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BSI Standards Publication

Protective clothing — Performance requirements for protective clothing worn by operators applying liquid pesticides

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National foreword

This British Standard is the UK implementation of ISO 27065:2011.

The UK participation in its preparation was entrusted to Technical Committee PH/3/3, Chemical, Biological, Radioactive and Nuclear Personal Protective Equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 27065 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

Introduction

This International Standard addresses the performance requirements for protective clothing worn by operators applying liquid pesticide products diluted with water. These products are also known as crop protection and plant protection products in certain countries. Registration of pesticide products, such as insecticides, herbicides and fungicides, involves the assessment of operator exposure and risk, factors which determine the need for personal protective equipment. Protection needs to correspond to the identified risks in order to avoid loss of comfort due to over-protection. Actual field trials are used to determine the operator risk while spraying pesticides under different scenarios. For the performance specification, data from field studies are used to categorize the garment performance and determine the minimum performance limits for the different levels. Laboratory tests, including accelerated tests, are used to determine whether the garment met the minimum requirements for that level. The minimum penetration requirements, evaluated by laboratory tests, are based on extensive studies comparing field study data with laboratory data. Laboratory data are often derived from accelerated tests to differentiate between different levels of performance; therefore, laboratory data cannot be used for direct comparison with field data or acceptable mitigation factors.

This International Standard defines performance requirements for three levels of protective clothing with specified resistance to penetration by pesticide products. It is up to the manufacturer of a specific pesticide product to indicate on the label the recommended level of protection (no protective clothing, Levels 1a, 1b, 2, 3) for the respective exposure conditions. A brief description of the different levels is given below.

Level 1 garments are suitable when the potential risk of contamination is relatively low. The performance requirements for Level 1a garments have been developed in view of low spray drift landing on the operator, e.g. from tractor boom sprayers. The performance requirements for Level 1b garments have been developed based on the performance of cotton and polyester/cotton garments, which are widely used for operator exposure studies.

Level 2 garments are suitable when the potential risk of contamination is higher but not so high as to require the use of liquid-tight materials.

Level 3 garments are suitable for use when the potential risk of contamination requires use of garments made with liquid-tight materials. This level is suitable for high-exposure scenarios where it has been determined that garments that prevent liquids from penetrating/permeating provide adequate protection.

This International Standard is intended for fabric and garment manufacturers, for manufacturers of pesticide products, 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 liquid pesticides

1 Scope

This International Standard establishes minimum performance, classification, and labelling requirements for protective clothing worn by operators applying liquid pesticide products diluted in water. Protective clothing covered by this International Standard includes, but is not limited to, shirts, jackets, trousers, coveralls, and spray-tight or liquid-tight garments. This International Standard addresses protection provided by protective accessories, with the exception of those used for the protection of the head, hands, and feet. This International Standard does not address protection against biocides, fumigants or highly volatile liquids.

2 Normative references

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

ISO 6330:2000, *Textiles — Domestic washing and drying procedures for textile testing*

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

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

ISO 13688, *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 13994, *Clothing for protection against liquid chemicals — Determination of the resistance of protective clothing materials to penetration by liquids under pressure*

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)*

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

EN 14786, *Protective clothing — Determination of resistance to penetration by sprayed liquid chemicals, emulsions and dispersions — Atomizer test*

3 Terms and definitions

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

3.1
biocide
non-agricultural pesticide

3.2
decontamination
removal of a contaminant or contaminants from the surface or matrix, or both, of chemical protective clothing to the extent necessary for its next intended action

3.3
fumigant
pesticide in the form of gas with the ability to spread to all areas of a sealed structure

3.4
garment
item of clothing such as a coverall or two-piece suit consisting of single or multiple layers

3.5
limited-use chemical protective clothing
chemical protective clothing for limited duration of use, intended to be worn until hygienic cleaning becomes necessary or contamination with pesticides has occurred and disposal is required

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

3.6
penetration
process by which a pesticide moves through porous materials, seams, pinholes, or other imperfections in a material on a non-molecular level

3.7
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

3.8
pesticide
substance or mixture of substances intended for preventing, destroying, repelling, or reducing any pest

NOTE The term pesticide applies to insecticides, herbicides, fungicides, and various other substances used to control pests.

3.9
protective clothing
clothing which covers or replaces personal clothing and which is designed to provide protection against one or more hazards

3.10
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

NOTE For the purpose of this International Standard, protective clothing materials include those materials used in the construction of the suit or garment that serve as the primary barrier for the wearer. Protective clothing materials do not include materials used in the construction of integral visors, gloves, and footwear.

3.11
re-usable chemical protective clothing
chemical 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

3.12
seam
permanent junction between two or more pieces of material created by sewing, welding, or another method

3.13
test chemical
liquid that is used to challenge the specimen of protective clothing material

3.14
toxicity
propensity of a substance to produce adverse biochemical or physiological effects

4 Classification and testing requirements

All protective clothing complying with this International Standard shall fulfil the requirements of ISO 13688 and shall be tested and classified by level of protection in accordance with the material, seam and garment requirements in Clauses 5, 6 and 7. Table 1 provides a summary of the tests to be conducted for each level of protection.

NOTE The stringency in testing requirements increases for each level. Therefore, any Level 2 garment necessarily meets Level 1a and Level 1b requirements, and so does not need to be tested to achieve that level of protection. Similarly, any Level 3 garment necessarily meets Level 1a, Level 1b, and Level 2 requirements.

The materials and seams of Level 1a and Level 1b garments shall demonstrate a minimum level of liquid penetration resistance when tested in accordance with the tests specified in Table 1. The mechanical strength performance requirements are the same for all levels of garments. Garments shall pass a practical performance test.

The material and seams of Level 2 garments shall demonstrate a higher level of liquid penetration resistance than Level 1 garments. The mechanical strength performance requirements are the same for all levels. The garments shall pass a practical performance test prior to being submitted to a low-level spray test of the whole garment.

The materials and seams of Level 3 garments shall demonstrate a minimum level of resistance to penetration by liquids under pressure. If, for a particular pesticide, additional testing is required to fully characterize the material (this shall be decided on the basis of the risk assessment provided for the registration of the specific pesticide), the material shall also be tested for permeation resistance using the pesticide in question. When tested with specific pesticide formulations, information regarding the test liquid shall be included in the information provided with the garment. The mechanical strength performance requirements are the same for all levels. The garments shall pass a practical performance test prior to being submitted to a high-level spray test of the whole garment, which is more severe than the test for Level 2 garments. Level 3 protective clothing includes accessories, such as aprons, protective sleeves, and material placed below knapsack/backpack sprayers, which are worn over garments (any level) for extra protection during spraying, mixing and loading. Whole-body testing is not required for accessories worn over whole-body garments.

Table 1 — Testing requirements for Level 1, 2 and 3 garments

Requirements	Sub-clause	Performance Test	Level			
			1a	1b	2	3
Material requirements	5.2.1	Liquid penetration resistance (EN 14786)	x			
	5.2.2	Liquid penetration resistance (ISO 22608)		x[a]	x[a]	
	5.3	Resistance to penetration by liquid under pressure (ISO 13994, Procedure E)				x
	5.4	Resistance to permeation (ISO 6529:2001, Method A)				x[b]
	5.5	Tensile strength (ISO 13934-1)	x	x	x	x
	5.6	Tear resistance (ISO 9073-4)	x	x	x	x
Seam requirements	6.2.1	Seam penetration resistance (EN 14786)	x			
	6.2.2	Seam penetration resistance (ISO 22608)		x[a]	x[a]	
	6.3	Seam resistance to penetration by liquid under pressure (ISO 13994, Procedure E)				x
	6.4	Seam resistance to permeation (ISO 6529:2001, Method A)				x[b]
	6.5	Seam tensile strength (ISO 13935-2)	x	x	x	x
Whole-garment requirements	7.2	Practical performance test	x	x	x	x
	7.3.1	Low-level spray test (ISO 17491-4, Method A)			x	
	7.3.2	High-level spray test (ISO 17491-4, Method B)				x

[a] The minimum performance requirement for Level 2 is significantly higher than that for Level 1b (see 5.2.2).

[b] If, for a particular pesticide, additional testing is required to fully characterize the material (this shall be decided on the basis of the risk assessment provided for the registration of the specific pesticide), the material shall also be tested for permeation resistance using the pesticide in question.

5 Performance requirements of protective clothing materials

5.1 Preconditioning

All protective clothing materials or material assemblies shall be cleaned before testing if the manufacturer's instructions indicate that the garments can be cleaned. The cleaning and maintenance procedures described in the manufacturer's instructions shall be followed [see 8.3 a)], except for drying between wash cycles (it is not necessary for garments to be dried between cleaning cycles). For machine-washable garments, ISO 6330 shall be used. If the manufacturer requires special cleaning or maintenance conditions, the information shall be included as part of a warning label, in accordance with 8.2 h).

The number of cleaning cycles to be performed shall be the maximum number of cycles for which product properties can be maintained, as indicated in the manufacturer's instructions. If the number of cleaning cycles is not specified in the manufacturer's instructions, garments shall undergo 30 cleaning cycles. If the manufacturer's instructions indicate that the life of the garment is less than 30 cleanings, the information shall be included as part of the warning label, in accordance with 8.2 h).

NOTE The purpose of the warning label is to inform the user of special requirements which, if not followed, may impact the protective properties of the garment. Examples of special conditions include, but are not limited to, use of a specific detergent or use of heat such as tumble drying or ironing to reactivate the repellent finish.

5.2 Material penetration resistance

5.2.1 Liquid penetration resistance (atomizer test)

Materials for Level 1a garments shall be conditioned and tested in accordance with EN 14786 and the average of three readings of percent penetration shall be used to classify the material. If the average of three readings is within 10 % of the minimum requirement, the test shall be repeated for an additional set of three readings and the average of six readings shall be used to classify the material. If more than one type of material is used to construct the garment, three specimens of each material shall be tested. Prowl 3.3 EC, an emulsifiable concentrate with 37,4 % pendimethalin, diluted with distilled water to 5 % a.i., should be used.[1)] The test chemical may be substituted as long as it has been verified that the same performance rating for materials and seams is achieved. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer fabric exposed to the test chemical. For single-layer garments constructed from different types of materials, each material shall be tested separately and the penetration classification based on the lowest performing level.

Materials for garments classified as Level 1a shall have an average penetration value of 5 % or less.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

5.2.2 Liquid penetration resistance (pipette test)

Materials for Level 1b and Level 2 garments shall be conditioned and tested in accordance with ISO 22608, Method A, using 0,2 ml of test liquid. The average of three percent penetration values shall be used to classify the material. If the average of three readings is within 10 % of the minimum requirement, the test shall be repeated for an additional set of three readings and the average of six readings shall be used to classify the material. If more than one type of material is used to construct the garment, three specimens of each material shall be tested. Prowl 3.3 EC, an emulsifiable concentrate with 37,4 % pendimethalin, diluted with distilled water to 5 % a.i., should be used. The test chemical may be substituted as long as it has been verified that the same performance rating for materials and seams is achieved. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer fabric exposed to the test chemical. For single-layer garments constructed from different types of materials, each material shall be tested separately and the penetration classification based on the lowest performing level.

Materials for garments classified as Level 1b shall have an average penetration value $\leq$40 %. If the material fails to meet the requirement, ISO 22608, Method B, an analytic method, can be used to verify the results obtained for Method A.

Materials for garments classified as Level 2 shall have an average penetration value of 5 % or less. If the material fails to meet the requirement, ISO 22608, Method B, an analytic method, can be used to verify the results obtained for Method A.

NOTE 1 Some materials, such as those with a microporous membrane, may allow water, and not the active ingredient, to penetrate through the fabric. If bright yellow, the colour of pendimethalin, is not visible on the collector layer, analytical testing is carried out in accordance with ISO 22608, Method B.

NOTE 2 The pipette test is an accelerated laboratory test that differentiates the penetration performance of materials. The maximum allowable penetration of 40 % is derived from the pipette data analysis of cotton and cotton/polyester garment materials 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 is not appropriate for use in calculating default protection factors used for exposure mitigation in operator exposure and risk assessment.

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1) The test chemical Prowl 3.3 EC is an example of a suitable product available commercially. It is available from Testfabrics, Inc. at www.testfabrics.com. This information is given for the convenience of users of this International Standard and does constitute an endorsement by ISO of this product.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8. If needed, Note 2 above can be added as an explanation.

5.3 Material resistance to penetration by liquid under pressure

Materials for Level 3 garments shall be conditioned and tested in accordance with ISO 13994, Procedure E. Three specimens shall be tested for each material. Prowl 3.3 EC, an emulsifiable concentrate with 37,4 % pendimethalin, diluted with distilled water to 5 % a.i., should be used. Test the specimens at 0 kPa pressure for 1 min. Then, increase the pressure at increments of 1 kPa every minute until failure is observed or a maximum of 15 kPa is reached. A material meets the requirements if all three specimens pass the test at a pressure $>$14 kPa. The test chemical may be substituted as long as it has been verified that the same performance rating for materials and seams is achieved. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer fabric exposed to the test chemical. For single-layer garments constructed from different types of materials, each material shall be tested separately and the penetration classification based on the lowest performing level.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

5.4 Material resistance to permeation

If, for a particular pesticide, additional testing is required to fully characterize the material (this shall be decided on the basis of the risk assessment provided for the registration of the specific pesticide), the material shall also be conditioned and tested in accordance with ISO 6529:2001, Method A, including visual assessment of the test specimen in accordance with ISO 6529:2001, 8.9. The average of the three permeation readings shall be used to determine the normalized breakthrough time. The test liquid shall be the specific pesticide formulation diluted with water in accordance with the manufacturer's instructions. Materials for garments classified as Level 3 shall have a normalized breakthrough time $\geq$30 min for the active ingredient. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

NOTE 1 Normalized breakthrough time will be reached when the normalized permeation rate of 1 µg/cm^2/min is achieved for an open collecting medium (BT 1.0) or when the normalized permeating mass of 2,5 µg/cm^2 is achieved for a closed collecting medium (BT 2.5).

NOTE 2 Pesticide formulations are mixtures that, when diluted in water, are often emulsions or suspensions. During the test, agitation in the challenge test cell can be necessary. Selective detection systems can be required to detect the active ingredient.

NOTE 3 The solvent in the pesticide mixture can impact permeation of the pesticide.

If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer fabric exposed to the test chemical. For single-layer garments constructed from different types of materials, each material shall be tested separately and the permeation classification based on the lowest performing level.

The chemical used to conduct the test and the results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

5.5 Material tensile strength

Garment materials shall be conditioned and tested in accordance with ISO 13934-1 and the average of five readings shall be calculated in both the machine and cross directions. 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 requirement. For limited-use garments, the tensile strength shall be a minimum of 30 N in both the machine and cross directions.

If the garment consists of a combination of separate layers of materials, the outer layer shall be tested. For single-layer garments constructed from different types of materials, each material shall be tested separately.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

5.6 Material tear resistance

Garment materials shall be conditioned and tested in accordance with ISO 9073-4. The average of five readings shall be a minimum of 10 N for re-usable and limited-use garments.

If the garment consists of a combination of separate layers of materials, the outer layer shall be tested. For single-layer garments constructed from different types of materials, each material shall be tested separately.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

6 Performance requirements of seams

6.1 Preconditioning

For seam testing, specimens shall be taken from a garment that has been cleaned, if the manufacturer's instructions indicate that the garment can be cleaned. The cleaning and maintenance procedures described in the manufacturer's instructions shall be followed [see 8.3 a)], except for drying between wash cycles (it is not necessary for garments to be dried between cleaning cycles). For machine-washable garments, ISO 6330 shall be used. If the manufacturer requires special cleaning or maintenance conditions, the information shall be included as part of a warning label, in accordance with 8.2 h).

The number of cleaning cycles to be performed shall be the maximum number of cycles for which product properties can be maintained, as indicated in the manufacturer's instructions. If the number of cleaning cycles is not specified in the manufacturer's instructions, garments shall undergo 30 cleaning cycles. If the manufacturer's instructions indicate that the life of the garment is less than 30 cleanings, the information shall be included as part of the warning label, in accordance with 8.2 h).

NOTE The purpose of the warning label is to inform the user of special requirements which, if not followed, may impact the protective properties of the garment. Examples of special conditions include, but are not limited to, use of a specific detergent or use of heat such as tumble drying or ironing to reactivate the repellent finish.

6.2 Seam penetration resistance

6.2.1 Liquid penetration (atomizer test)

Specimens with seams used in the construction of Level 1a garments shall be conditioned and tested in accordance with EN 14786. Prowl 3.3 EC, an emulsifiable concentrate with 37,4 % pendimethalin, diluted with distilled water to 5 % a.i., should be used. The seam shall be tested by placing the specimen such that the seam is centred. All types of seam used in the construction shall be tested if more than one type of seam is used. The average of three penetration readings shall be used to determine the seam performance. Seams classified as Level 1a shall have an average penetration value of 5 % or less (see 5.2.1). The average penetration of the lowest performing seam type shall be used to determine the performance. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

6.2.2 Liquid penetration test (pipette test)

Specimens with seams used in the construction of Level 1b and Level 2 garments shall be conditioned and tested in accordance with ISO 22608, Method A, using 0,2 ml of test liquid. Prowl 3.3 EC, an emulsifiable concentrate with 37,4% pendimethalin, diluted with distilled water to 5 % a.i., should 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. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

The average of three penetration readings shall be used to determine the seam performance. Seams classified as Level 1b shall have an average penetration value ≤40 %. If the material fails to meet the requirement, ISO 22608, Method B, an analytic method, can be used to verify the results obtained for Method A (see 5.2.2).

Seams classified as Level 2 shall have an average penetration value of 5 % or less. If the material fails to meet the requirement, ISO 22608, Method B, an analytic method, can be used to verify the results obtained for Method A (see 5.2.2).

The average penetration of the lowest performing seam type shall be used to determine the performance.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

6.3 Seam resistance to penetration by liquid under pressure

Specimens with seams used in the construction of Level 3 garments shall be conditioned and tested in accordance with ISO 13994, Procedure E. Three specimens shall be tested for each seam. Prowl 3.3 EC, an emulsifiable concentrate with 37,4 % pendimethalin, diluted with distilled water to 5 % a.i., should be used. Test the specimens at 0 kPa pressure for 1 min. Then, increase the pressure at increments of 1 kPa every minute until failure is observed or a maximum of 15 kPa is reached. A seam meets the requirements if all three specimens pass the test at a pressure >14 kPa. The test chemical may be substituted as long as it has been verified that the same performance rating for materials and seams is achieved. All types of seam used in the construction shall be tested if more than one type of seam is used. Test chemicals and contaminated waste shall be disposed of in accordance with local, regional and national laws.

The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

6.4 Seam resistance to permeation

If, for a particular pesticide, additional testing is required to fully characterize the material (this shall be decided on the basis of the risk assessment provided for the registration of the specific pesticide), the seam shall also be conditioned and tested in accordance with ISO 6529:2001, Method A, including visual assessment of the test specimen in accordance with ISO 6529:2001, 8.9. The average of the three permeation readings shall be used to determine the normalized breakthrough time. The test liquid shall be the specific pesticide formulation diluted with water in accordance with the manufacturer's instructions. Materials from garments classified as Level 3 shall have a normalized breakthrough time ≥30 min for the active ingredient. All types of seam used in the construction shall be tested if more than one type of seam is used, and the lowest performing seam type shall be used to determine the performance.

NOTE 1 Normalized breakthrough time will be reached when the normalized permeation rate of 1 μg/cm^2/min is achieved for an open collecting medium (BT 1.0) or when the normalized permeating mass of 2,5 μg/cm^2 is achieved for a closed collecting medium (BT 2.5).

NOTE 2 Pesticide formulations are mixtures that, when diluted in water, are often emulsions or suspensions. During the test, agitation in the challenge test cell can be required. Selective detection systems can be required to detect the active ingredient.

NOTE 3 The solvent in the pesticide mixture can impact permeation of the pesticide.

The chemical used to conduct the test and the results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

6.5 Seam tensile strength

A sample of each type of straight seam construction shall be conditioned and tested in accordance with ISO 13935-2. The seam strength of a re-usable material shall be at least 150 N. Materials with an elongation of more than 50 % are exempted from the 150 N requirement. For limited-use garments, the seam tensile strength shall be a minimum of 30 N. If more than one type of seam is used to construct the garment, the seams shall be classified according to the lowest measured level of performance in terms of seam strength for all types of seam tested. The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

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

7 Performance requirements of garments

7.1 Preconditioning

All garments shall be cleaned before testing if the manufacturer's instructions indicate that the garments can be cleaned. The number of cleaning cycles to be performed shall be the maximum number of cycles for which product properties can be maintained, as indicated in the manufacturer's instructions. However, if the manufacturer’s instructions indicate that the life of the garment is less than 30 cleanings, the information shall be included as part of the warning label, in accordance with 8.2 h). If the number of cleaning cycles is not specified in the manufacturer's instructions, garments shall undergo 30 cleaning cycles. The cleaning and maintenance procedures described in the manufacturer's instructions shall be followed [see 8.3 a)], except for drying between wash cycles. If the manufacturer requires special cleaning conditions, this information shall be included as part of a warning label, in accordance with 8.2 h).

NOTE The purpose of the warning label is to inform the user of special requirements which, if not followed, may impact the protective properties of the garment. Examples of special conditions include, but are not limited to, use of a specific detergent or use of heat such as tumble drying or ironing to reactivate the repellent finish.

7.2 Practical performance

Garment inspection and the practical performance test shall be performed on two separate garments or protective suits. Once inspected, the garments shall be tested for practical performance using the procedures specified in Annex A.

Protective clothing shall meet the following criteria:

a) Garments shall have no design feature (e.g. sleeve plackets) that would allow the pesticide products against which the garment is intended to offer protection to penetrate through the garment. Outside pockets are allowed only if it is ensured that the pesticide products cannot penetrate or adhere to the pockets.

NOTE Outside pockets with drain gutter, flap or perforation are possible designs that fulfil the requirement.

b) Garments shall not restrict the test subject from performing any task.

c) Garment closures shall be fully secured. During the duration of the test, there shall be no gaps or openings between closures that might have the potential to allow liquid penetration.

If the test subject is not able to perform one or several movements due to the hindrance of the garment or if the movements result in substantial damage to the garment or if the garment closures do not remain secure for the duration of the test, the garment shall fail the practical performance test and no further testing shall be conducted.

Comments, including those regarding garment comfort, provided by the wearer during the practical performance testing shall be recorded. A negative comment does not constitute a failure of this test.

A negative comment regarding comfort shall be addressed by the manufacturer in accordance with 8.3 e) and other information from the test subject shall be collected for possible refinement of methodology in the future.

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.

7.3 Liquid penetration resistance

7.3.1 Low-level spray test

Level 2 garments shall be conditioned by being worn for the procedure specified in Annex A and subsequently tested for liquid penetration resistance using a spray test in accordance with ISO 17491-4, Method A. The garment shall show no penetration greater than three times the total calibrated stain area. This whole-garment liquid penetration resistance testing shall be performed on two garments using a separate test subject for each test. Each garment shall pass the test. The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

NOTE The test liquid 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).

7.3.2 High-level spray test

Level 3 garments shall be conditioned by being worn for the procedure specified in Annex A and subsequently tested for liquid penetration resistance using a spray test in accordance with ISO 17491-4, Method B. The garment shall show no penetration greater than three times the total calibrated stain area. This whole-garment liquid penetration resistance testing shall be performed on two garments using a separate test subject for each test. Each garment shall pass the test. The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

NOTE The test liquid 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).

7.4 Ergonomics

If applicable, recommendations that are intended to prevent heat stress, such as maximum continuous wearing time, shall be given in the instructions for use [see 8.3 e)]. The information provided in accordance with 8.3 e) shall also address any comments with respect to garment comfort provided by the wearer during the practical performance testing (7.2).

8 Marking and information supplied by the manufacturer

8.1 General

The garment shall be supplied to the customer together with information supplied by the manufacturer at least in the official language(s) of the country in which it is being sold. Instruction sheets shall provide the information for limited-use garments. Permanent labels shall be used to provide information for re-usable garments.

8.2 Labelling

The protective garment shall include a label that is permanently attached in a conspicuous location and includes at least the following information in letters at least 1,5 mm high:

a) name, trademark, or other means of identifying the manufacturer;

b) manufacturer's type number, identification, or model number for the garment;

c) a reference to this International Standard (ISO 27065) followed by the level of protection (Level 1a, Level 1b, Level 2, or Level 3 according to requirements in Table 1); the test chemical shall be included below the level for Level 3 garments which have undergone permeation testing;

d) size designation in accordance with the regulations for the country or region in which the garment is sold (if no regulations exist, size designation should be in accordance with ISO 13688);

e) care instructions in accordance with the regulations for the country or region in which the garment is sold (if no regulations exist, care pictograms should be in accordance with ISO 3758);

f) year of manufacture, and also the month of manufacture if the expected shelf-life of the garment is less than 24 months; this information may be marked on every commercial packaging unit instead of being marked on every item of clothing;

g) a warning alerting the user to the life of the garment if, according to the manufacturer, the garment cannot be cleaned or cannot withstand 30 laundering cycles, as specified for preconditioning;

h) a warning placed prominently alerting the user to any special cleaning or maintenance conditions which, if not followed, can impact the protective properties of the garment. Examples of special conditions include, but are not limited to, use of a specific detergent or use of heat such as tumble drying or ironing to reactivate the repellent finish.

8.3 Instructions for use

The manufacturer shall provide instructions with every garment or alternatively shall provide instructions with at least every commercial packaging unit. The purpose is to guarantee that the wearer sees these instructions.

The instructions shall contain the information given on the label and at least the following information, as applicable:

a) cleaning and decontamination instructions and precautions as follows:

   1) the decontamination, cleaning and maintenance procedures to be followed, including possible treatments to restore material properties;

   2) the maximum number of cleaning cycles whereby material properties can be maintained, if applicable;

   3) a statement advising users not to use garments that are not thoroughly cleaned and dried;

b) if applicable, retirement criteria such as end-of-life indicators (e.g. measuring repellency by applying drops of a liquid supplied with the garment);

c) instructions to remove the garment immediately if contaminated by concentrate spill;

d) expected shelf-life if aging can occur;

e) warning of potential for heat stress and information to assist the user in making decisions regarding selection and use of the garment, if applicable;

f) limitations of use including conditions or factors that significantly reduce the protective qualities of the protective clothing;

g) donning/doffing procedures, if applicable;

h) information with respect to inspection, including visual inspection for tear and abrasion prior to each use;

i) instructions with respect to repair, if repair of mechanical damage is permitted by the manufacturer;

j) disposal requirements.

The manufacturer shall provide information and/or warnings, if appropriate, to prevent possible problems with the use of the clothing or its misuse in unsuitable environments.

8.4 Product technical information

8.4.1 General

The manufacturer shall make available all test results and classifications required by this International Standard. This information may be combined with the instructions for use (8.3). A complete description of the product shall be given as to materials, component parts and assemblies.

8.4.2 Chemical resistance information

All penetration test data shall be provided in a table for each material or seam tested. This data shall include a list of chemicals and chemical products (specifying the chemicals and their concentrations) against which the materials have been tested.

Annex A
(normative)

Test subject exercises for practical performance evaluation

The following activities, which are identical to those given in ISO 16602:2007, A.3 (Procedure C), shall be performed as part of the practical performance evaluation and to evaluate the garment for gapping and design requirements.

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 will 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 described below.

Starting from a standing position in each case, carry out the following sequence of movements:

— movement 1: kneel on both knees, lean forward and place both hands on the floor (45 ± 5) cm in front of the knees; crawl forwards and backwards on hands and knees for a distance of 3 m in each direction;

— movement 2: climb a vertical ladder at least four steps, with rungs as encountered on a typical ladder;

— movement 3: position hands at chest level, palms out; reach directly overhead, interlock thumbs, extend arms fully upwards;

— movement 4: kneel on right knee, place left foot on floor with left knee bent (90 ± 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°;

— movement 5: extend arms fully in front of body, lock thumbs together, twist upper body (90 ± 10)° left and right;

— movement 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;

— movement 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.

Annex B
(informative)

Material water-vapour resistance (optional)

If tested in accordance with ISO 11092, the water-vapour resistance of all layers of a garment shall be classified in accordance with Table B.1. The results shall be reported in the manufacturer's product technical information, as specified in Clause 8.

Table B.1 — Classification of water-vapour resistance

Class	1	2	3
Water-vapour resistance, R_{et} (m^2·Pa/W)	$R_{et} > 40$	$20 < R_{et} \leq 40$	$R_{et} \leq 20$

Table B.2 shows recommended wearing times for scenarios with minimum physiological strain and working environments with temperatures of 25 °C or less. The information is included as an example to illustrate the effect of water-vapour permeability on the recommended continuous wearing time of a garment. Comfort trials are recommended to evaluate the use of garments in hot climatic conditions.

Table B.2 — Recommended maximum continuous wearing time for a complete suit consisting of jacket and trousers without thermal lining

Temperature of working environment °C	**Wearing time**[a] min		
	Class 1 $R_{et} > 40$ m^2·Pa/W	**Class 2** 20 m^2·Pa/W $< R_{et} \leq 40$ m^2·Pa/W	**Class 3** $R_{et} \leq 20$ m^2·Pa/W
25	60	105	205
20	75	250	–
15	100	–	–
10	240	–	–
5	–	–	–
"–" indicates an absence of limit for wearing time.			
[a] The recommended wearing times given in this table are valid for a medium physiological strain, M, of 150 W/m^2, standard-man, at 50 % relative humidity, and wind speed, v_a, of 0,5 m/s.			

Other test methods are available for the evaluation of water-vapour resistance. Procedures also exist for the evaluation of thermal stress and heat stress caused by a garment. These methods or wear trials may be used as a basis for recommendations for maximum continuous wearing time.

If, because of the protection required, the use of materials with low water-vapour resistance is not possible, then the garment should be designed in such a way as to reduce the physiological strain as much as possible (e.g. by ventilation).

Annex C
(informative)

Atomizer test

The test method outlined in this annex is described in more detail in EN 14786.

The atomizer test measures a penetration index for protective clothing materials against atomized emulsions and dispersions of liquid chemicals, e.g. pesticides used in agricultural crop spraying. These materials are intended to be used in both limited-use and re-usable protective clothing.

Penetration is expressed in percent, as a ratio of the amounts of chemical applied and retained by the textile. The methods of quantitative physical-chemical analysis used for mass detection will depend on the chemical under test.

A test specimen is contaminated by a small quantity of atomized liquid chemical, emulsion or dispersion, injected by a two-phase nozzle operated by a microprocessor-controlled step motor. Part of the chemicals will penetrate and wet the test specimen. The flow of chemical passing through the material will be taken up by a collector layer under the test specimen.

After an exposure time of 30 min, the textile and the collector layer are extracted and analysed in order to determine the penetration of the chemical through the fabric. Depending on the type of chemical, different techniques such as high-pressure liquid chromatography (HPLC) or gas chromatography (GC) are used for the quantitative analysis.

Annex D
(informative)

Additional testing requirements for Type 6 and Type 4 garments

This annex provides information on additional testing requirements that Type 6 and Type 4 garments in accordance with ISO 16602 would need to undergo in order to qualify as Level 2 and Level 3 garments respectively. In addition to the testing, compliance with the labelling requirements specified in Clause 8 would be required. This annex does not provide information on test requirements that would enable Level 2 and Level 3 garments to qualify as Type 6 and Type 4 garments, respectively, in accordance with ISO 16602.

Table D.1 — Additional testing in order for Type 6 and Type 4 garments in accordance with ISO 16602 to meet the requirements for Level 2 and Level 3 garments respectively

Requirements	Sub-clause	Performance Test	Additional requirements:	
			Type 6	Type 4
Materials requirements	5.2.2	Liquid penetration resistance (ISO 22608)	x	
	5.3	Resistance to penetration by liquid under pressure (ISO 13994, Procedure E)		x[a]
	5.4	Resistance to permeation (ISO 6529:2001, Method A)		x[a]
	5.5	Tensile strength (ISO 13934-1)	x[b]	x[b]
	5.6	Tear resistance (ISO 9073-4)	x[b]	x[b]
Seam requirements	6.2.2	Seam penetration resistance (ISO 22608)	x	
	6.3	Seam resistance to penetration by liquid under pressure (ISO 13994, Procedure E)		x[a]
	6.4	Seam resistance to permeation (ISO 6529:2001, Method A)		x[a]
	6.5	Seam tensile strength (ISO 13935-2)	x	x

[a] Either the permeation resistance test or the test for resistance to penetration by liquid under pressure shall be used.

[b] The minimum requirement for the respective level (2 or 3) shall be met.

Annex E
(informative)

Selection of test chemical for penetration tests

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, 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 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 as the reference liquid. Dunnett's multiple comparisons test was used to compare the test chemicals and 5 % Prowl for all six fabrics. Analysis of the data indicates that, in general, mean percent penetration of 5 % Prowl is either similar to, or higher than, other test chemicals. Further testing was conducted using 5 % Prowl 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 almost identically, with percent penetration for Prowl slightly higher than for the other two formulations. As there was no major difference in percent penetration and as Prowl represents the formulation type with the highest penetration, there was no rationale for testing with multiple formulations. In the future, additional formulations can be added if data supports the need for testing with more than one formulation. Considering that countries may prefer to use formulations easily available and currently in use, this International Standard allows the test chemical to be substituted as long as it has been verified that the same performance rating for materials and seams is achieved.

See Reference [4] for further details of the study.

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[1] ISO 3758, *Textiles — Care labelling code using symbols*

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[3] ISO 16602:2007, *Protective clothing for protection against chemicals — Classification, labelling and performance requirements*

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