientations; thus 60 min spray in total on one specimen. Liquid penetration resistance is determined by the absence of liquid inside the chemical protective clothing on the inner liquid-absorptive garment. The chemical protective clothing is rated as passing if liquid does not penetrate and as failing if liquid does penetrate.

5 Test agent and test subject

5.1 Test agent, unless specified in the performance specification, the following standard test agent shall be used.

Prepare the test agent by dissolving a wetting agent and water-soluble fluorescent or visible dye in water at ambient temperature to form a non-toxic, non-foaming solution with the following characteristics.

The surface tension shall be $(30 \pm 5) \times 10^{-3}\,\mathrm{N/m}$. Any method may be used to determine the surface tension of the test agent provided it can measure to the tolerance given above, for example, a Wright surface tension and interfacial tension torsion balance using a standard 12-mm-diameter platinum ring would be acceptable.

NOTE A typical concentrated solution can be made by dissolving 4 g methyl blue (CAS number 28983–56–4), 2 ml anionic surfactant liquid [sodium lauryl ether sulphate (CAS number 009004–82–4)], and, as stabilizer for the dye, 125 g citric acid (CAS number 77–92–9, analytical grade) in 1 l of tap water. The mixture is stirred for 15 min to 20 min with a magnetic stirrer and eventually 200 ml of it is diluted in 10 l of water.

It shall be ensured that the surface tension is stable throughout the test, i.e. the surface tension of the liquid leaving the nozzle as well as the tension of the liquid in the tank shall meet the requirements. This shall be verified before and after each test.

Avoid dyes that adhere too strongly to the fibres of the absorbent material, resulting in a wet spot larger than the coloured spot.

The necessary measures shall be taken to avoid contamination of the surface water drainage system.

5.2 Test subject, consisting of a human-form manikin, appropriately sized for testing the protective clothing or protective ensemble.

The selected manikin should provide as much contact with the protective clothing or protective ensemble as possible. The manikin shall have a water-resistant coating. The manikin shall have straight arms and legs with the arms at the manikin's sides.

The necessary measures shall be taken to protect the test subject and to avoid contamination of the surface water drainage system.

6 Apparatus

6.1 Absorbent overall, shall be a one-piece garment with a hood.

It shall be made from a water-absorbent material that is sufficiently homogeneous to produce absorption spots which vary less than 10 % in surface from the mean value for a given volume of liquid, when sampled at any place on the garment.[1)]

6.2 Calibration stain, shall be produced on every absorbent overall used under the test suit.

This can be done before the spray test is performed or immediately afterwards.

Select an area of the absorbent overall that is not likely to be contaminated. Put under it a piece of undergarment and ensure that both layers are in contact. Put the assembly under a dispenser. The lower tip of the dispenser shall be at a vertical distance of (5 ± 0,5) cm from the assembly. Dispense a volume of (25 ± 5) µl of the test liquid to produce a clearly visible stain on the surface of the overall. Define the outline of the stain before it is measured. Several methods can be used to measure the calibration stain, such as a planimeter. The minimum area of the stain shall be 1 cm^2.

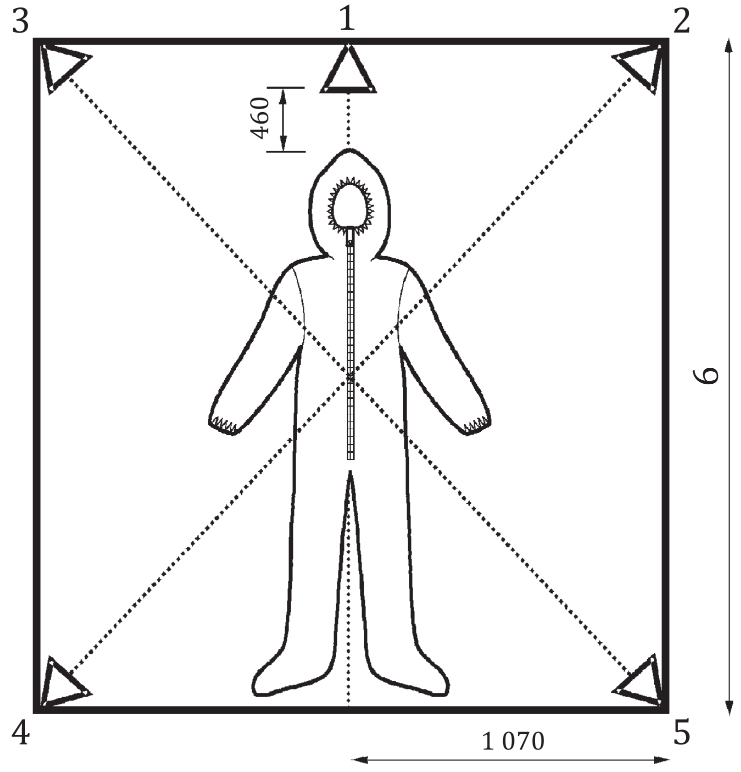
1) Details of suitable products for this purpose are available from ISO/TC 94/SC 13.

The calibrated stain shall be used as a reference for the pass/fail evaluation of the tested suit. Pass/fail criteria shall be defined in the corresponding product standard (see Reference [4]).

6.3 Shower system, consisting of five low-flow showerhead nozzles and a pressurized liquid supply.

The five nozzles shall be oriented with respect to the manikin as specified in Figure 1. The pressurized liquid supply shall be delivered at (3,0 ± 0,2) l/min through each nozzle. 2)

Dimensions in millimetres



FRONT VIEW

Key

1 nozzle position 1 directly above top of suit at distance of 460 mm

2 nozzle position 2 at top corner

3 nozzle position 3 at opposite top corner

4 nozzle position 4 at bottom corner

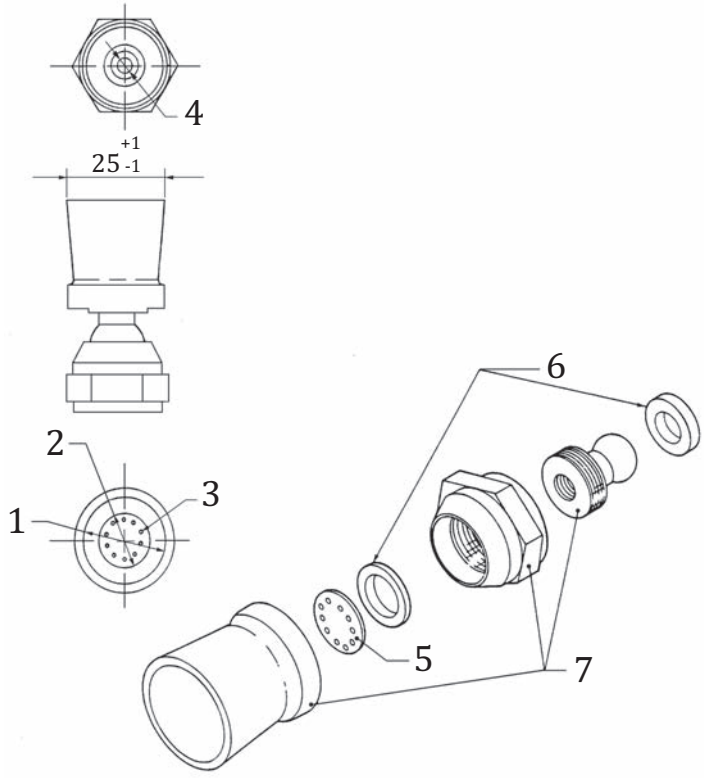
5 nozzle position 5 at opposite bottom corner

6 total height of apparatus is height of suit plus 460 mm

Figure 1 — Positions of shower nozzles

2) Details of suitable products for this purpose are available from ISO/TC 94/SC 13.

Dimensions in millimetres



Key

1 internal nozzle diameter, 23 mm
2 spray plate diameter, 14,6 mm, brass
3 0,8 mm diameter holes through 10 places equally spaced on a 9 mm diameter centred circle
4 3,75 mm diameter bore
5 brass spray plate
6 rubber gaskets
7 stainless steel

Figure 2 — Example of shower nozzle specifications

6.4 Stopwatch, or other appropriate timing device accurate to 1 s.

7 Specimen preparation

7.1 Protective clothing or protective ensemble components, shall be tested as received and in accordance with the manufacturer's instructions. Duct tape or other non-uniform methods for closing or sealing, or both, interfaces shall not be used.

7.2 Parts of the protective clothing or protective ensemble that are not to be tested, shall be suitably blocked off to prevent liquid from penetrating those areas. For example, in the case of ensembles without gloves, block off the outer end of the sleeves with waterproof tape or some other sealant to prevent liquid penetration at the hands.

8 Procedure

8.1 Prior to each test, inspect the absorbent overall and protective clothing or protective ensemble (and other ensemble components and equipment to be tested) for total dryness before using.

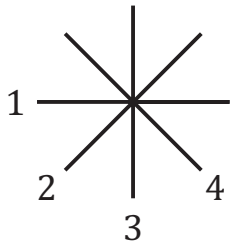
8.2 Put the absorbent overall on the manikin. The absorbent overall shall cover all areas of the manikin that are of interest.

8.3 Put the protective clothing or protective ensemble to be tested over the absorbent overall on the manikin in accordance with the manufacturer's instructions. Place and attach additional ensemble components and equipment on the manikin in accordance with the manufacturer's directions.

8.4 Block off from exposure to the liquid spray any areas of the manikin or protective clothing or protective ensemble not being evaluated. For example, tie or tape a plastic bag over the manikin's head. Ties or tape, or both, shall not extend more than 10 mm past the edge of the protective clothing or protective ensemble.

8.5 Add a sufficient amount of test agent to the water supply to achieve a surface tension of $(30 \pm 5) \times 10^{-3}\,\mathrm{N/m}$.

8.6 Expose the suited manikin to the liquid spray for a period of 15 min in each of the four orientations shown in Figure 3. The manikin's torso shall be oriented with the shoulders parallel to the indicated orientation. Spray liquid at the rate of (3,0 ± 0,2) l/min through each nozzle simultaneously. Ensure that each nozzle is not partly plugged or closed at the start of each test.



NOTE Figure 3 shows the top-down view for the suited manikin. Position 1 is the baseline position with the line parallel to the body plane with both arms at the manikin's sides. The suited manikin is rotated through each of the four positions.

Figure 3 — Orientation of suited manikin exposure (top view)

8.7 At the end of the liquid spray period, remove excess liquid from the surface of the test garment. Paper towelling is one method that works well.

8.8 Inspect the protective clothing or protective ensemble within 10 min of the end of the liquid spray period for evidence of liquid penetration. Determine liquid penetration by one of the following procedures.

a) Remove the protective clothing or protective ensemble and any other ensemble components or equipment from the manikin in a dry area and examine the absorbent overall, garment liners, and garment interior for signs of dye staining. Record these areas as locations of dye staining or wetting.

b) If a dye is added to the liquid, remove the protective clothing or protective ensemble and any other ensemble components or equipment from the manikin and examine the absorbent overall, garment

liners, and garment interior for the appearance of any dye-coloured areas. Record these areas as locations of wetness.

c) If a fluorescent dye is added to the liquid, examine the absorbent overall, garment liners, and garment interior under ultraviolet lighting in a dark room for fluorescing areas. Record these areas as locations of wetness.

8.9 Record any protective clothing or protective ensemble as passing if no areas of wetness are observed. If there are areas of wetness, record the protective clothing or protective ensemble as failing. Describe the probable reason for each failure.

9 Test report

The test report shall include the following information:

a) a reference to this part of ISO 17491 (i.e. ISO 17491-5);

b) the manufacturer/supplier and any identification mark of the tested protective clothing;

c) a description of all means that may have been used for the purpose of blocking off parts of the protective clothing worn by the manikin or for the purpose of blocking off parts of the manikin at the time of testing in order to prevent liquid from penetrating at those areas;

d) the composition and surface tension of the liquid used in the tests;

e) for each spray test,

   1) the location and approximate areas of contamination of the internal surfaces of the test clothing and the external surface of the absorbent overall, and

   2) any contaminated areas should preferably be indicated by shading on diagrams of a human figure (front and back, separately) or by reference to photographs;

f) the size range of the garment tested as defined in ISO 13688;

g) any further qualifying remarks and observations.

Bibliography

[1] ISO 6529, *Protective clothing — Protection against chemicals — Determination of resistance of protective clothing materials to permeation by liquids and gases*

[2] ISO 6530, *Protective clothing — Protection against liquid chemicals — Test method for resistance of materials to penetration by liquids*

[3] ISO 13994, *Clothing for protection against liquid chemicals — Determination of the resistance of protective clothing materials to penetration by liquids under pressure*

[4] EN 14605, *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])*

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