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

Part 4:

**Determination of resistance to  
penetration by a spray of liquid (spray  
test)**

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

*Partie 4. Détermination de la résistance à la pénétration par  
vaporisation de liquide (essai au brouillard)*



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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17491-4 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 162, *Protective clothing including hand and arm protection and lifejackets*, in collaboration with Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 17491-4, together with ISO 17491-3, cancels and replaces ISO 17491:2002, Clauses 6 and 7 of which have 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 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)*

The following parts are under development:

- 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)*

## Introduction

This part of ISO 17491 describes a test method for determining the spray penetration resistance of chemical protective clothing Type 4 (with spray-tight connections between different parts of the clothing and, if applicable, between the clothing and other items of personal protective equipment) and Type 6 (limited performance protective clothing).

Such clothing comprises one or more items covering the full surface of the body and is intended to be worn under conditions where there is a risk of exposure to a spray of a liquid chemical. Other requirements with regard to this type of clothing and its constituent materials can be found in the respective product standards (see Bibliography [4]).

Interlaboratory testing has shown that this test method is a repeatable pass/fail method.

A document on the selection, use and maintenance of chemical protective clothing is available (see Bibliography [5]).

**CAUTION — Some of the procedures specified in this part of ISO 17491 involve the use of processes which could lead to hazardous situations and hence appropriate precautions should be taken.**

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

Part 4:

## Determination of resistance to penetration by a spray of liquid (spray test)

### 1 Scope

This part of ISO 17491 specifies methods for determining the resistance of chemical protective clothing to penetration by sprays of liquid chemicals at two different levels of intensity:

- a) Method A: low-level spray test. This is applicable to clothing that covers the full body surface and is intended to be worn when there is a potential risk of exposure to small quantities of spray or accidental low-volume splashes of a liquid chemical.
- b) Method B: high-level spray test. This is applicable to clothing with spray-tight connections between different parts of the clothing and, if applicable, between the clothing and other items of personal protective equipment, which covers the full body surface and which is intended to be worn when there is a risk of exposure to sprayed particles of liquid.

This part of ISO 17491 does not address chemical permeation resistance of the materials from which the chemical protective clothing is made.

### 2 Normative references

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

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

##### **connection**

assemblage or join

#### 3.2

##### **calibrated stain**

fluorescent or visible stain, with a defined minimum area, generated by dropping a specified quantity of test liquid on to an absorbent overall

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

**3.3 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 of test method

An aqueous spray, containing a fluorescent or visible dye tracer, is directed under controlled conditions at the chemical protective clothing worn by a human test subject. Inspection of the inside surface of the clothing and the outside surface of the absorbent overall worn under the test garment allows any points of inward leakage to be identified.

## 5 Liquid for application in the form of a spray

A test liquid containing the following substances shall be used:

- water at  $(20 \pm 2)$  °C;
- a water-soluble fluorescent or visible dye, e.g. methyl blue (CAS number [28983-56-4]);
- a surfactant, e.g. Genapol LRO liquid (sodium lauryl ether sulphate, CAS number [009004-82-4]);
- a stabilizer for the dye (if needed), e.g. citric acid (CAS number [77-92-9], analytical grade).

Prepare the test liquid by dissolving the dye in water. Add the surfactant and the dye stabilizer (if needed) in the appropriate proportions to obtain a solution with following characteristics:

- a) for method A: a surface tension of  $(52 \pm 7,5) \times 10^{-3}$  N/m;
- b) for method B: a surface tension of  $(30 \pm 5) \times 10^{-3}$  N/m.

**NOTE** A typical concentrated solution for a high-level spray test can be made by dissolving 4 g methyl blue, 25 ml Genapol LRO liquid and 125 g citric acid 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 the mixture is diluted in 10 l of water.

To measure the surface tension within the stated tolerance, any suitable method may be used, e.g. a Wright torsion balance using a standard 12 mm diameter platinum ring. Agents other than surfactants may be mixed with water if the same surface tension can be obtained.

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 protect the test subject and to avoid contamination of the surface water drainage system.

## 6 Apparatus and test subjects

### 6.1 Absorbent overall

The 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.<sup>1)</sup>

NOTE In order to protect the test subject from the test liquid, water-repellent undergarments should be worn under the absorbent overall.

### 6.2 Calibrated stain

Calibrated stains shall be used as a reference for the pass/fail evaluation of the tested suit. Pass/fail criteria shall be defined in the relevant product standard (see Bibliography [4]).

A calibration stain shall be produced before starting a series of tests and immediately after a test where a leakage has been detected.

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, with the lower tip of the dispenser at a vertical distance of  $(5 \pm 0,5)$  cm above the assembly. Dispense a volume of  $(25 \pm 5)$   $\mu$ l 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<sup>2</sup>.

### 6.3 Turntable

A waterproof platform capable of supporting a test subject and rotating at  $(1 \pm 0,1)$  full circle per minute.

### 6.4 Test liquid container

The test liquid shall be prepared and stored in a container.

### 6.5 Hydraulic pump

A self-priming, recirculating-type pump shall be used. The pump shall be equipped with a pressure gauge and adjustment, a variable output control filter and hoses to convey the test liquid from the test liquid container to the spray boom. A four-way distribution tube shall be connected to the pump outlet, with each of the four outlets connected directly to a nozzle.

The pump shall be capable of supplying a minimum pressure of 400 kPa. Provisions shall be taken to avoid the test starting before the pressure is completely built up.

### 6.6 Stopwatch

A stopwatch accurate to 1 s shall be used.

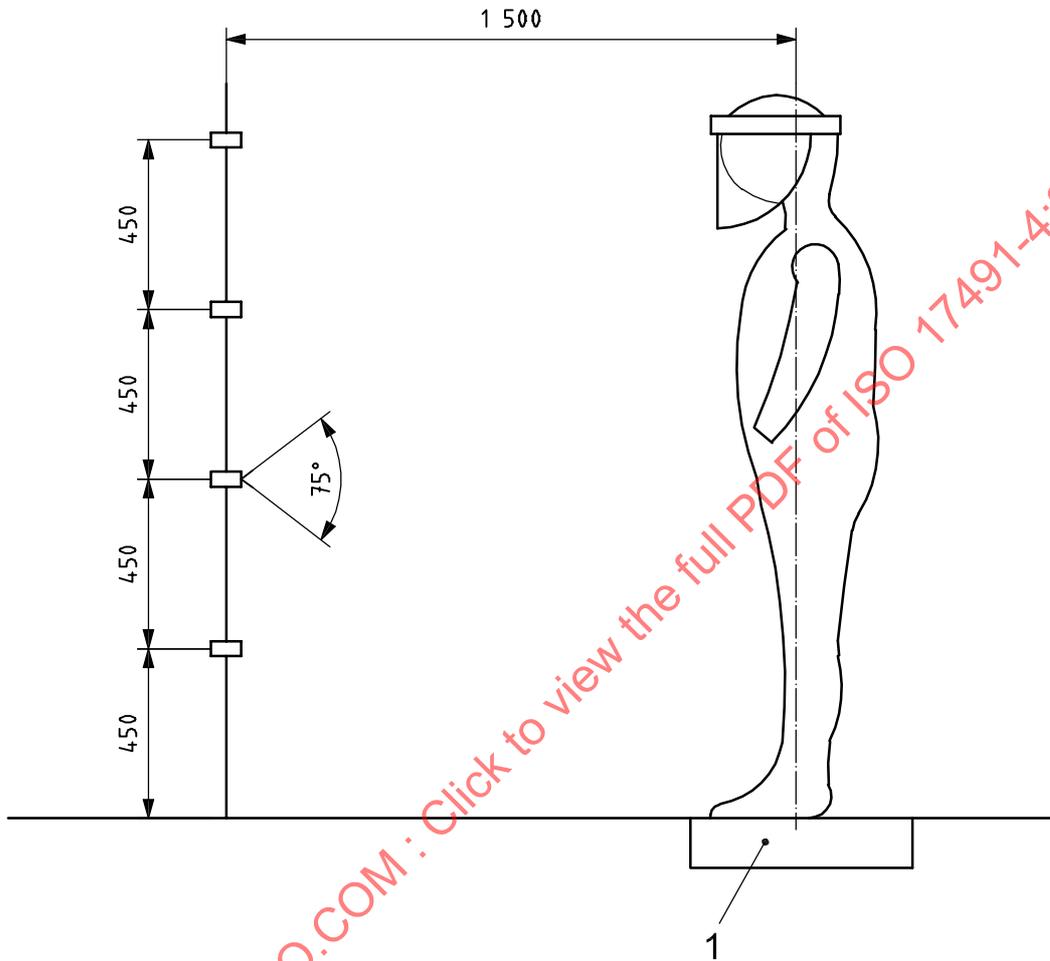
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1) Sontara PES/Woodpulp 45/55 and Poligard Adsorbant garments are suitable for this purpose. This information is given for the convenience of users of this part of ISO 17491 and does not constitute an endorsement by ISO of the products named. Equivalent products may be used if they can be shown to lead to the same results.

6.7 Spray boom

A vertical rod or frame to which four nozzles can be attached 45 cm apart from each other (see Figure 1).

Dimensions in millimetres



Key

1 turntable

Figure 1 — Apparatus for determining the resistance to spray

6.8 Hydraulic nozzles

Nozzles shall be of the hollow cone type, each nozzle supplying liquid at a rate of:

- $(0,47 \pm 0,05)$  l/min at a 300 kPa pressure for method A;
- $(1,14 \pm 0,10)$  l/min at a 300 kPa pressure for method B.

Each nozzle shall be equipped with an individual pressure gauge and pressure control valve in order to obtain the same pressure at each nozzle.<sup>2)</sup>

NOTE Nozzles are subject to deterioration with use. A flowrate verification procedure should be installed to check if they are still fit for use. For easy exchange of nozzles, it is recommended to mount the nozzles on a bayonet-nut connector since the nozzles typically use plastic screw-rings, which may become loose over time.

## 6.9 Test subject

Some of the procedures specified in this part of ISO 17491 involve the use of processes that could lead to a hazardous situation for a human test subject. Attention is drawn to the hazards for the test subject's eyes, ears, nose and mouth, deriving from the application of a liquid spray.

NOTE 1 This part of ISO 17491 does not claim to indicate all hazards which might occur during its application. For the protection of the test subject, national laws and requirements apply.

Tests shall only be carried out by test subjects whose body dimensions are within the range indicated on the size label of the suit to be tested.

NOTE 2 Garment sizes should be provided to suit the body dimensions of known test subjects, taking into account that the test subject is wearing undergarments and an absorbent overall under the test garment. The test subjects should be selected as close as possible to the upper limit of the size range. If garments are too big, leakages may not be detected because there is no contact between the test garment and the absorbent overall.

## 7 Preparation of the test subject for the spray test

The test subject, wearing one layer of undergarments, shall be dressed with the absorbent overall, and subsequently with the test garment, in accordance with the manufacturer's instructions, as well as other items of protection.

If the manufacturer's instructions do not require the suit to be taped to any part of the body of the wearer (such as wrists and ankles) or to any additional item worn by the test subject (e.g. gloves or boots), then it shall not be taped.

## 8 Preparation of the spray application system

### 8.1 Nozzle output

Start the flow of test liquid to the spray nozzles and adjust the pressure at the pump and at every nozzle to obtain a flow rate of:

- $(0,47 \pm 0,05)$  l/min from each nozzle for method A;
- $(1,14 \pm 0,1)$  l/min from each nozzle for method B.

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2) Typical spray nozzles may be obtained from Lurmark (Hypro EU Ltd, Longstanton, Cambridge CB4 5DS, UK), preferably made of PVDF, material prefix 90:

- for the low-level spray: disc DC-03, core CR-23;
- for the high-level spray: disc DC-04, core CR-25.

This information is given for the convenience of users of this part of ISO 17491 and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

NOTE 1 This can be checked by pulling a rubber tube over each nozzle and collecting the output in a beaker for one minute.

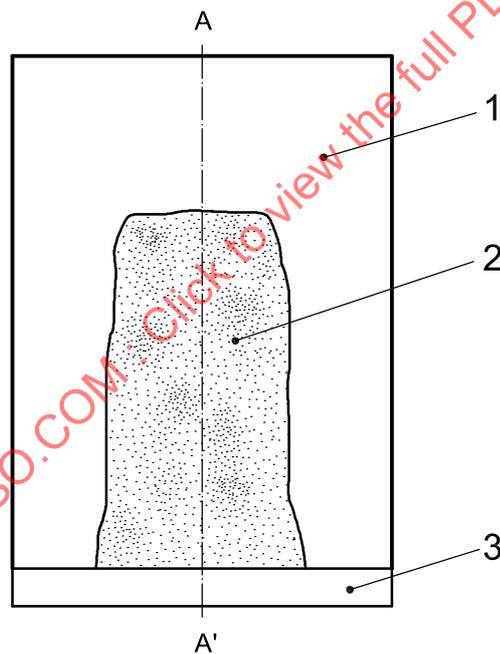
Depending on the construction of the whole tubing, it may take up to 15 s until the full pressure of 3 bar is reached at the nozzles. Therefore, an opening valve, which opens at  $(3^{+0,5}_{-0})$  bar, should be used.

NOTE 2 Minor adjustments to obtain the required output can be made by increasing or decreasing the pressure at each nozzle by a maximum of 0,2 bar. If this is not sufficient, the core and the disc at the nozzle should be replaced by new ones. Since core and disc are subject to ageing, they should be replaced after 50 spray sessions.

**8.2 Alignment of spray nozzles**

The spray emission from the nozzles shall be directed towards the geometric centre of the turntable at a distance of  $(1,5 \pm 0,1)$  m and produce a spray pattern that is symmetrical along a vertical line through the centre point of the turntable.

NOTE The correct alignment and distance of the nozzles can be checked with an artificial target used for collecting the spray. This target can consist of a sheet of non-absorbing fabric of 2 m x 2,5 m, placed vertically at 90° to the nozzle outlet and at the centre point of the turntable. With the equipment set up correctly, the spray should form a pattern of liquid on the target fabric, distributed symmetrically along a vertical line through the centre point of the turntable (see Figure 2). The difference in width between opposite sides of the vertical line should be a maximum of 20 cm. If this is not the case, adjustments should be made.



- Key**
- 1 non-absorbing fabric (target fabric)
  - 2 spray pattern on the target fabric
  - 3 turntable
  - AA' axis line through the centre of the turntable

**Figure 2 — Checking the alignment of the nozzles (schematic representation)**

## 9 Procedure

Position the test subject wearing the chemical protective clothing on the centre of the turntable and mark the position of the feet.

Apply the spray for 1 min to the test subject, whilst the turntable is rotated through 360°. During the spray period, the test subject shall alternately raise each foot approximately 20 cm from the turntable ( $30 \pm 5$ ) times and put it back in its original position. Meanwhile, the arms are kept straight and swung from the back to the front, above the head and back downwards, in unison with the leg movements.

Turn the turntable off and allow the clothing to drain for 2 min while the subject is still standing on the turntable.

Remove respirator and gloves first before opening the test garment. Remove the chemical protective clothing carefully in order to avoid contamination of the absorbent overall and examine the internal surface of the test garment for signs of penetration, paying special attention to openings, seams, closures and zippers. Mark them.

Similarly, examine visually the external surface of the absorbent overall. Once the absorbent clothing is removed, mark the location and extent of any sign of penetration on the absorbent coverall. Measure the area of every spot, with a planimeter for example, and report the total area.

The absorbent overall or a photograph of it shall be retained as a quality record.

## 10 Test report

The test report shall include the following information:

- a) a statement that the test was carried out in accordance with this part of ISO 17491;
- b) the name of the manufacturer/supplier and any identifying mark;
- c) the size of the suits tested and the body dimensions (total length, chest girth) of the test subjects wearing the garments (see Bibliography [1]);
- d) a description of the absorbent overall;
- e) a description of any additional protective equipment or any accessories used during the test and whether and in what manner it was taped to the suit;
- f) the test room temperature;
- g) the method carried out: method A (low-level spray test) or method B (high-level spray test);
- h) the composition and surface tension of the liquid used in the tests;
- i) the test liquid supply pressure at each nozzle;
- j) the areas of contamination of the internal surfaces of the test clothing and the absorbent overall indicated on a diagram of a human figure, by shading the approximate area, (front and back separately) or by reference to photographs;
- k) the total number of penetration spots and the total area measured for all spots;
- l) a description of any pre-treatment and/or pre-conditioning of the suits tested, if applicable;
- m) any further qualifying remarks, observations and comments considered appropriate by the person who has carried out the tests.