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Standard Performance Specification for Protective Clothing Worn by Operators Applying Pesticides[1]

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1. Scope

1.1 This specification establishes minimum performance, classification, and labeling requirements for protective clothing worn by operators applying pesticide products, primarily field strength, in liquid form.

1.2 Protective clothing items covered by this specification include, but are not necessarily limited to, liquid-tight or spray-tight garments, coveralls, jackets, shirts, and pants.

1.3 This specification addresses protection provided by protective accessories, with the exception of those used for the protection of the head, hands, and feet.

1.4 This specification does not address protection against biocides, fumigants, or highly volatile liquids.

1.5 The values given in SI units are to be regarded as the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1424 Test Method for Tearing Strength of Fabrics by Falling-Pendulum (Elmendorf-Type) Apparatus

D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

D5035 Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

F739 Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact

F903 Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids

F2130 Test Method for Measuring Repellency, Retention, and Penetration of Liquid Pesticide Formulation Through Protective Clothing Materials

2.2 *ISO Standards:*[3]

ISO 13688 ISO Protective Clothing—General Requirements

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 27065 Protective Clothing—Performance Requirements for Work and Protective Clothing for Horticultural and Agricultural Pesticide Workers

3. Terminology

3.1 *Definitions:*

3.1.1 *decontamination*, *n*—~~removal of a contaminant or contaminants from the surface or matrix or both of chemical protective clothing (CPC) to the extent necessary for its next intended action (for example, reuse and disposal).~~ —reduction, removal, or neutralization of a contaminant or contaminants from protective clothing to the extent necessary to safely permit the protective clothing to be doffed (taken off), or reused, or discarded.

3.1.2 *finish*, *n*—chemical or mechanical modification or both of the fabric for a specific performance result.

3.1.3 *garment*, *n*—single item of clothing (for example, a shirt).

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3.1.4 *penetration*, *n*—for chemical protective clothing, the movement of substances through voids in protective clothing materials or items on a non-molecular level.

3.1.4.1 *Discussion*—Voids include gaps, pores, holes, and imperfections in closures, seams, interfaces, and protective clothing materials. Penetration does not require a change of state; solid chemicals move through voids in the materials as solids, liquids as liquids, and gases as gases. Penetration is a distinctly different mechanism from permeation.

3.1.5 *permeation*, *n*—for chemical protective clothing, ~~chemicals move as molecules~~the movement of chemicals through protective clothing material items by the processes of (*1*) absorption of the chemical into the contact surface of the material, (*2*) diffusion of the absorbed molecules throughout the material, and (*3*) desorption of the chemical from the opposite surface of the material.

3.1.5.1 *Discussion*—Permeation is a distinctly different mechanism from penetration.

3.1.6 *protective clothing*, *n*—an item of clothing that is specifically designed and constructed for the intended purpose of isolating all or part of the body from a potential hazard; or, isolating the external environment from contamination by the wearer of the clothing.

3.1.6.1 *Discussion*—For the purpose of this specification, protective clothing materials include those materials used in the construction of the suit or clothing 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.

3.1.7 *seam*, *n*—junction between two or more pieces of material created by sewing, welding, or another method.

3.1.8 *test chemical*, *n*—~~liquid or gas that is used to challenge the protective clothing material specimen.~~ solid, liquid, or gas, or mixture thereof, used to evaluate the performance of a protective clothing material.

3.1.8.1 *Discussion*—For the purpose of this specification, the test chemical selected is limited to a liquid chemical.

3.1.9 *toxicity*, *n*—propensity of a substance to produce adverse biochemical or physiological effects.

4. Classification and Test Requirements

4.1 All protective clothing complying with this specification shall fulfill the requirements of ISO 13688 and shall be tested and classified by the level of protection based on the material, seam, and garment requirements included in Sections 5-7. Information on tests to be conducted for each level of protection is included in Table 1.

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

4.3 Level 2 garments shall be made of materials and with seams that 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 before being submitted to a low-level spray test of the whole garment.

~~4.4Level 3 garments shall be made of materials and with seams that demonstrate a minimum level of resistance to penetration by liquids under pressure. It is possible that additional tests, such as permeation resistance testing with the actual test chemical, will be necessary to characterize fully the material for a particular application. When additional tests to determine permeation are required, the penetration by liquid under pressure shall be replaced by the permeation test. When tested with specific pesticide formulations, information regarding the test chemical 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 before being submitted to a high-level spray test of the whole garment, which is more severe than the test for Level 2 garments.~~

TABLE 1 Testing Requirements for Level 1, 2, and 3 Garments

	Specific Performance Test	Level		
		1[A]	2	3
Material Requirements	Liquid penetration resistance (Test Method F2130)	x[B]	x[B]	
	Resistance to penetration by liquid under pressure (Test Method F903)			x
	Resistance to permeation (Test Method F739)			x[C]
	Breaking strength (Test Method D5035)	x	x	x
	Tearing strength (Test Method D1424)	x	x	x
Seam requirements	Liquid penetration resistance (Test Method F2130)	x[B]	x[B]	
	Resistance to penetration by liquid under pressure (Test Method F903)			x
	Resistance to permeation (Test Method F739)			x[C]
	Breaking strength (Test Method D5034)	x	x	x
Whole garment requirements	Practical performance test	x	x	x
	Low-level spray test (ISO 17491-4, Method A)		x	
	High-level spray test (ISO 17491-4, Method B)			x

[A] Level 1 is equivalent to Level 1b of ISO 27065.

[B] The minimum performance requirement for Level 2 is considerably more severe than for Level 1 (see 5.2).

[C] If, for a particular ~~pe~~sti~~bl~~cide ~~th~~, at additional testing is ~~such as pe~~ rmeatquionresisd to fully chanracetestring wize th ~~the~~ maetuerial (~~test chemics shal will be n~~ decided on the basis~~ary t~~ o ~~ef~~ thae risk aessessment provided for the regizstration of the specif~~ully~~ic pesticide), the material shall also be tested for ~~a~~ paermeaticula~~on~~ resistance using the p~~p~~lesticaide in question. When ~~a~~ testede with specio~~nal tf~~ic pests toicidete formulatio~~ne pes~~, informeation ~~a~~ rega~~required;~~ing the ~~p~~ tenes~~tration by~~ liquid ~~under pre~~ ssure ~~s~~hall be ~~repla~~ included ~~by~~ in the ~~pe~~ information provided with the~~s~~ garment.

~~Level 3 protective clothing includes accessories such as aprons, protective sleeves, and material placed below knapsack/backpack sprayers, which is used for extra protection during spraying, mixing, and loading. Whole body testing is not required for accessories worn over whole body garments.~~

4.4 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 before 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 is used for extra protection during spraying, mixing, and loading. Whole body testing is not required for accessories worn over whole body garments.

5. Performance Requirements of Protective Clothing Materials

5.1 *Preconditioning*—All protective clothing materials or material assemblies shall undergo 30 cycles of cleaning in accordance with the manufacturer's instructions before testing, if the manufacturer's instructions indicate that the garment can be cleaned. However, garments that, in accordance with the manufacturer's instructions, can be cleaned fewer than 30 times shall undergo only as many cycles of cleaning as indicated by the manufacturer's instructions. After the last cleaning cycle, materials to be tested for penetration shall be air dried and shall not be ironed before testing.

NOTE 1—Garments do not need to be dried between wash cycles.

5.1.1 If the manufacturer requires special cleaning or maintenance conditions, this information shall be included as part of a warning label in accordance with Section 8.

NOTE 2—The purpose of the warning label is to inform the user of special requirements that, if not followed, have the potential to 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 dry or ironing to reactivate the repellent finish.

5.2 *Material Penetration Resistance*:

5.2.1 Penetration testing for Level 1 and Level 2 garments shall be conducted in accordance with Test Method F2130, Method A, using 0.2 mL of test chemical. 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 threshold, 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, an emulsifiable concentrate with 37.4 % pendimethalin, diluted with distilled water to 5 % active ingredient (a.i.) shall be used. It is acceptable to substitute the test chemical as long as it has been verified that the same performance rating for materials and seams is achieved.

5.2.2 If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer ~~layer shall be tested.~~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.

5.2.3 Materials classified as Level 1 shall have an average penetration value ≤40 %. If the material fails to meet the requirement, Test Method F2130, Method B, an analytic method, can be used to verify the results obtained for Method A.

5.2.4 Materials classified as Level 2 shall have an average penetration value of 5 % or less. If the material fails to meet the requirement, Test Method F2130, Method B, an analytic method, can be used to verify the results obtained for Method A.

NOTE 3—It is possible that some materials, such as those with a microporous membrane, will allow water and not the a.i. to penetrate through the fabric. If bright yellow, the color of pendimethalin, is not visible on the collector layer, proceed with analytical testing using Method B.

NOTE 4—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 shall not be used to calculate default protection factors used for exposure mitigation in operator exposure and risk assessment.

5.2.5 The results shall be reported in the manufacturer's product technical information (see Section 8).

5.3 *Material Resistance to Penetration by Liquid under Pressure*:

5.3.1 Resistance to penetration by liquid under pressure for Level 3 garments shall be tested in accordance with Test Method F903. Three specimens shall be tested for each material. Use Prowl 3.3, an emulsifiable concentrate with 37.4 % pendimethalin, diluted with distilled water to 5 % a.i.. 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. It is acceptable to substitute the test chemical as long as it has been verified that the same performance rating for materials and seams is achieved.

5.3.2 If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer ~~layer shall be tested.~~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.

5.3.3 The results shall be reported in the manufacturer's product technical information (see Section 8).

5.4 *Material Resistance to Permeation (Alternative to Liquid Pressure Test)*:

~~5.4.1When additional testing is required to characterize fully the material for a particular application, the material shall be tested in accordance with Test Method~~

5.4.1 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 in accordance with Test Method F739~~, and the lowest~~ . The average of the three permeation readings shall be used to determine the normalized breakthrough time (see Note 5). The test ~~chemical~~liquid shall be the specific pesticide formulation diluted with water in accordance with the ~~field strength.~~manufacturer's instructions. Materials classified for Level 3 garments shall have a normalized breakthrough time >30 min for the active ingredient (see Note 6).

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

NOTE 6—Pesticide formulations are mixtures that, when diluted in water, are often emulsions or suspensions. During the test, it is possible that agitation in the challenge test cell will be required. It is possible that selective detection systems will be required to detect the active ingredient.

NOTE 7—It is possible that the solvent in the pesticide mixture will impact permeation of the pesticide.

5.4.2 If the garment consists of a combination of separate layers of materials, all layers shall be tested together with the outer ~~layer shall be tested.~~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.

5.4.3 The results shall be reported in the manufacturer's product technical information (see Section 8).

5.5 *Material Breaking Strength* :

5.5.1 Breaking strength of clothing materials shall be tested in accordance with Test Method D5035 and the average of five readings shall be calculated in both the machine and cross directions. The breaking strength of reusable materials shall be a minimum of ~~500~~180 N in both the machine and cross directions. Materials with an elongation of more than 50 % are exempted from the ~~500-N~~180-N requirement. For limited-use garments, the breaking strength shall be a minimum of 30 N in both the machine and cross directions.

5.5.2 If the garment consists of a combination of separate layers of materials, the outer layer shall be tested. For single-layer