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**Protective clothing — Performance  
requirements for protective clothing  
worn by operators applying pesticides  
and for re-entry workers**

*Habillement de protection — Exigences de performance pour les  
vêtements de protection portés par les opérateurs appliquant des  
pesticides et pour les travailleurs de rentrée*





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# Contents

Page

<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>2</b>
<b>4 Classification and testing requirements</b> .....	<b>3</b>
<b>5 Pre-treatment and conditioning</b> .....	<b>5</b>
5.1 Pre-treatment by cleaning .....	5
5.2 Conditioning.....	5
<b>6 Performance requirements of protective clothing materials</b> .....	<b>5</b>
6.1 General.....	5
6.2 Material resistance to penetration (pipette test).....	6
6.3 Material Repellency (pipette test).....	6
6.4 Material resistance to permeation.....	7
6.5 Material tensile strength .....	7
6.6 Material tear resistance.....	7
6.7 Material puncture resistance.....	8
<b>7 Performance requirements of seams</b> .....	<b>8</b>
7.1 General.....	8
7.2 Seam resistance to penetration.....	8
7.3 Seam resistance to permeation .....	8
7.4 Seam tensile strength.....	9
<b>8 Performance requirements of protective clothing</b> .....	<b>9</b>
8.1 General.....	9
8.2 Ergonomic tests (practical performance).....	9
8.3 Liquid penetration resistance.....	9
8.3.1 Low-level spray test .....	9
8.3.2 High-level spray test.....	10
<b>9 Marking</b> .....	<b>10</b>
9.1 General.....	10
9.2 Specific.....	10
<b>10 Information supplied by the manufacturer</b> .....	<b>10</b>
<b>Annex A (normative) Test subject exercises for practical performance evaluation</b> .....	<b>12</b>
<b>Annex B (normative) Testing requirements for Levels C1, C2 and C3 protective clothing</b> .....	<b>13</b>
<b>Annex C (informative) Selection of test chemical for penetration tests</b> .....	<b>14</b>
<b>Annex D (informative) Material water-vapour resistance (optional)</b> .....	<b>15</b>
<b>Annex E (informative) Food and Agricultural Organization (FAO) Pesticide Labelling Pictograms</b> .....	<b>16</b>
<b>Annex F (informative) Risk assessment — PPE to mitigate risk</b> .....	<b>17</b>
<b>Bibliography</b> .....	<b>18</b>

## 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 documents 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)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: [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 — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

This second edition cancels and replaces the first edition (ISO 27065:2011), which has been technically revised.

The main changes compared to the previous edition are as follows:

- major changes have been made to Levels 1 and 3 requirements;
- protective clothing for re-entry workers has been included in the scope.

## Introduction

This document addresses the performance requirements for protective clothing worn by operators handling liquid pesticide products as well as protective clothing worn by re-entry workers. It includes requirements for protective clothing (e.g. shirts, jackets, trousers, and coveralls) and partial-body protective clothing (e.g. aprons, smocks, protective sleeves, hoods/caps, and material placed below knapsack/backpack sprayers). Requirements for protective clothing, including partial-body, constructed with multiple layers or materials are also included in this document.

This document classifies protective clothing, including partial-body, into three performance levels. A brief description for the three levels is given below.

Level C1 protective clothing, including partial-body, is suitable when the potential risk is relatively low. Level C1 protective clothing provides the least protection and is not suitable for use with concentrated pesticide formulations. It can be used as the base protective clothing with additional items worn when the potential risk is relatively higher. See [Annex F](#) for additional information on risk assessment and use of PPE for risk mitigation.

Level C2 protective clothing, including partial-body, is suitable when it has been determined that the protection required is higher than that provided by Level C1 protective clothing. Level C2 protective clothing typically provides a balance between comfort and protection. This protective clothing is not suitable for use with concentrated pesticide formulations. It can be used as the base protective clothing with additional items worn when the potential risk is relatively higher.

Level C3 protective clothing, including partial-body, is suitable for use when it has been determined that the potential risk is high. Precautionary measures such as short duration for use are necessary for Level C3 suits/coveralls that may cause heat build-up resulting in heat exhaustion/stress. Level C3 protective clothing, including partial-body, is suitable for use with diluted as well as concentrated pesticides.

Personal Protective Equipment (PPE) is often used for risk mitigation. See [Annex F](#) for information on risk assessment and use of PPE for risk mitigation. Since protective clothing can be contaminated in various ways (e.g. fine spray, contact with wet surface, contact with pesticide product sprayed under pressure, contact between the protective clothing and a contaminated surface), laboratory test methods used in the standard rate materials and clothing rather than simulate the various field conditions.

ISO 16602 focuses on industrial chemicals, whereas this document focuses on protection against pesticides that are frequently applied in aqueous solutions. Penetration, permeation, and repellency tests in ISO 16602 are typically done with neat chemicals not used in pesticide application. In this document, penetration, permeation, and repellency tests are conducted with a mixture. The test chemical selected for testing is an emulsifiable concentrate that is representative of a worst case scenario for penetration and repellency. Testing for penetration is conducted with diluted formulation. For permeation, the standard provides a provision for testing with diluted formulation and concentrate. In addition, it allows for testing with additional pesticide products, if required, based on risk assessment conducted for the required pesticide product.

This document is intended for fabric and protective clothing manufacturers and pesticide product manufacturers, as well as trainers, regulators, and other individuals or organizations that make decisions regarding protective clothing for protection against pesticide products.



# Protective clothing — Performance requirements for protective clothing worn by operators applying pesticides and for re-entry workers

## 1 Scope

This document establishes minimum performance, classification, and marking requirements for protective clothing worn by operators handling pesticide products as well as re-entry workers. For the purpose of this document, the term pesticide applies to insecticides, herbicides, fungicides, and other substances applied in liquid form that are intended to prevent, destroy, repel, or reduce any pest or weeds in agricultural settings, green spaces, roadsides, etc. It does not include biocidal products used for agricultural and non-agricultural settings.

Pesticide handling includes mixing and loading, application, and other activities such as cleaning contaminated equipment and containers. Concentrated pesticides are typically handled during mixing and loading. Protective clothing covered by this document includes, but is not limited to, shirts, jackets, trousers, coveralls, aprons, protective sleeves, caps/hats and other headwear (excluding hard hats made of rigid materials, e.g. hats worn by construction workers), and accessories used under knapsack/backpack sprayers.

This document does not address items used for the protection of the respiratory tract, hands, and feet. This document does not address protection against fumigants.

## 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 9073-4, *Textiles — Test methods for nonwovens — Part 4: Determination of tear resistance*

ISO 13688:2013, *Protective clothing — General requirements*

ISO 13934-1, *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method*

ISO 13935-2, *Textiles — Seam tensile properties of fabrics and made-up textile articles — Part 2: Determination of maximum force to seam rupture using the grab method*

ISO 13937-3, *Textiles — Tear properties of fabrics — Part 3: Determination of tear force of wing-shaped test specimens (Single tear method)*

ISO 13996, *Protective clothing — Mechanical properties — Determination of resistance to puncture*

ISO 17491-4:2008, *Protective clothing — Test methods for clothing providing protection against chemicals — Part 4: Determination of resistance to penetration by a spray of liquid (spray test)*

ISO 19918, *Protection against chemicals — Measurement of cumulative permeation of chemicals with low vapour pressure through materials*

ISO 22608, *Protective clothing — Protection against liquid chemicals — Measurement of repellency, retention, and penetration of liquid pesticide formulations through protective clothing materials*

### 3 Terms and definitions

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

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

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

#### 3.1 **analytical technique**

procedure whereby the concentration of the chemical is determined quantitatively

Note 1 to entry: These techniques are often specific to individual chemical and collection medium combinations. Applicable techniques include, but are not limited to, flame ionization, photo ionization, electro-chemical, ultraviolet and infrared spectrophotometry, gas and liquid chromatography, and colourimetry.

#### 3.2 **cumulative permeation mass**

total amount of chemical that permeates during a specified time from the time the material specimen is first contacted with the test chemical

#### 3.3 **decontamination**

removal of a contaminant or contaminants from the surface or matrix, or both, of protective clothing to the extent necessary for its next intended action

#### 3.4 **fumigant**

pesticide in the form of gas

#### 3.5 **limited-use protective clothing**

protective clothing for limited duration of use, intended to be worn until damaged, hygienic cleaning becomes necessary, or contamination with pesticides has occurred and disposal is required

Note 1 to entry: Limited-use protective clothing shall not be cleaned.

Note 2 to entry: This includes protective clothing for single use and for limited re-use, according to the information supplied by the manufacturer.

#### 3.6 **partial-body protective clothing**

protective clothing that does not provide full-body coverage

Note 1 to entry: Partial-body protective clothing may be used separately or in combination with other protective clothing to increase the protection level of specific parts of the body. Examples applicable to this document include items such as aprons, overshoes, sleeve protectors, material placed below knapsack/backpack sprayers, and smocks.

#### 3.7 **penetration**

process by which a pesticide moves through porous materials, seams, pinholes, or other imperfections in a material on a non-molecular level

#### 3.8 **permeation**

process by which a pesticide moves through a material on a molecular level, involving

- sorption of the molecules of the chemical into the contacted (outside) surface of a material,
- diffusion of the sorbed molecules in the material, and



— desorption of the molecules from the opposite (inner) surface of the material

### 3.9

#### **pesticide**

substance or mixture of substances intended for preventing, destroying, repelling, or reducing any pest or weeds

Note 1 to entry: Pesticides (plant protection products) approved for use in one country may not be approved in another country.

### 3.10

#### **pesticide operator**

person handling pesticides in agricultural settings, green spaces, roadsides, etc.

Note 1 to entry: Handling includes tasks such as mixing, loading, transferring, or applying pesticides; cleaning, adjusting, or repairing the parts of mixing, loading, or application equipment that may contain pesticide residues; assisting with the application of pesticides; and disposing of pesticides or pesticide containers.

Note 2 to entry: Farm, forest, nursery, and greenhouse are examples of agricultural settings.

### 3.11

#### **protective clothing**

clothing which covers or replaces personal clothing and which is designed to provide protection against one or more hazards

### 3.12

#### **protective clothing material**

material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from a potential hazard. Protective clothing materials do not include materials used in the construction of integral visors, gloves, and footwear

Note 1 to entry: For the purpose of this document, protective clothing materials include those materials used in the construction of whole or partial-body protective clothing that serve as the barrier for the wearer.

### 3.13

#### **re-entry worker**

person who can be in contact with a plant protection product in an area that has previously been treated

### 3.14

#### **re-usable protective clothing**

protective clothing that is constructed from materials which allow the clothing to be cleaned after repeated exposure to pesticides such that it remains suitable for continued use

### 3.15

#### **seam**

permanent junction between two or more pieces of material created by sewing, welding, or another method

### 3.16

#### **test chemical**

liquid that is used to challenge the specimen of protective clothing material

### 3.17

#### **toxicity**

propensity of a substance to produce adverse biochemical or physiological effects

## **4 Classification and testing requirements**

All protective clothing complying with this document shall fulfil the applicable requirements of ISO 13688 and shall be tested and classified by level of protection in accordance with the material, seam, and whole-body protective clothing requirements in [Clauses 6, 7, and 8](#).

Level C1 protective clothing, including partial-body: The materials and seams shall demonstrate a minimum level of liquid penetration resistance. The protective clothing, including partial-body, shall pass a practical performance test. A Level C1 item is not suitable for use with concentrated pesticide formulations. It can be used as the base protective clothing with additional items worn when the potential risk is relatively higher.

Level C2 protective clothing, including partial-body: The material and seams shall demonstrate a higher level of liquid penetration resistance than Level C1 protective clothing. The protective clothing, including partial-body, shall pass the practical performance test. The whole-body protective clothing shall pass the low-level spray test. A Level C2 item is not suitable for use with concentrated pesticide formulations. It can be used as the base protective clothing with additional items worn when the potential risk is relatively higher.

Level C3 protective clothing, including partial-body: The materials and seams shall demonstrate a minimum level of resistance to permeation. The concentration of the test chemical and duration of testing shall be based on the intended use claimed by the manufacturer and included in information provided by the manufacturer [see [Clause 10 c](#)]. The protective clothing, including partial-body, shall pass the practical performance test. The whole-body protective clothing shall pass a high-level spray test. A Level C3 item is suitable for use with concentrated as well as diluted pesticide formulations.

[Table 1](#) provides a summary of the tests to be conducted for each level of protection. The stringency in testing requirements to determine protection increases for each level. Therefore, any Level C2 protective clothing necessarily meets Level C1 requirements, and so does not need to be tested to achieve that level of protection. Similarly, any Level C3 protective clothing necessarily meets Level C1 and Level C2 requirements. The strength requirements are the same for all levels of protection, and the puncture resistance test is not mandatory. If high puncture resistance is claimed, the item shall be tested as stated in [Table 1](#) and the information supplied by the manufacturer shall include a statement informing the user that the item is suitable for scenarios where puncture risk exists.

NOTE The puncture resistance test may provide beneficial information for purchasers selecting protective clothing, including partial-body, for scenarios such as orchard spraying. It is not a mandatory requirement as puncture resistance may not be important for other scenarios.

**Table 1 — Testing requirements for Level C1, C2, and C3 protective clothing, including partial-body**

	Sub-clause	Performance test	Levels		
			C1	C2	C3
Material Requirements	<a href="#">6.2</a>	Material resistance to penetration (ISO 22608)	x	x <sup>a</sup>	
	<a href="#">6.3</a>	Material repellency (ISO 22608)		x	
	<a href="#">6.4</a>	Material resistance to permeation (ISO 19918)			x <sup>b</sup>
	<a href="#">6.5</a>	Tensile strength (ISO 13934-1)	x	x	x
	<a href="#">6.6</a>	Tear resistance (ISO 9073-4 or ISO 13937-3 as applicable)	x	x	x
	<a href="#">6.7</a>	Puncture resistance (ISO 13996)	x <sup>c</sup>	x <sup>c</sup>	x <sup>c</sup>
Seam requirements	<a href="#">7.2</a>	Seam penetration resistance (ISO 22608)	x		
	<a href="#">7.3</a>	Seam resistance to permeation (ISO 19918)			x <sup>b</sup>
	<a href="#">7.4</a>	Seam tensile strength (ISO 13935-2)	x	x	X
<p><sup>a</sup> The minimum performance requirement for Level C2 is significantly higher than that for Level C1 (see <a href="#">6.2</a>).</p> <p><sup>b</sup> The permeation test is more severe than the penetration test. Therefore, material that meets <a href="#">6.4</a> automatically meets the <a href="#">6.2</a> penetration requirement. Also, if additional testing is required for a particular pesticide, the material shall also be tested for permeation resistance using the pesticide in question.</p> <p><sup>c</sup> Puncture resistance shall be tested if claimed by the manufacturer.</p> <p><sup>d</sup> Not required for partial-body protective clothing.</p>					

Table 1 (continued)

	Sub-clause	Performance test	Levels		
			C1	C2	C3
Whole protective clothing requirements	<a href="#">8.1</a>	Practical performance test ( <a href="#">Annex A</a> )	x	x	X
	<a href="#">8.3.1</a>	Low-level spray test (ISO 17491-4:2008, Method A)		x <sup>d</sup>	
	<a href="#">8.3.2</a>	High-level spray test (ISO 17491-4:2008, Method B)			x <sup>d</sup>
<p><sup>a</sup> The minimum performance requirement for Level C2 is significantly higher than that for Level C1 (see <a href="#">6.2</a>).</p> <p><sup>b</sup> The permeation test is more severe than the penetration test. Therefore, material that meets <a href="#">6.4</a> automatically meets the <a href="#">6.2</a> penetration requirement. Also, if additional testing is required for a particular pesticide, the material shall also be tested for permeation resistance using the pesticide in question.</p> <p><sup>c</sup> Puncture resistance shall be tested if claimed by the manufacturer.</p> <p><sup>d</sup> Not required for partial-body protective clothing.</p>					

## 5 Pre-treatment and conditioning

### 5.1 Pre-treatment by cleaning

Specimens used for each test specified in [Clauses 6, 7, and 8](#) shall be pre-treated by cleaning. The cleaning shall be in accordance with the manufacturer's instructions on the basis of standardized processes. If the manufacturer's instructions indicate that cleaning is not allowed, i.e. limited-use protective clothing, then testing shall be carried out on new material.

Testing shall be carried out for the number of cleaning cycles for which the manufacturer guarantees the performance. If the number of cleaning cycles is not specified, the tests shall be carried out after 30 cleaning cycles. In all cases, the number of cycles, after which testing was conducted, shall be included in accordance with [Clause 10](#). If the manufacturer's instructions indicate that both dry cleaning and laundering are allowed, the test specimen shall undergo the laundering procedure only.

NOTE 1 One cleaning cycle consists of one washing and one drying.

NOTE 2 Drying can be omitted in the pre-treatment if the method specified by the manufacturer is not machine drying.

NOTE 3 Manufacturer's instructions typically indicate one or several of the various methods and processes of ISO 6330, ISO 15797, ISO 3175-2 or equivalent as standardized processes for cleaning.

If re-treatment is required, detailed instructions shall also be provided in [Clause 10](#).

### 5.2 Conditioning

All test specimens used for tests specified in [Clause 6](#), [Clause 7](#), and [8.2](#) shall be conditioned for at least 24 h in accordance with the conditions specified in the respective test standards.

## 6 Performance requirements of protective clothing materials

### 6.1 General

Specimens for testing shall be taken from the original garment or from material or materials used in the finished garment. The size, shape, and quantity shall be as required for each test procedure. If a material is constructed of multiple layers, the specimen shall be cut with the order of each layer maintained and tested with the outer layer on top. For protective clothing constructed from different types of materials in different body areas, each single material shall be tested separately.

For testing and classification of materials, all individual specimen results shall meet the performance class requirement for the concerned property (see [Annex B](#)). The results shall be reported in accordance with [Clause 10](#).

Materials used for certain parts of the protective clothing that provide higher performance (e.g. added protection and/or strength) shall be tested if claimed by the manufacturer. The information regarding the higher performing material, that may assist the purchaser in protective clothing selection, shall be included in accordance with [Clause 10 f](#)).

NOTE For example, a protective clothing manufacturer can request permeation testing for the Level C2 protective clothing to determine if the material will comply with Level C3 requirements.

## 6.2 Material resistance to penetration (pipette test)

Materials for Level C1 and Level C2 protective clothing shall be tested in accordance with ISO 22608, Method A, using 0,2 ml of test chemical. Three specimens shall be tested for each material. Prowl® 3.3 EC<sup>1)</sup> an emulsifiable concentrate with 37,4 % pendimethalin, diluted with distilled water to 5 % active ingredient (a.i.), shall be used. See [Annex C](#) concerning selection of test chemical.

For materials for protective clothing classified as Level C1, the upper limit for percent penetration shall be 40 %. For materials classified as Level C2, the upper limit for percent penetration shall be 5 %. ISO 22608 Method B shall be used for validation a) when the test results are within 20 % of the upper limit, or b) when the bright yellow colour of pendimethalin (a.i. in Prowl® 3.3 EC) is not visible on the collector layer, but the percent penetration value(s) exceeds the Level C2 upper limit of 5 %. In this case, the results obtained by Method B instead of the results obtained by Method A shall be used for determining penetration classification and reporting requirements.

For materials for protective clothing classified as Level C1, the three specimens tested shall have maximum penetration of 40 %.

For materials for protective clothing classified as Level C2, the three specimens tested shall have maximum penetration of 5 %.

NOTE ISO 22608 is an accelerated laboratory test that differentiates the penetration performance of materials and seams. The maximum allowable penetration of 40 % is derived from the data analysis of cotton and cotton/polyester protective clothing used for operator exposure studies. The 40 % penetration limit for Level C1 protective clothing is based on analysis of lab data as well as operator exposure study data. Studies conducted with the reference fabric for Level C1 had less than 5 % penetration through the garment in operator exposure studies. Therefore, it is not possible to substitute laboratory penetration data for field penetration data. For this reason, the laboratory test data are used only to classify materials and seams. It cannot be used as default protection factors for risk assessment. References [4] and [5] provide additional information on the analysis to establish the 40 % limit value for Level C1 and the 5 % limit value for Level C2.

## 6.3 Material Repellency (pipette test)

For Level C2 protective clothing, percent repellency shall also be calculated when ISO 22608:2004, Method A, described in [6.2](#), is conducted to measure resistance to penetration.

Materials for protective clothing classified as Level C2 shall have a minimum repellency of 80 % for all three specimens tested.

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1) The test chemical Prowl® 3.3 EC is a commercial pesticide product manufactured by BASF. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product as a pesticide. To ensure consistency in formulation used for testing, BASF has reserved product for testing. , ISO/TC 94/SC 13/WG 3 has agreed to availability of this test chemical through BASF to any laboratory worldwide. To obtain test chemical for this standard, contact BASF France Division Agro, DTAR-HOM, 69130 Ecully Cedex, France, [demandechantillons@basf.com](mailto:demandechantillons@basf.com).

## 6.4 Material resistance to permeation

For Level C3 protective clothing, three specimens shall be tested for cumulative permeation in accordance with ISO 19918. Use(s) claimed by the manufacturer and stated in accordance with [Clause 10 c\)](#) shall be used as the basis for conducting the permeation test.

- For protection against diluted formulations, the test shall be conducted for 1 h using Prowl® 3.3 EC diluted with distilled water to 5 % a.i..
- For protection against concentrates for short duration, the test shall be conducted for 15 min using Prowl® 3.3 EC (without dilution).

Additional testing may be required to determine cumulative permeation through material for specific pesticides. For additional testing, the procedure, test methods, and pass criteria shall be the same as that for Prowl® 3.3 EC stated above. The test chemical shall be the specific pesticide formulation, either concentrated or diluted with water, in accordance with the pesticide product labelling.

Materials for protective clothing classified as Level C3 shall have a maximum cumulative permeation of 1 µg/cm<sup>2</sup> for all three specimens tested with Prowl® 3.3 EC formulations.

**NOTE 1** The duration of the test is not based on actual use time since the permeation test is an accelerated test in which the surface of the specimen is in constant contact with the test chemical. During field application with dilute formulation, the duration of exposure may be for a longer period of time. However, the entire surface of a PPE item is not in constant contact with the test chemical. During mixing and loading, contact with concentrates results only from an accidental spill, in which case the operator is required to remove the protective clothing immediately. Therefore, the contact time with concentrates is much shorter.

**NOTE 2** This accelerated test is used to classify materials, and therefore the 1 µg/cm<sup>2</sup> maximum limit is not appropriate for use in calculating default protection factors used for exposure mitigation in operator exposure and risk assessment. The 5 % a.i. is used for the 1 h accelerated test; a lower concentration for that duration may result in problems with not being able to detect the amount permeating through the material.

**NOTE 3** The permeation test in [6.4](#) is more severe than the penetration test in [6.2](#). Therefore, material that meets the [6.4](#) requirement automatically meets the [6.2](#) penetration requirement.

**NOTE 4** Some pesticides are mixtures that when diluted with water may be emulsions or suspensions. In such cases, during the test agitation in the test cell may be necessary. Selective detection systems may be required to detect the active ingredient.

**IMPORTANT** — The use of this test recognizes that existing permeation tests (ISO 6529, EN 16523-1, ASTM F739) are not suited to the measurement of permeation chemicals with low vapour pressure and/or solubility in water.

## 6.5 Material tensile strength

Materials shall be tested in accordance with ISO 13934-1. Five specimens shall be tested in the machine direction and five in the cross direction. The tensile strength of re-usable materials shall be a minimum of 180 N in both the machine and cross directions. Materials with an elongation of more than 50 % are exempted from the 180 N requirements. For limited-use protective clothing, the tensile strength shall be a minimum of 30 N in both the machine and cross directions.

Each single-layer material or the outer layer of each multiple-layer material that is used in the protective clothing shall be tested separately.

## 6.6 Material tear resistance

Nonwovens and coated fabrics shall be tested in accordance with ISO 9073-4. Woven fabrics shall be tested in accordance to ISO 13937-3. Five specimens shall be tested in the machine direction and five in the cross direction. The tear strength for re-usable and limited-use protective clothing materials shall be 10 N.

Each single-layer material or the outer layer of each multiple-layer material that is used in the protective clothing shall be tested separately.

## 6.7 Material puncture resistance

Puncture resistance is not a mandatory requirement and therefore not used for classification.

If claimed by the manufacturer, protective clothing materials shall be tested in accordance with ISO 13996. Five specimens shall be tested for puncture resistance. A minimum of 10 N for re-usable and limited-use protective clothing is required for puncture resistance data to be included in [Clause 10 e](#)).

## 7 Performance requirements of seams

### 7.1 General

Specimens for testing shall be taken from the original garment. All seam types shall be tested. For testing and classification of seams, all individual specimen results shall meet the performance class requirement for the concerned property (see [Annex B](#)).

### 7.2 Seam resistance to penetration

Specimens with seams used in Level C1 protective clothing shall be tested in accordance with ISO 22608, Method A, using 0,2 ml of test chemical. Three specimens shall be tested for each type of seam. Prowl® 3.3 EC, an emulsifiable concentrate with 37 % pendimethalin, diluted with distilled water to 5 % a.i., shall be used. The seam shall be tested by placing the specimen such that the seam is centred along the length so that the test chemical falls directly on it. The test shall be repeated if the test chemical does not fall directly onto the seam during application. The specimen shall be discarded and the test repeated with a new specimen. All types of seams used in the construction shall be tested if more than one type of seam is used.

For seams for protective clothing classified as Level C1, the upper limit for percent penetration shall be 40 %. For values within 20 % of the upper limit, ISO 22608:2004, Method B, shall be used to validate the results obtained by Method A. In this case, the results obtained by Method B instead of the results obtained by Method A shall be used for determining whether seams meet the penetration classification requirement.

**NOTE** The pipette test is an accelerated laboratory test that differentiates the penetration performance of materials and seams. The maximum allowable penetration of 40 % is derived from the pipette data analysis of cotton and cotton/polyester protective clothing typically used for operator exposure studies. Therefore, it is not possible to substitute laboratory data from the pipette method for field penetration data. For this reason, the 40 % limit for the pipette method is used only to classify materials and seams. It is not appropriate for use in calculating default protection factors used for exposure mitigation in operator exposure and risk assessment.

### 7.3 Seam resistance to permeation

Specimens with seams used in Level C3 protective clothing shall be tested in accordance with ISO 19918. Three specimens shall be tested for each type of seam. The seam shall be tested by placing the specimen such that the seam is centred.

Use(s) claimed by the manufacturer and stated in accordance with 10 c) shall be used as the basis for conducting the permeation test.

- For protection against diluted formulations, the test shall be conducted for 1 h using Prowl® 3.3 EC diluted with distilled water to 5 % a.i.
- For protection against concentrates for short duration, the test shall be conducted for 15 min using Prowl® 3.3 EC (without dilution).



Additional testing may be required to determine cumulative permeation through seams for specific pesticides. For additional testing, the procedure, test methods, and pass criteria shall be the same as that for Prowl® 3.3 EC stated in this clause. The test chemical shall be the specific pesticide formulation, either concentrated or diluted with water, in accordance with the pesticide product labelling.

All seams for items classified as Level C3 shall have a maximum cumulative permeation of 1 µg/cm<sup>2</sup>. When tested with specific pesticide formulations, information regarding the test chemical shall be included in the information provided in accordance with [Clause 10 d](#)).

NOTE The permeation test in [7.3](#) is more severe than the penetration test in [7.2](#). Therefore, a seam that meets the [7.3](#) requirement automatically meets the [7.2](#) penetration requirement.

## 7.4 Seam tensile strength

Each type of straight seam shall be tested in accordance with ISO 13935-2. Five specimens shall be tested for each seam type. The seam tensile strength of re-usable materials shall be a minimum of 180 N. For limited-use protective clothing, the tensile strength shall be a minimum of 30 N.

NOTE The test method described in ISO 13935-2 is applicable only to seams joining two pieces of material.

# 8 Performance requirements of protective clothing

## 8.1 General

Protective clothing shall comply with the general ergonomic requirements as stated in ISO 13688:2013, Clause 4.

The protective clothing shall allow the wearer freedom of movement and shall be as comfortable as possible, consistent with the protection afforded by the garment. The above shall be verified by the test described in [Annex A](#).

Pockets and openings in the protective clothing shall not have design feature(s) that permit penetration or sequestration of liquid pesticides so as to increase the likelihood of permeation. An outside pocket with a flap is an example of a pocket that fulfils the design requirement

## 8.2 Ergonomic tests (practical performance)

Protective clothing inspection and the practical performance test shall be performed on three separate protective clothing items by one subject. The test shall be conducted in accordance with [Annex A](#).

The test subject shall successfully complete all seven movements stated in [Annex A](#). The answer shall be “yes” to all statements in the table in [Annex A](#). No further testing shall be conducted if the test subject responds “no” to any question in the table in [Annex A](#).

The practical performance procedure specified in [Annex A](#) also serves as a precondition for the high- and low-level spray tests in accordance with ISO 17491-4. Therefore, if applicable, the test subject shall proceed to spray testing upon successful completion of the practical performance test.

## 8.3 Liquid penetration resistance

### 8.3.1 Low-level spray test

Level C2 protective clothing, preconditioned by being worn for the procedure specified in [Annex A](#), shall subsequently be tested for liquid penetration resistance using a spray test in accordance with ISO 17491-4, Method A. The total stain area on any one undergarment shall be less than or equal to three times the calibrated stain area. This liquid penetration resistance testing shall be performed on

three protective clothing items using the same test subject for each test. Each protective clothing item shall pass the test.

NOTE The test chemical for the low-level spray test consists of water with dye and a surfactant added to produce a surface tension of  $(52 \pm 7,5) \times 10^{-3}$  N/m (see ISO 17491-4:2008, Clause 5).

### 8.3.2 High-level spray test

Level C3 protective clothing, preconditioned by being worn for the procedure specified in [Annex A](#), shall subsequently be tested for liquid penetration resistance using a spray test in accordance with ISO 17491-4:2008, Method B. The total stain area on any one undergarment shall be less than or equal to three times the calibrated stain area. This liquid penetration resistance testing shall be performed on three protective clothing items using the same test subject for each test. Each protective clothing item shall pass the test.

NOTE The test chemical for the high-level spray test consists of water with dye and a surfactant added to produce a surface tension of  $(30 \pm 5) \times 10^{-3}$  N/m (see ISO 17491-4:2008, Clause 5).

## 9 Marking

### 9.1 General

General marking requirements shall be in accordance with ISO 13688:2013, 7.1.

### 9.2 Specific

The marking shall meet the requirements specified in ISO 13688:2013, 7.2. The pictogram shall be the ISO 7000-3126 with ISO 27065 written at the bottom and the level of protection (stated as C1, C2, or C3 based on the level) on the right of the pictogram (see [Figure 1](#)).



Figure 1 — Placement of text for ISO 7000-3126 pictogram

In countries where FAO pesticide labelling pictograms (see [Annex E](#)) are used, the pictograms can be used on protective clothing in addition to the ISO pictogram.

## 10 Information supplied by the manufacturer

The information supplied by the manufacturer shall be in accordance with ISO 13688:2013, Clause 8. In addition, the manufacturer shall provide all applicable information and/or warnings from the list below.

- Information shall contain the number of cleaning cycles after which the protective clothing was tested. The following sentence shall be included in the information: "The stated maximum number of cleaning cycles is not the only factor related to the lifetime of the garment. The lifetime will also depend on usage, care, storage, etc."
- All necessary information for decontamination shall be provided. In addition, a warning shall be included alerting the user to any special cleaning or maintenance conditions which, if not followed, can impact the protective properties of the protective clothing. Examples of special conditions



include, but are not limited to, use of specific detergents, or use of heat such as tumble drying or ironing to reactivate the repellent finish.

- c) For Level C3 protective clothing, the manufacturer shall specify the intended use of the protective clothing. Does it provide protection against a) diluted pesticide and, b) concentrates during mixing and loading, or both? The claim shall be used to determine the conditions for permeation testing in [Clauses 6](#) and [7](#).
- d) Cumulative permeation for any additional pesticide(s) tested on both the fabric and seam.
- e) Information regarding puncture resistance properties if puncture resistance is claimed by the manufacturer.
- f) Information on material(s) with higher performance used in certain parts of the protective clothing to provide additional protection or strength.
- g) Instructions to remove the protective clothing immediately in case of an accidental spill.
- h) Donning/doffing procedures to prevent contamination.
- i) Limitations of use and information to assist the user in making decisions regarding selection and use of the protective clothing. This information is required for Level C3 whole body protective clothing and, if applicable, for other protective clothing with a potential for heat stress. Examples of limitations are time of continued use for given temperature and humidity. Manufacturers can use [Annex D](#) as a basis. This information is recommended for Level C1 or Level C2 if this attribute is claimed and the test is conducted.
- j) Conditions or factors that significantly reduce the protective qualities of the item.
- k) Information with respect to inspection, including visual inspection for tear and abrasion prior to each use.

## Annex A (normative)

### Test subject exercises for practical performance evaluation

The following activities shall be performed as part of the practical performance test.

A practical test shall be carried out by a human test subject. If more than one size of protective clothing is manufactured, the test subject shall be asked to select the appropriate size according to the manufacturer's information leaflet.

The test shall comprise three repetitions, at moderate speed, of the sequence of seven movements. The standing position shall be the starting point for each movement. The form below shall be completed to verify freedom of movement and comfort. State whether you can comfortably perform the movements described below.

Movement	Description	Response
1.	kneel on both knees, lean forward and place both hands on the floor ( $45 \pm 5$ ) cm in front of the knees; crawl forwards and backwards on hands and knees for a distance of 3 m in each direction;	<input type="checkbox"/> Yes <input type="checkbox"/> No
2.	climb a vertical ladder at least four steps, with rungs as encountered on a typical ladder;	<input type="checkbox"/> Yes <input type="checkbox"/> No
3.	position hands at chest level, palms out; reach directly overhead, interlock thumbs, extend arms fully upwards;	<input type="checkbox"/> Yes <input type="checkbox"/> No
4.	kneel on right knee, place left foot on floor with left knee bent ( $90 \pm 10$ )° and touch thumb of right hand to toe of left shoe; repeat movement with alternative posture, i.e. by kneeling on left knee and placing right foot on the floor with knee bent at 90°;	<input type="checkbox"/> Yes <input type="checkbox"/> No
5.	extend arms fully in front of body, lock thumbs together, twist upper body ( $90 \pm 10$ )° left and right;	<input type="checkbox"/> Yes <input type="checkbox"/> No
6.	stand with feet shoulder width apart, arms at side; raise arms until they are parallel to the floor in front of the body; squat down as far as possible;	<input type="checkbox"/> Yes <input type="checkbox"/> No
7.	kneel as in movement 4, with left arm hanging loosely at side, and raise arm fully overhead; repeat movement with alternative posture by alternating arms.	<input type="checkbox"/> Yes <input type="checkbox"/> No

Where protection is provided by an outer two piece suit, it shall be determined that an overlap between the jacket and trousers shall always be retained when the practical performance test is conducted. Upon completion of the tests, comments provided by the test subject regarding movement restrictions and thermal discomfort shall be documented. The comments shall be included in the report provided to the manufacturer.

## Annex B (normative)

### Testing requirements for Levels C1, C2 and C3 protective clothing

**Table B.1 — Testing requirements for Level C1, C2, and C3 protective clothing**

	Sub-clause	Performance test		Level		
				C1	C2	C3
Material & Seam Requirements	<a href="#">6.2</a> and <a href="#">7.2</a>	Material and seam penetration resistance for Level C1 and material for Level C2 (ISO 22608) <sup>b</sup>	Re-usable and limited-use	≤40 %	≤5%	
	<a href="#">6.3</a>	Material repellency (ISO 22608:2004 Method A)	Re-usable and limited-use		≥80 %	
	<a href="#">6.4</a> and <a href="#">7.3</a>	Material and seam resistance to permeation (ISO 19918)	Re-usable and limited-use			≤1 µg/cm <sup>2</sup>
	<a href="#">6.5</a>	Tensile strength (ISO 13934-1)	Re-usable	≥180 N	≥180 N	≥180 N
			Limited-use	≥30 N	≥30 N	≥30 N
	<a href="#">6.6</a>	Tear resistance (ISO 9073-4 or ISO 13937-3 as applicable)	Re-usable and limited-use	≥10 N	≥10 N	≥10 N
	<a href="#">6.7</a>	Puncture resistance (ISO 13996) <sup>a</sup>	Re-usable and limited-use	≥10 N	≥10 N	≥10 N
	<a href="#">7.4</a>	Seam tensile strength (ISO 13935-2)	Re-usable	≥180 N	≥180 N	≥180 N
			Limited-use	≥30 N	≥30 N	≥30 N
Whole Protective Clothing Requirements	<a href="#">8.1</a>	Practical performance test ( <a href="#">Annex A</a> )	Re-usable and limited-use	Pass	Pass	Pass
	<a href="#">8.3.1</a>	Low-level spray test (ISO 17491-4:2008, Method A)	Re-usable and limited-use		≤3× calibrated stain area	
	<a href="#">8.3.2</a>	High-level spray test (ISO 17491-4:2008, Method B)	Re-usable and limited-use			≤3× calibrated stain area
<sup>a</sup> Puncture resistance is not mandatory and therefore shall not be used for classification (see <a href="#">6.6</a> ).						
<sup>b</sup> Specify method used (Method A or B).						

## Annex C

### (informative)

### Selection of test chemical for penetration tests

[Annex C](#) describes the important properties of a test chemical, and why Prowl® 3.3 EC was chosen as the test chemical. The test chemical chosen for the penetration tests is the result of a multifaceted selection process. Pesticide formulation chemists were consulted to identify key factors that affect pesticide penetration through fabrics. Tests were then conducted using different types of formulations to select test chemicals that would be representative of the formulation(s) with the highest pesticide penetration. One of the first studies conducted was to measure pesticide penetration with different types of formulations using ISO 22608:2004, Method A (gravimetric method) and Method B (chemical analysis method) [4]. That study concluded that formulations with small particle size have the highest percent penetration. Therefore, an additional study was conducted using emulsifiable concentrates (EC) and soluble (liquid) concentrates (SL), both of which have a small particle size. The EC and SL concentrates were diluted with distilled water to different levels of concentration (typically 10 %, 5 % and 2,5 % a.i.), allowing for comparison of pesticide penetration of the formulation with different viscosity and surface tension (the two properties change when the concentrates are diluted).

For the study, Method A was used to measure percent penetration through six woven and nonwoven fabrics. Analysis of variance showed that formulation chemistry had a significant impact on penetration. Prowl® 3.3 EC showed the highest penetration values across all fibre types, fabric constructions, and fabric finishes. Those results, combined with desirable characteristics such as colour and ease of analysis and shipment, were used to select 5 % Prowl® 3.3 EC as the reference liquid. Dunnett's multiple comparisons test was used to compare the test chemicals and 5 % Prowl® 3.3 EC for all six fabrics. Analysis of the data indicates that, in general, mean percent penetration of 5 % Prowl® 3.3 EC is either similar to, or higher than, other test chemicals. Further testing was conducted using 5 % Prowl® 3.3 EC and two additional formulations, 5 % Roundup® and 2 % ready-mixed glyphosate with surfactant. Thirty-seven woven fabrics with and without repellent finish were tested with each formulation. In general, the formulations behaved similarly, with percent penetration for Prowl® 3.3 EC slightly higher than for the other two formulations. As there was no major difference in percent penetration and as Prowl® 3.3 EC represented the formulation types with the highest penetration, there was no rationale for testing with multiple formulations. See References [5] and [6] for further details of the study. In the future, additional formulations can be added if data supports the need for testing with more than one formulation. A surrogate test chemical will be developed based on tests conducted in 2016 with 65 formulations representative of commonly used pesticide formulation types. Once a surrogate is developed and validated, it will replace 5 % Prowl® 3.3 EC as the test chemical representative of the worst case scenario.

## Annex D (informative)

### Material water-vapour resistance (optional)

ISO 11092 or other standards are available for the evaluation of water-vapour resistance to determine the water- vapour resistance of single and multiple layers in a protective clothing item.

[Table D.1](#) provides performance guidelines to assist in determining continuous wear time. This information is from a study conducted by Hohenstein Institute, Germany, in which clothing made with fabrics of varying  $R_{et}$  were worn by individuals while working out on a treadmill. The input provided by the subjects was obtained and correlated with the  $R_{et}$  values of the fabrics.

**Table D.1 — Performance guideline for water-vapour resistance**

Range	Performance
$R_{et}$ 0–6	Very good or extremely breathable. Comfortable for higher activity rate
$R_{et}$ 6–13	Good or very breathable. Comfortable for moderate activity rate
$R_{et}$ 13–20	Satisfactory or breathable. Uncomfortable for high activity rate
$R_{et}$ 20–30	Unsatisfactory or slightly breathable. Moderate comfort at low activity rate
$R_{et}$ 30+	Unsatisfactory or not breathable. Uncomfortable and short tolerance time

$R_{et}$  - ( $\text{m}^2 \cdot \text{Pa} / \text{W}$ )

Material water-vapour resistance, laboratory methods of measuring thermal stress and heat stress caused by protective clothing and/or wear trials, may be used as a basis for recommendations for maximum continuous wearing time specified in [Clause 10 i](#)).

NOTE If, because of the protection required, the use of materials with low water-vapour resistance is not possible, then the protective clothing could be designed in such a way as to reduce the physiological strain as much as possible (e.g. by ventilation), provided that the protection requirements are met.

## **Annex E** (informative)

### **Food and Agricultural Organization (FAO) Pesticide Labelling Pictograms**

In some countries, the following FAO pictograms are used to communicate Personal Protective Equipment (PPE) to be worn when handling pesticides. The manufacturers can choose to place these pictograms in addition to the ISO pictogram and text in [9.2](#). The use of these pictograms on protective clothing may assist the user to recognize a pictogram that they see on pesticide product labels. The ISO standard and level can be included above the pictogram.



## **Annex F**

### **(informative)**

#### **Risk assessment — PPE to mitigate risk**

Globally, pesticide products are known as plant protection products (PPP). Pesticides or PPP are strictly regulated by regulatory bodies responsible for the authorization of the product to be placed on the market. In order to register their products for sale, companies are required to submit dossiers to the authorizing agency. Based on the documents provided by the registrant, the authorizing body determines the potential risk to human health and the environment, including risks to the pesticide operator and re-entry worker. The toxicity of the product and the exposure are typically used to determine potential risk. Since potential exposure can vary considerably, field studies that are representative of different exposure scenarios are often used to determine potential exposure. The potential risk is typically calculated for the different exposure scenarios in which the pesticide product can be used. For example, for a pesticide product, exposure assessment could be calculated for overhead spraying using an open tractor cab, knapsack spraying and indoor application using a spray gun, and other means of application that are prevalent in the country where the product is being registered. In addition, calculations are done for mixing and loading and other operations. The risk assessment often serves as the basis for determining the PPE to be used to mitigate risk, taking into account the part of the body that needs the most protection<sup>[2]</sup>.

An individual's risk when handling pesticide/PPP is a function of the hazard (ability to cause harmful effects due to the toxicity of the product) and the exposure of the individual. Once the product is placed on the market, the only way to reduce risk is by reducing exposure. Exposure can be reduced by administrative and engineering controls and use of PPE, as well as good work practices. It is the responsibility of the risk assessors to determine the PPE required for risk mitigation. Level C1 protective clothing requirements are based on exposure studies and can therefore be used for scenarios for which the cotton and cotton/polyester coveralls used for exposure studies provided adequate protection. Based on the exposure scenarios and type of task, partial-body protective clothing may be required to protect certain parts of the body. For example, a cap/hat/hood may be required for overhead spraying applications; an apron may be required for mixing and loading; and an accessory to protect the back may be required for knapsack/backpack applications. Based on risk assessment, higher protection may be required for products with higher toxicity and/or scenarios with higher exposure. Risk assessment is beyond the scope of this document.

Some regional/national legislations require pesticide/PPP producers to inform users about the most appropriate PPE to be worn when using a particular PPP. This document can be used by countries to specify PPE requirements on pesticide/PPP label and Safety Data Sheets.

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