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Protective clothing — Protection against chemicals — Measurement of cumulative permeation of chemicals with low vapour pressure through materials

Habillement de protection — Protection contre les produits chimiques — Mesure de la perméation cumulée à travers des matériaux des produits chimiques ayant une faible pression de vapeur

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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO 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).

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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.

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

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Introduction

When assessing the performance of personal protective equipment (PPE) against chemical risks, it is clearly important to determine the ability of PPE materials to resist chemical ingress. The term "ingress" is used here specifically so as not to distinguish between penetration and permeation. Penetration is ingress through physical holes in the fabric such as pores, stitch-holes, and gaps in a protective coating. Penetration is usually quite a rapid process, leading to the ingress of chemical within a matter of minutes, whereas permeation is usually a slower process with molecular diffusion through a polymer or elastomer. However, from the perspective of the wearer of PPE (gloves, footwear, protective clothing) the mechanism of ingress is far less relevant than the fact that a quantity of chemical may at some point migrate through the fabric of the personal protective equipment.

Standards to measure permeation are designed to measure the performance of materials that include a polymer or elastomer as the movement in these materials is at the molecular level. However, although they are intended to measure movement of chemicals at a molecular level, it may be difficult to differentiate between penetration and permeation in materials with small pores, pinholes, and gaps in coating.

A number of standards, including ISO 6529, EN 16523-1 and ASTM F739, measure permeation of chemicals that are volatile and/or soluble in water or other liquid or gaseous collection media. In the above-mentioned standards, volatility or solubility in water or other liquid that does not interact with the material allows use of gaseous or liquid collection medium. However, based on the scopes of ISO 6529, EN 16523-1 and ASTM F739, these standards are not well-suited for quantifying the ingress of chemicals and mixtures that are involatile and/or insoluble in water and other liquids that do not interact with the material being tested. This document complements the above-mentioned standards as it is suitable for measuring chemicals that cannot be measured by other standards and vice versa.

This document is intended to be used to evaluate the barrier effectiveness materials used in personal protective equipment against permeation by solid and liquid chemicals with low vapour pressure and/or low solubility in commonly used liquid and gaseous collection media. This test method is not suitable for measurement of volatile chemicals that may evaporate before the chemical analysis is complete.

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Protective clothing — Protection against chemicals — Measurement of cumulative permeation of chemicals with low vapour pressure through materials

1 Scope

This document describes laboratory test methods to determine the resistance of materials, closures, and seams used in personal protective equipment (PPE) to permeation by solid or liquid chemicals with low vapour pressure (less than 133,322 Pa at 25 °C) and/or insolubility in water or other liquids commonly used as collection media. These chemicals that are often part of pesticide formulations and other mixtures cannot be measured using other standards for measuring permeation. This test method is suitable for field strength and concentrated pesticide formulations as well as other mixtures in which the active ingredient is a chemical with low vapour pressure and/or low solubility in commonly used liquid and gaseous collection media.

This test method is not intended to be used in place of standards such as ISO 6529, EN 16523-1 and ASTM F739, which measure permeation of chemicals that are either volatile or soluble in water or other liquids that do not interact with the material being tested. This document is not suitable for measurement of volatile chemicals that may evaporate before the chemical analysis is complete.

The degree of contamination depends on numerous factors, such as type of exposure, application technique, and chemical formulation. As the level of exposure can vary considerably, this method is designed to rate relative performance of PPE materials for different durations.

This method is designed to measure cumulative permeation. Breakthrough time cannot be measured by this method. This test method does not measure resistance to penetration or degradation.

The test method standard may be used for the evaluation of PPE materials that are new or those for which the product standard requires treatment, such as laundering or simulated abrasion. Details of the treatment shall be reported.

2 Normative references

No normative references are required for this document.

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:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
analytical technique
method of quantifying the amount of permeated chemical in the collection medium

Note 1 to entry: Such methods are often specific to individual chemical and collection-medium combinations.

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3.2
breakthrough detection time
elapsed time measured from the start of the test to the sampling time that immediately precedes the sampling time at which the test chemical is first detected

3.3
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

3.4
degradation
deleterious change in one or more properties due to contact with a chemical or heat

3.5
limit of quantification
minimum quantity of a substance which can be measured

Note 1 to entry: It is the value where the uncertainty of measurement is equal to 50% of the determined value.

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

Note 1 to entry: For the purpose of this document, penetration refers to only chemicals, not micro-organisms.

Note 2 to entry: For the purpose of this document, materials include protective clothing, footwear, and glove materials.

3.7
permeation
process by which a chemical moves through a material on a molecular level

Note 1 to entry: Permeation involves (1) adsorption of molecules of the chemical onto the contacted (outside) surface of a material, (2) diffusion of the adsorbed molecules into and through the material, and (3) desorption of the molecules from the opposite (inside) surface of the material.

Note 2 to entry: For the purpose of this document, materials include protective clothing, footwear, and glove materials.

3.8
solid collection medium
solid material on the “clean” side of the test specimen in which any permeated chemical is collected

3.9
test chemical
chemical or mixture of raw materials, including but not limited to, active ingredients, inert ingredients, and a base solvent used in a formulation

Note 1 to entry: For the purpose of this test method, test chemicals are limited to chemicals (including mixtures) with low vapour pressure less than 133,322 Pa at 25 °C and/or insolubility in water or other liquids commonly used as collection media.

3.10
vapour pressure
pressure exerted by the vapour above the liquid in equilibrium at a given temperature

3.11
insoluble chemical
chemical having solubility of less than 50 mg/l at 23 °C in water or other liquids commonly used as collection media

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3.12
closure
system or component which makes possible the closing of an item of PPE

4 Principle

A prepared collector disc shall be used to measure the cumulative permeation of chemicals with low vapour pressure and/or insolubility in water and other commonly used collection media.

The collector disc is placed under the test material in the test assembly (see Annex A). The cell is placed on a horizontal surface and filled with test chemical.

After the predetermined duration of the test, the cell is emptied and the collector disc is removed for extraction and quantitative analysis. The predetermined duration stated in the product standard should be used when testing.

The data are used to calculate cumulative permeation.

5 Apparatus and supplies

5.1 The permeation cell consists of a base and a cylinder that are assembled with three bolts to form a cell. The centre of the base and the bottom surface of the cylinder are raised to improve contact between the two surfaces. See Annex B for a technical drawing, including measurements for the permeation cell. The gasket, collector disc, and test specimen are placed between the base and the cylinder. The test specimen's normal inside surface is in contact with the collector disc. The material's outer surface is toward the side that faces the test cylinder. The two pieces are connected with three bolts. The top surface of the cylinder has a spout to make it easier to drain the test chemical. The schematic diagram of the permeation cell is shown in Annex A.

The cylindrical, hollow insert illustrated in Figure B.4 fits into the centre of the cell. The insert is to maintain contact between the collector disc and the test specimen while the cell is being assembled. It shall be filled to bring the mass to (100 ± 1) g.

See Annex B for the drawing and description of PTFE cell used for the interlaboratory study. Measurements (including tolerance limits) in Figures B.2 to B.4 pertain to the cell in Annex B.

NOTE 1 Annex C includes a list of suppliers for the PTFE permeation cell, gaskets, and collector discs.

NOTE 2 Cells made with other materials and designs have not been tested.

NOTE 3 Other cells with similar design that give equivalent results could also be used.

5.2 **Gasket**, with (90,0 ± 0,1) mm outer diameter (OD) and (35,0 ± 0,1) mm inner diameter (ID) with holes for the bolts.

The gasket shall be used to prevent leakage. Care shall be taken to ensure that test chemical cannot leak out of the challenge side of the apparatus, flow around the edge of the test specimen, and then leak into the collection side. This is most likely to happen by capillary action if the outer side of a multicomponent material is from woven or nonwoven material. The size of the gasket may be changed to control leakage. Information on selection and size of gaskets is included in Annex D.

5.3 **Collector disc**, a solid collection medium, with (50 ± 1) mm diameter and (20,0 ± 0,5) mm pre-cut centre**,** made of Benchkote® Plus[1)]. The pre-cut centre is attached to the outer ring at two opposite ends.

1) Benchkote® Plus is the trade name of a polyethylene-backed, absorbent paper manufactured by Whatman/GE Healthcare. Benchkote® Plus is available through scientific product suppliers. This information is given for the convenience of users and does not constitute an endorsement by ISO of this product.

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