



**International
Standard**

ISO 17491-5

**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)**

*Habillement 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
pulvérisation de liquide (essai au brouillard à l'aide d'un
mannequin)*

**Second edition
2024-07**

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Contents

	Page
Foreword.....	iv
Introduction.....	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	2
5 Test liquid and test subject	2
5.1 Test liquid.....	2
5.2 Test subject.....	2
6 Apparatus	3
7 Specimen preparation	6
7.1 Test items.....	6
7.2 Blocking instructions.....	6
8 Procedure	6
9 Test report	8
Annex A (informative) Non-absorbent fabric and absorbent overall	9
Annex B (informative) Alignment of this test method with various nationally recognized standards	10
Bibliography	11

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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).

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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. This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Personal protective equipment*, Subcommittee SC 13, *Protective clothing*.

This second edition cancels and replaces the first edition (ISO 17491-5:2013), which has been technically revised.

The main changes are as follows:

- various editorial revisions;
- clarification of the test liquid;
- adding measurements for the test manikin;
- adding additional specifications for the test overall and manikin platform;
- adding tolerances for measurements of the nozzles;
- adding annex material for overall material;
- adding annex material for use of this method in other nationally recognized standards.

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

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

Introduction

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.

The following test methods are used when measuring the chemical resistance of materials, seams and assemblages:

- 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.

The integrity test methods specified by the ISO 17491 series are used when measuring the chemical resistance of complete items or ensembles and are as follows:

- ISO 17491-1 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.
- ISO 17491-2 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.
- ISO 17491-3 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.
- ISO 17491-4 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.
- ISO 17491-5 This method determines the resistance to chemical spray penetration and 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. Since ISO 16602 is considering adoption of this method, the availability

ISO 17491-5:2024(en)

of such laboratories should be maintained and therefore this standard will not preclude the use of ASTM F1359 in order to meet the requirements of this standard.

General protective clothing requirements are specified in ISO 13688.

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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)

1 Scope

This document specifies a test method for determining the resistance of complete protective clothing to inward leakage of liquid chemicals (protective clothing integrity).

This method specifies an alternative method for determining the resistance to spray penetration because it uses a static manikin instead of a test subject; it also uses a different spray configuration and duration than the other methods within ISO 17491 series. This test method is aligned with ASTM F1359 since the only laboratories with equipment of this kind are performing testing according to that standard.

This test method is 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 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 13688, *Protective clothing — General requirements*

ISO 11610, *Protective clothing — Vocabulary*

3 Terms and definitions

For the purposes of this document, the following 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 testing of chemical protective clothing

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* (3.1)

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. Treated water 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 in four specimen orientations. Liquid penetration resistance is determined by the absence of liquid inside the chemical protective clothing on the inner absorbent garment. The chemical protective clothing is rated as passing if liquid does not penetrate and as failing if liquid does penetrate.

5 Test liquid and test subject

5.1 Test liquid

Unless specified in the performance specification, the following standard test liquid shall be used.

A test liquid containing the following substances and characteristics shall be used:

- water at ambient temperature;
- an optional water-soluble fluorescent or visible dye, e.g. methyl blue (CAS number [28983-56-4]) with a concentration of $(0,2 \pm 0,02)$ g/l;
- a surfactant, e.g. Genapol LRO liquid (sodium lauryl ether sulphate, CAS number [9004-82-4]) that generates a surface tension of $(30,0 \pm 5,0) \times 10^{-3}$ N/m;
- a stabilizer for the dye (if needed), e.g. citric acid (CAS number [77-92-9], analytical grade) with a concentration of $(2,45 \pm 0,05)$ g/l;

Any method may be used to determine the surface tension of the test liquid 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.

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.

The optional water-soluble dye can be used to enhance the ability to see leakage. If dye is not used, the testing lab shall determine with confidence that leakage can be detected.

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

The test subject shall consist of a human-form manikin¹⁾. The preferred manikin size is provided in [Figure 1](#) and consists of the dimensions found in [Table 1](#).

1) An example of a suitable product is available commercially through NYC Display, model SFM72-FT, PO BOX 20396 New York, NY 10001 United States, <https://nycdisplay.com>. This information is given for the convenience of the users of this document and does not constitute an endorsement by ISO for this product.

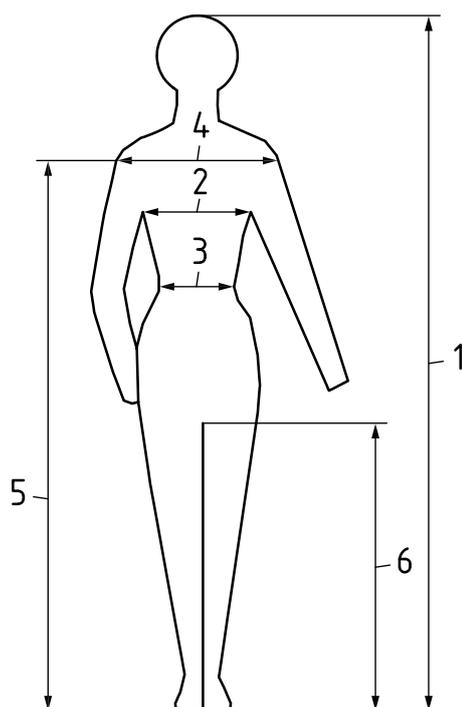


Figure 1 — Manikin size

Table 1 — Measurements for manikin

	Measurement location	Dimension mm	Tolerance mm
1	Total height	1 828	±12
2	Chest circumference at largest value	965	±12
3	Waist circumference at narrowest position	750	±12
4	Circumference at shoulder	1 016	±12
5	Height at shoulders	1 420	±12
6	Crotch to sole of foot along the inside of the leg (inseam)	787	±12

The manikin shall have a water-resistant coating, straight arms and legs with the arms at the manikin's sides. Alternative manikins may be used if specified in the report.

6 Apparatus

6.1 Absorbent overall.

The absorbent overall shall be a one-piece garment with a hood and made with absorbent off-white or grey fabric. The overall shall not include elastic waistband/gathers at the waist as it affects contact between the test garment and the absorbent overall. Alternative absorbent garments may be used to cover all test areas of the manikin as long as the interfacing between those individual garments does not interfere with the ability to evaluate the observation of performance.

The absorbent overall 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 overall.

See [Annex A](#) for absorbent overall requirements.

6.2 Calibrated stain.

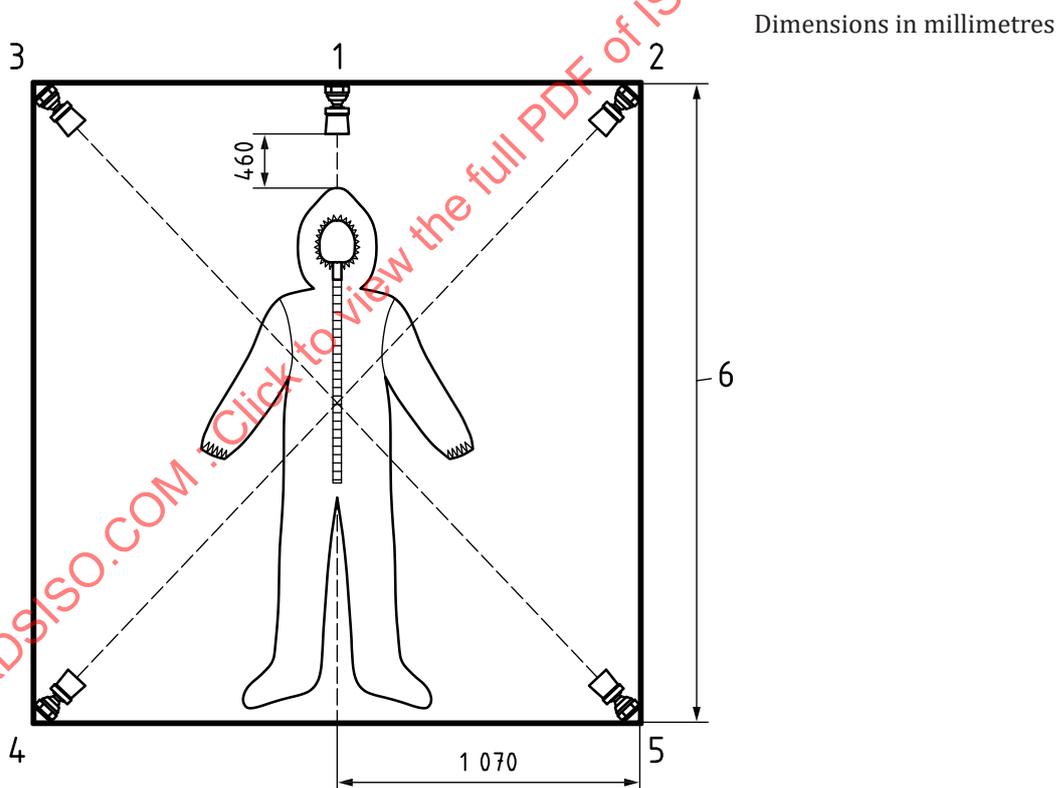
A calibrated stain shall be produced before starting a series of tests and immediately after a test where a leakage has been detected. If using the optional dye, select an area of the absorbent overall that is not likely to be contaminated. When not using the optional dye, the absorbent overall must be completely dry before performing the test. After selecting where to perform the calibrated stain, place a piece of undergarment under the absorbent overall 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 ± 5) μ 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^2 after 5 min (± 15 s).

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.

The shower system shall consist of five low-flow showerhead nozzles and a pressurized liquid supply.

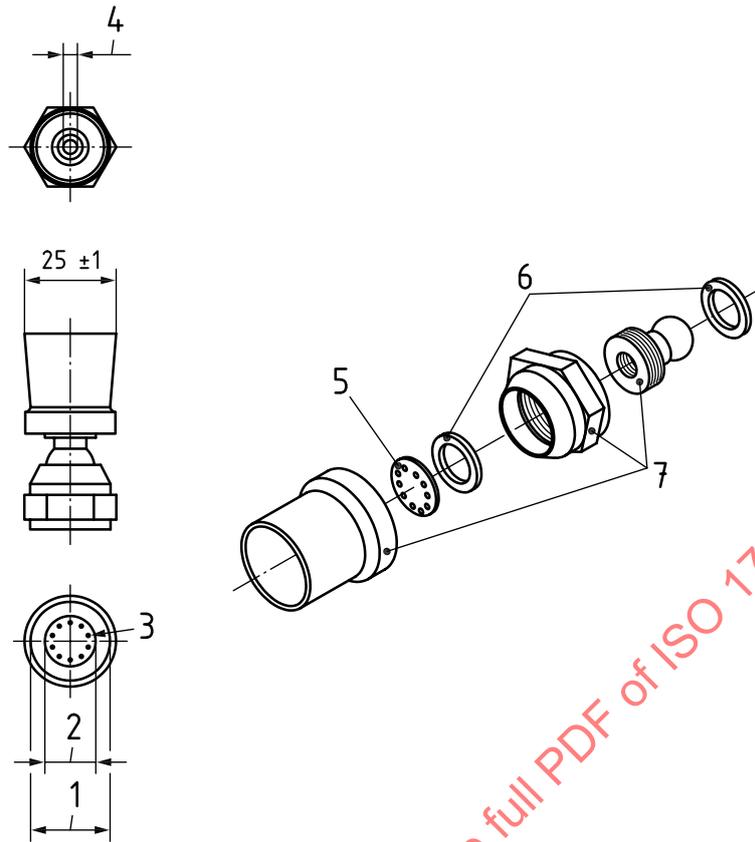
The five nozzles shall be oriented with respect to the manikin as specified in Figure 2. The pressurized liquid supply shall be delivered at $(3,0 \pm 0,2)$ l/min through each nozzle (see Figure 3).



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 2 — Positions of shower nozzles (front view)

**Key**

- 1 internal nozzle diameter, 23 mm ($\pm 0,1$ mm)
- 2 spray plate diameter, 14,6 mm, brass ($\pm 0,1$ mm)
- 3 0,045 mm ($\pm 0,05$ mm) diameter holes through 10 places equally spaced on a 9,1 mm ($\pm 0,1$ mm) diameter centred circle
- 4 3,7 mm ($\pm 0,1$ mm) diameter bore
- 5 brass spray plate
- 6 rubber gaskets
- 7 chrome-plated brass

Figure 3 — Example of shower nozzle specifications

6.4 Stopwatch.

A timing device consisting of a stopwatch or other appropriate timing device accurate to 1 s.

6.5 Manikin platform.

The manikin shall be able to be secured to a horizontal platform that allows it to rotate between the positions in [Figure 4](#). When mounting the manikin, footwear or other means shall be used to allow the manikin to be mounted in a vertical position and centered under nozzle 1 as shown in [Figure 2](#).

7 Specimen preparation

7.1 Test items

Protective clothing or protective ensemble components shall be tested as received and in accordance with the manufacturer's instructions. The garment size shall be selected by the laboratory from the size range provided by the manufacturer to fit the laboratory's manikin covered by the absorbent overall with sufficient ease as one would choose clothing for a person. Duct tape or other non-uniform methods for closing or sealing, or both, interfaces shall not be used.

7.2 Blocking instructions

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 test garments (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 test areas of the manikin that are of interest.

8.3 Put the test garments 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 test garments 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.

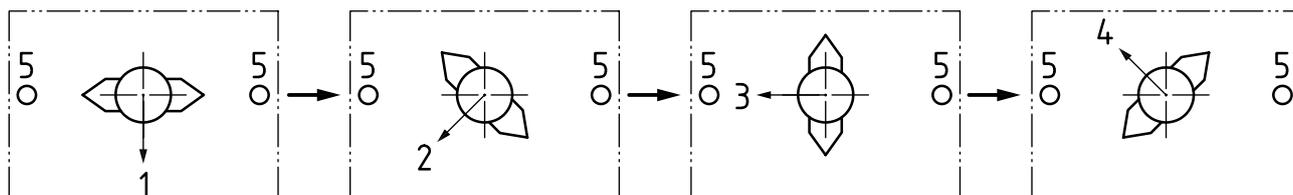
8.5 Add a sufficient amount of test liquid to the water supply to achieve a surface tension of $(30,0 + 5,0) \times 10^{-3}$ N/m.

8.6 Expose the suited manikin to the liquid spray in four different orientations as shown in [Figure 4](#). The manikin's torso shall be oriented with the shoulders parallel to the indicated orientation. Spray liquid at the rate of $(3,0 \pm 0,2)$ l/min through each nozzle simultaneously. Ensure that each nozzle is not partly plugged or closed at the start of each test.

The suited manikin shall be exposed for 15 min at each rotation, for a total of 60 min. Alternative exposure times can be found in [Annex B](#). If alternative times are used, these shall be indicated in the report.

NOTE 1 The exposure is performed at four different static locations due to the limitations of current test equipment. Continuous movement of the manikin may be permissible if the testing laboratory is able to verify equivalency.

Back of apparatus



Key

- 1 to 4 position demonstrating the front of the manikin, perpendicular to the manikin shoulders
- 5 side shower nozzles

Figure 4 — Orientation of suited manikin exposure (top view)

NOTE 2 [Figure 4](#) shows the top-down view for the suited manikin. Each position demonstrates the front of the manikin, perpendicular to the manikin shoulders. The suited manikin is rotated through each of the four positions.

8.7 At the end of the liquid period, turn off the liquid spray and allow the clothing to drain for 2 min (+1/-0 min). Remove excess liquid from the surface of the test garment. The use of paper towels to remove the excess liquid is one method that works well.

8.8 Inspection of the test garments shall occur within 10 min of the end of the liquid spray period. Determine liquid penetration by one of the following procedures.

- a) Remove the test garments and any other ensemble components or equipment from the manikin in a dry area and examine the absorbent overall and garment interior for signs of liquid or staining if dye was used. Record these areas as locations of liquid penetration.
- b) If a dye is added to the liquid, remove the test garments and any other ensemble components or equipment from the manikin and examine the absorbent overall and garment interior for the appearance of any dye-coloured areas. Record these areas as locations of liquid penetration.
- c) If a fluorescent dye is added to the liquid, examine the absorbent overall and garment interior under ultraviolet lighting in a dark room for fluorescing areas. Record these areas as locations of liquid penetration.

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

NOTE If permissible, inspection of the protective clothing occurs while still mounted to the manikin platform. This reduces the possibility for false positive results.

9 Test report

The test report shall include the following information:

- a) a reference to this document, i.e. ISO 17491-5:2024;
- 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.

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