



**International  
Standard**

**ISO 17491-4**

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

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

*Habillement 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  
pulvérisation de liquide (essai au brouillard)*

**Second edition  
2024-05**

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CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
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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 document 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](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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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](http://www.iso.org/iso/foreword.html).

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

This second edition cancels and replaces the first edition (ISO 17491-4:2008), which has been technically revised. It also incorporates the Amendment ISO 17491-4:2008/Amd.1:2016.

The main changes are as follows:

- specifications for test liquid have been revised/added;
- [Clause 6](#) has been revised to provide more specificity. Specification have been changed and/or revised for absorbent overall, calibrated stain, turntable, spray booth, spray boom, hydraulic nozzles in [Clause 6](#) and other applicable clauses;
- details for the selection of the right overall size have been added in [6.10](#) as well as in [Annex B](#);
- [8.3](#) has been revised and heading changed to “Distribution of the spray liquid and alignment of spray nozzles.”;
- figure and additional information have been added in [9.1](#) to provide more specificity;
- inclusion of [Annex A](#) on absorbent fabric for the detector suit and non-absorbent fabric for the calibration pattern;
- inclusion of [Annex B](#) on test subject size measurement and right overall size fitting;
- inclusion of [Annex C](#) on right donning and doffing, as well as stain area measurement;
- inclusion of [Annex D](#) with the ILT results.

A list of all parts in the ISO 17491 series can be found on the ISO website.

## ISO 17491-4:2024(en)

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](http://www.iso.org/members.html).

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## Introduction

This document 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<sup>[1]</sup>.

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<sup>[2]</sup>.

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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)

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

#### 1 Scope

This document specifies the test method 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 liquid chemical.

This document does not apply to chemical permeation resistance of the materials from which the chemical protective clothing is made.

#### 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 11610, *Protective clothing — Vocabulary*

#### 3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

##### 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

### 3.2

#### calibrated stain

visible stain, with a defined minimum area, generated by dropping a specified quantity of test liquid on to an absorbent overall (3.1)

Note 1 to entry: The calibrated stain is used to measure liquid penetration during spray and jet testing of chemical protective clothing.

## 4 Principle of test method

An aqueous spray, containing a 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.

An interlab was performed and the results and conclusion can be found in [Annex D](#).

## 5 Test liquid

To prepare the test chemical add methyl blue dye and dye stabilizer prior to adding the surfactant to water. The temperature of the test liquid shall be between 20 °C and 30 °C.

For methods A and B, the concentration of the methyl blue dye (CAS number 28983-56-4) shall be  $(0,2 \pm 0,02)$  g/l. The dye stabilizer shall be analytical grade citric acid (CAS number 77-92-9) with a concentration of  $(2,45 \pm 0,05)$  g/l.

The surfactant is then added to achieve the required surface tension. Mixtures such as dish washing detergent that include other ingredients are not considered surfactants and shall not be used.

a) For method A: a surface tension of  $(52,0 \pm 7,5) \times 10^{-3}$  N/m;

b) For method B: a surface tension of  $(30,0 \pm 5,0) \times 10^{-3}$  N/m.

NOTE 1 Surfactants: Genapol LRO liquid<sup>1)</sup> [sodium lauryl ether sulfate (CAS number [009004-82-4])] that can be used to achieve the required surface tension at the concentration of 0,03 ml/l for method A and 0,5 ml/l for method B. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the products named. Equivalent products can be used if they can be shown to lead to the same results.

NOTE 2 To measure the surface tension within the stated tolerance, any suitable method can be used, e.g. a wright torsion balance using a standard 12 mm diameter platinum ring.

It shall be ensured that the surface tension and temperature of the test liquid are 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 day of test and shall meet all the above requirement in this clause according to either Method A or Method B.

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 overall shall be a one-piece garment with a hood made with absorbent white or off-white fabric. It shall not include elastic waistband/gathers at the waist as it affects contact between the test garment and the absorbent overall. The absorbent overall shall be sufficiently homogeneous to produce absorption spots which vary less than 10 % in surface area from the mean value for a given volume of liquid, when sampled

1) Genapol LRO liquid is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

at any place on the garment. It shall be made from a water-absorbent material. See [Annex A](#) for absorbent overall requirements.

## 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 specified in the relevant product standard<sup>[1]</sup>.

A calibration stain shall be produced only after a test where a leakage has been detected on the absorbent overall.

Select an area of the absorbent overall where no leakage has been detected right after the doffing of the garment. 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  $(5,0 \pm 0,5)$  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. After 5 min ( $\pm 15$  s), 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> after 5 min ( $\pm 15$  s).

## 6.3 Turntable.

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

The diameter of the turntable shall be 60 cm or more.

## 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.

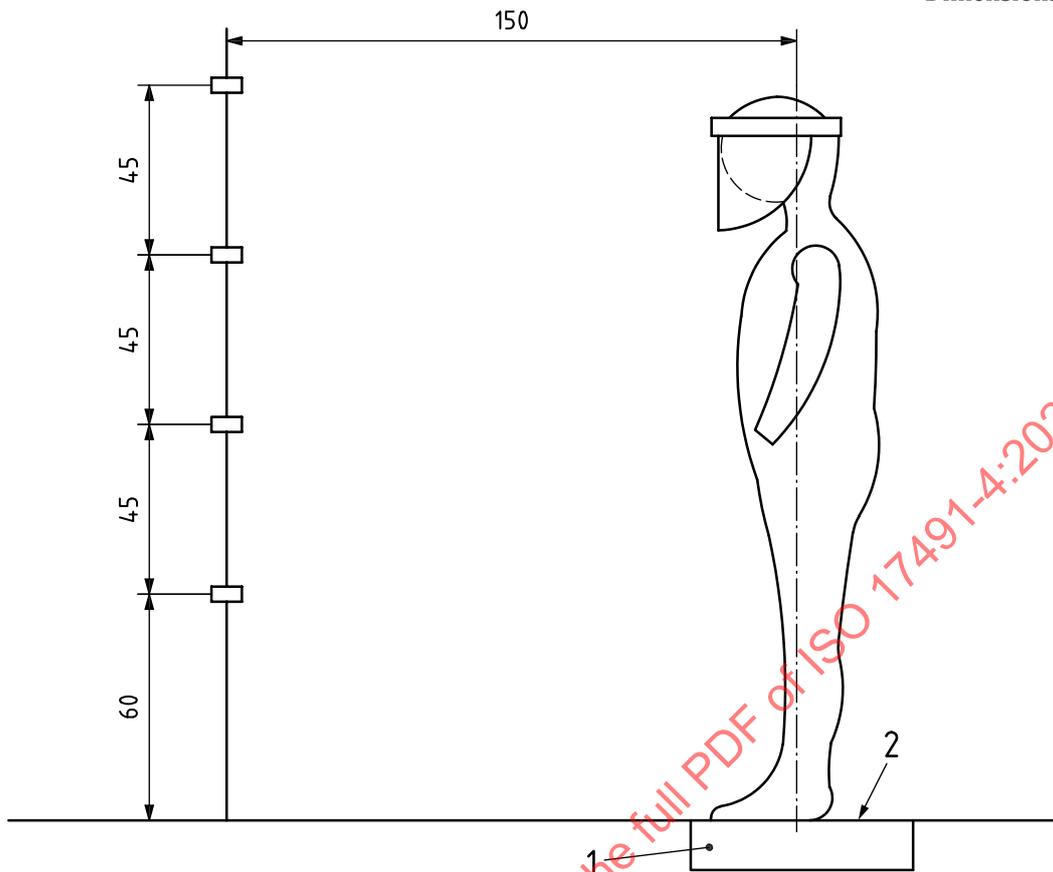
A stopwatch accurate to 1 s shall be used.

## 6.7 Spray booth.

The size of the spray booth shall be at least 2,14 m (H)  $\times$  1,2 m (W)  $\times$  2 m (D), but it shall not exceed 3 m (H)  $\times$  3 m (W)  $\times$  3,5 m (D).

## 6.8 Spray boom.

A vertical rod or frame to which four nozzles can be attached  $(45,0 \pm 0,5)$  cm apart from each other starting from the top of the turntable (see [Figure 1](#)). In [Figure 1](#), the turntable surface is at the same level as the floor. For cabins with turntable above the floor, the lowest nozzle shall be  $(60,0 \pm 0,5)$  cm from the surface of the turntable and not from the cabin floor.

**Key**

- 1 turntable
- 2 top of turn table (cabin floor may be even with or lower than turn table)

**Figure 1 — Apparatus for determining the resistance to spray**

### 6.9 Hydraulic nozzles.

Hydraulic nozzles<sup>2)</sup> 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.

Nozzles are subject to deterioration with use. A flowrate verification procedure is recommended 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 since the nozzles typically use plastic screw rings, which can become loose over time.

2) Typical spray nozzles can be obtained from Lurmark (Hypro EU Ltd, Longstanton, Cambridge CB4 5DS, UK), Agrotop (Agrotop GmbH, Obertraubling 93083, Germany), Albuz (Solcera, Evreux 27000, France) and Teejet (Spraying Systems Co, Glendale Heights, IL 60139-3408, USA):

- for the method A: disc DC-03, core CR-23 with a spraying angle of  $(70 \pm 10)^\circ$  300 kPa pressure
- for the method B: disc DC-04, core CR-25 with a spraying angle of  $(70 \pm 10)^\circ$  300 kPa pressure

This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products (same nozzle spraying type, flow and spraying angle at the indicated pressure) can be used if they can be shown to lead to the same results.

## 6.10 Test subjects and test subject dimensions.

The body dimensions of the test subject, in particular the chest measurements, shall be measured including all the garments underneath the test garment (e.g. underwear, undergarments, any garment worn to protect the test subject, absorbent overall). The test garment size shall be based on the range indicated on the size label of the suit to be tested using the above measurements.

Garment fit: although the test subjects should be selected as close as possible to the upper limit of the size range, the garment should not be too tight before the practical performance test as this may stretch the seams. If garments are too big, leakages may not be detected because there is no contact between the test garment and the absorbent overall. Overall, a garment that is too tight is worse, than slightly too loose. Contact between the absorbent overall and the inside of the test garment is important for this test procedure, care should be taken to ensure that garment size selection for both the absorbent overall and the test garment can achieve contact given the human subject's body dimension (see [Annex B](#)).

Some of the procedures specified in this document 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 This document 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.

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

The test subject shall be dressed in the absorbent overall (see [6.1](#)), and subsequently with the test garment (see [6.10](#)), in accordance with the manufacturer's instructions, as well as any other items of protection including the requirements in [Annex C](#).

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

The practical performance test described for the product standard (for example ISO 16602, EN 13034 or EN 14605), shall be carried out by repeating each of the 7 movements three times prior to moving to the next movement.

## 8 Preparation of the spray application system

### 8.1 Test liquid

Before each test, a verification shall be performed to confirm that the surface tension and the temperature of the test liquid are the same as mentioned in [Clause 5](#).

### 8.2 Nozzle output

Before each test, calibration of the nozzles shall be performed. The flow of test liquid to the spray nozzles and the pressure at the pump and at every nozzle shall be adjusted to obtain a flow rate according to [6.8](#) and [6.9](#) and depending whether Method A or Method B are to be used. It may be required to adjust the nozzle output by increasing or decreasing  $\pm 10$  % of the pressure at each nozzle. If this is not sufficient, the nozzle shall be replaced by new ones before the test.

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

NOTE 2 Depending on the construction of the whole tubing, it may take up to 15 s until the full pressure of 300 kPa is reached at the nozzles

### 8.3 Distribution of the spray liquid and alignment of spray nozzles

The spray emission from nozzles shall be directed vertically to the target sheet at a distance of  $(1,5 \pm 0,1)$  m for 1 min.

The target sheet shall be made of a white or off-white non-absorbent fabric (see [Annex A](#)) that allows the spray liquid to adhere to the surface for at least 4 min to 5 min to allow the spray pattern to be determined.

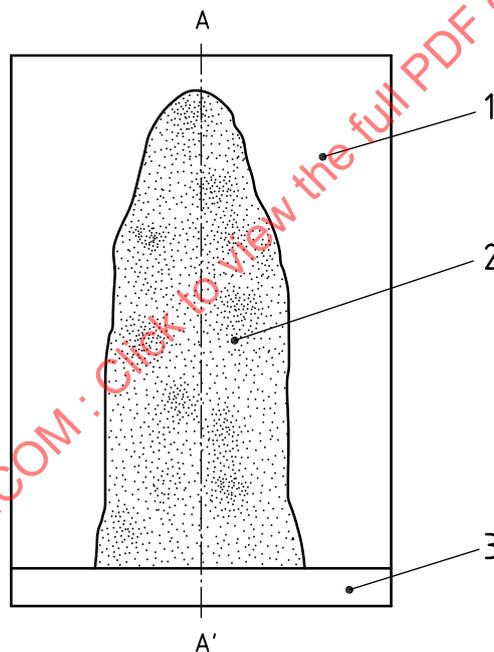
The target sheet shall be at least 2 m long and at least 1 m wide. The target sheet shall be mounted on a frame and placed perpendicular and at the centre of the turntable. The bottom of the target sheet shall touch the turntable.

The distribution for both methods shall

- produce a spray pattern that is symmetrical along a vertical line through the centre point ( $\pm 10$  cm) of the turntable,
- reach a height of at least 185 cm.

The correct alignment of the nozzles can be checked by the height and the deviation from vertical line of the spray pattern (see [Figure 2](#)).

NOTE Depending on the fabric used, the spray pattern for Method A can be continuous (as seen in [Figure 2](#)) or concentric circles for each nozzle.



**Key**

- 1 white or off-white non-absorbent target sheet/fabric
- 2 spray pattern on the target sheet
- 3 turntable
- AA' vertical line through the centre of the turntable

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

If required, the nozzles placement should be adjusted in order to obtain the right calibration pattern before proceeding with the spraying test.

## 9 Procedure

### 9.1 Spray procedure

Position the test subject wearing the test garment at the centre of the turntable and mark the position of the feet.

Apply the spray for  $(1,0 \pm 0,1)$  min to the test subject, whilst the turntable is rotated through  $360^\circ$ .

During spraying, the test subject steps on the turntable at a frequency of  $(30 \pm 5)$  steps/min. When raised, the bottom of the foot is 20 cm above the turntable. Meanwhile the arms move back and forth, at the same frequency as the feet, with minimal to no bending of the elbow. When raised, the hand is at about the same level as the top of the head. The movements of test subject are shown in the forms of stick figures in [Figure 3](#).

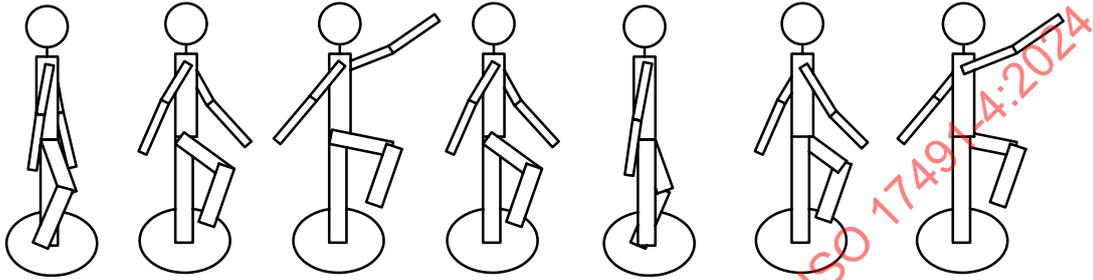


Figure 3 — movement of test subject on turntable

Turn both the spray and the turntable rotation off and allow the clothing to drain for 2 min while the test subject is still standing in the spray booth. During this time, the test subject shall jump a few (2 to 4) times, shake arms and legs and manually pull on the garment's pleats to remove the possible accumulation of liquid and the droplets on the test garment. After 2 min the test subject shall walk out of the spray booth.

Wipe off the face shield/respirator and gloves to prevent contamination of the absorbent overall or inner test garment while removing the test garment (see requirements in [C.3](#)). If the respirator is equipped with a filter cartridge, wipe it off and remove it; then wipe of the cartridge holder before doffing.

Carefully remove the test garment in order to avoid contamination of the absorbent overall (see requirements in [C.3](#)).

**NOTE** To avoid contamination, the outer surface of the absorbent overall can rest on the boots as the test subject gets out of the boots. Removal of taped opening may require extra care.

### 9.2 Procedure for penetration and stains

Examine the internal surface of the test garment for signs of penetration, paying special attention to openings, seams, closures and zippers. Mark areas and report where penetration is visible. Contamination due to the removal of the test garment should not be considered (see requirements in [C.4](#)).

Similarly, examine visually the external surface of the absorbent overall.

Marking the area where the stain is visible on the absorbent overall shall start at 5 min ( $\pm 15$  s) from the time the spraying has been completed. The marking should be with a permanent marker in order to preserve the results. Images of the stained area are permissible if it can be quantified. Measure the area of every spot and report the total area. However, this does not apply to cases where the leak spots of inside the garment to be counted have been transferred to the absorbent overall.

**NOTE** The area can be measured using a planimeter, CAD or other software.

The test garment, absorbent overall or photographs of it shall be retained as a quality record of all the penetrations or stains.

Create an aggregated diagram of a human figure (front and back) showing all the areas of penetration of the internal surfaces of the test garment and stains on the absorbent overall. Indicate on a diagram, by shading the approximate area, (front and back separately) or by reference to photographs. Areas of penetration of the internal surfaces of the test garment and stains on the absorbent overall that cover the same location shall not be counted twice.

## 10 Test report

The test report shall include the following information:

- a) a statement that the test was carried out in accordance with this document, i.e ISO 17491-4:2024;
- b) the period of testing;
- c) the name of the manufacturer/supplier and any identifying mark;
- d) the size of the garments tested and the body dimensions (height, chest girth) of the test subjects wearing all the garments underneath the test garment;
- e) a description of the absorbent overall;
- f) 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;
- g) the temperature of test liquid;
- h) the method carried out: method A (low-level spray test) or method B (high-level spray test);
- i) the composition and surface tension of the liquid used in the tests;
- j) the test liquid supply pressure at each nozzle;
- k) the areas of penetration of the internal surfaces of the test garment and the stains of 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;
- l) the total number of penetration spots and the total area measured for all spots;
- m) a description of any pre-treatment and/or pre-conditioning of the garments tested, if applicable;
- n) any further qualifying remarks, observations and comments considered appropriate by the person who has carried out the tests.
- o) any deviation from the procedure

## Annex A (informative)

### The non-absorbent fabric and absorbent overall

#### A.1 Non-absorbent fabric

The fabric to be used to determine the spray pattern in [8.3](#) should be a non-absorbent fabric that allows spray to adhere to the surface of the fabric. The fabric should

- not be inherently water repellent (e.g. plastic film), and
- be without water-repellent finish or treatment (e.g. oil or fluorocarbon).

NOTE Different fabrics were used for the round robin study. Based on the results, greige cotton plain weave fabric allows the spray to adhere to the surface of the fabric.

#### A.2 Absorbent overall

Material	Sontara® <sup>a</sup> Style 8802	Sontara® Style 9977
Weight (gsm)	67,8	69
Thickness (mm)	0,36	0,39
Composition	55 % woodpulp/45 % polyester	52 % woodpulp/48 % polyester

<sup>a</sup> Sontara® fabric is manufactured by Jacob Holm ([www.sontara.com](http://www.sontara.com)). 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.

## Annex B (informative)

### Body measurements and selection sizing of the test garment

#### B.1 General

Selection of the correct garment size is important as sizing may affect the test results.

#### B.2 Body measurements

Chest measurements of the test subjects shall be taken with the test subject wearing any undergarments and the absorbent overall that will be worn under the test garment. These chest measurements shall be used to select the correct size for testing (see [6.10](#)).

#### B.3 Selection of test garments

The sizing chart provided by the manufacturer shall be used for the selection of the test garment. Chest measurements, measured in accordance with [B.2](#), shall be used as the primary dimensions for the selection of the test garment.

For garments that include chest and height measurements, decision may have to be made by the test laboratory if the chest and height measurements are not in the same size range. Garments that are too tight may fail as a result of added stress on the seams. Whereas garments that are too loose may pass the test because the test garment is not in contact with the absorbent overall or even fail as puddles form at the zipper or crotch level. [Figure B.1](#) and [Figure B.2](#) provide guidance in size selection.



The garment is too tight. Note the stretch marks on the torso, arm, and the crotch.



The garment is too loose. Additionally, the hands and feet are covered by garment and the crotch is closer to the knees because the height of the test subject is less than 150 cm.

Figure B.1 — Examples of fit issues that may affect the test results



This garment is the correct fit. The slight loose fitting prevents undue stress and allows contact with the absorbent overall.

Figure B.2 — Correct fit

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## **Annex C** (normative)

### **Donning and doffing of test garment and marking of stain**

#### **C.1 Donning prior to spraying**

The following sequence shall be used for proper donning:

- a) Wear absorbent overall over the undergarments.
- b) Put on gloves.
- c) Don test garment with the sleeves over the gloves but without putting the hood.
- d) Put on the boots with bottom hems of the test garment over the boots.
- e) Fit the respirator according to respirator manufacturer's instructions on top of absorbent overall.
- f) Close the garment per manufacturer's instructions.
- g) Wear the test garment with hood over the edge of the respirator face piece. Wear gloves with sleeves over the first gloves and the test garment at the wrists level.

#### **C.2 Sequence between completion of the spraying and doffing (2 min)**

The following sequence is to be followed to remove excess droplets from the surface of the fabric.

- a) After spraying, the test subject stands in spray booth for 2 min. During this time the test subject jumps a couple of times, shakes their arms and legs and pulls the garment's pleats to remove possible accumulation of liquid in pleats and the droplets on the test garment.
- b) After 2 min the test subjects walk out of the spray booth for doffing (see [9.1](#)).

#### **C.3 Doffing after completion of the test (3 min max to complete)**

The following sequence shall be followed for doffing.

- a) Wipe off the droplets from the respirator and the gloves with a towel.
- b) Remove the filter cartridge of the respirator and wipe off the droplets on the cartridge holder with a towel.
- c) Unstick the zipper flap (if needed) and open the zipper till about half of its full length. Note any leakage that may have occurred through the zipper area. To make the doffing easier, you can turn the zipper flap inside out and stick it on the test garment (if possible).
- d) Next, carefully turn the test garment inside out starting from the hood and lower it down to the boots. Wiping excess droplets shall be avoided as it may affect the test results. Note any leakage that may have occurred on the seams of the test garment.
- e) Remove the test garment and the boots.
- f) Finally, remove the gloves and respirator.

#### C.4 Marking and measurement of the stain

Mark the areas of stain after a maximum of 5 min ( $\pm 15$  s) after the completion of spray test (see [9.2](#)).

Then, measure all stains/spots on the outside of the absorbent and any spots on the test garment that have not been transferred on the absorbent overall.

A special attention shall be given during the doffing of the tested overalls to possible contamination of the absorbent overall. These stains shall not be considered for the final stain area calculation.

#### C.5 Calibration stain (see [6.2](#))

If leakages have been detected on the absorbent overall, a calibration stain shall be produced on a section of the absorbent overall that was not contaminated right after completion of [C.4](#). Follow the procedure of [6.2](#).

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## Annex D (informative)

### Interlaboratory study (ILS) observations for ISO 17491-4 Methods A and B

#### D.1 Method A (Type 6/Low spray) test results

##### D.1.1 General

Several interlaboratory studies were conducted to refine the methodology for Method A. This subclause includes information on the interlaboratory test used for reproducibility and reliability. Six laboratories worldwide took part in the round robin trial organized by ISO/TC 94/SC 13 WG 3. Tests were conducted with two non-woven Type 6 single-use overalls supplied by two manufacturers. The full report can be found under ISO TC 94/SC 13 WG 3 as document number N180.

##### D.1.2 Procedure

**D.1.2.1** As part of the ILT for Method A, a study was conducted to measure the characteristics of hollow cone nozzles used by participating laboratories. Prior to spraying, equivalency of the nozzle characteristics (flow rate, droplets size and spraying angle at 300 kPa) was confirmed. Study report can be found under ISO TC 94/SC 13 WG 3 as document number N179.

**D.1.2.2** Each participating laboratory tested alignment of spray nozzles. Information of fabric used for testing is included in the study report.

**D.1.2.3** Five laboratories tested the overalls with two test subjects and one laboratory used the same test subject to test the two replicates. Two overalls were tested by test subjects of varying height and weight. The minimum height requirement was 165 cm.

**D.1.2.4** The interlaboratory study was conducted in accordance with the procedure reflected in this document. One laboratory tested with methylene blue instead of methyl blue dye (CAS number 28983-56-4).

##### D.1.3 Study observations

**D.1.3.1** During this interlaboratory test, it has been observed that all test subjects were sprayed from head to toe.

**D.1.3.2** The spray angle of 75° specified in the earlier version of the standard is for spraying with hollow cone nozzles at a higher pressure. At 300 kPa the spray angle of the nozzles is lower. Based on the nozzle study, the spray angle has been changed to  $(70 \pm 10)^\circ$  in this document.

**D.1.3.3** The distribution of the spray liquid (see [8.3](#)) varied based on the fabric properties of the non-absorbent fabrics used by the participating laboratories. - laboratories had continuous spray distribution similar to that seen in [Figure 2](#). - laboratories had concentric circles for each nozzle, typical pattern for hollow cone nozzles. The concentric circles were observed for fabrics in which the spray droplets adhered to the surface. Continuous pattern was observed for materials in which the droplets did not adhere to the surface, the rolling down of the droplets resulted in a continuous pattern.

[Clause 6](#) revisions are primarily as a result of the methodology development studies conducted prior to the final ILT for repeatability and reliability. For most sub-clauses in [Clause 6](#), specifications have been added. In