INTERNATIONAL STANDARD

ISO 6529

Second edition
2001-10-15

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

Vêtements de protection — Protection contre les produits chimiques — Détermination de la résistance des matériaux utilisés pour la confection des vêtements de protection à la perméation par des liquides et des gaz

Reference number
ISO 6529:2001(E)

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Printed in Switzerland

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 6529 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 6529:1990), which has been technically revised.

Annexes A to D of this International Standard are for information only.

Introduction

Workers involved in the production, use, transportation, and emergency response with liquid and gaseous chemicals can be exposed to numerous compounds capable of causing harm upon contact with the human body. The deleterious effects of these chemicals can range from acute trauma such as skin irritation and burn to chronic degenerative disease, such as cancer. Since engineering controls may not eliminate all possible exposures, attention is often placed on reducing the potential for direct skin contact through the use of protective clothing that resists permeation, penetration and degradation.

These test methods are normally used to evaluate the barrier effectiveness of materials used for protective clothing and specimens from finished items (see Note 1) of protective clothing against permeation of either liquid or gaseous chemicals. Options are provided for conducting this testing under both conditions of continuous or intermittent contact with the chemicals.

These test methods provide various options for reporting test results in terms of breakthrough time, permeation rate and cumulative permeation to allow a comparison of protective clothing material permeation resistance. These parameters are key measures of the effectiveness of a clothing material to act as a barrier to the test chemical. Such information is used in the comparison of clothing materials during the process of selecting clothing for protection from hazardous chemicals. Long breakthrough detection times and normalized breakthrough detection times as well as low permeation rates are characteristic of the best barriers.

Resistance to penetration by liquid chemicals should be determined by using ISO 6530 while resistance to penetration by liquid chemicals under pressure should be determined by using ISO 13994. These International Standards are listed in the Bibliography.

It has been assumed in the drafting of this International Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people for whose guidance it has been prepared and that appropriate precautions will be taken to avoid injury to health and contamination of the environment.

NOTE 1 Finished items of protective clothing include gloves, arm shields, aprons, suits, hoods, boots, etc. The phrase “specimens from finished items” encompasses seamed and other discontinuous regions as well as the usual continuous regions of protective clothing items.

NOTE 2 At present, no quantitative information exists about acceptable levels of dermal contact. Therefore, the data obtained using this test method cannot be used to infer safe exposure levels.

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

1 Scope

This International Standard describes laboratory test methods that enable a determination of the resistance of materials used in protective clothing to permeation by liquid or gaseous chemicals under the conditions of either continuous or intermittent contact.

Method A (see 8.3) is applicable to the testing of liquid chemicals, either volatile or soluble in water, expected to be in continuous contact with the protective clothing material.

Method B (see 8.4) is applicable to the testing of gaseous chemicals expected to be in continuous contact with the protective clothing material.

Method C (see 8.5) is applicable to the testing of liquid chemicals, either volatile or soluble in water, expected to be in intermittent contact with the protective clothing material.

These test methods are only suitable for the testing of air-impermeable protective clothing materials. They assess the permeation resistance of the protective clothing material under laboratory conditions in terms of breakthrough time, permeation rate, and cumulative permeation. These test methods also enable observations to be made of the effects of the test liquid on the protective clothing material under test.

These test methods address only the performance of materials or certain material constructions (e.g. seams) used in protective clothing. These test methods do not address the design, overall construction and components, or interfaces of garments or other factors which may affect the overall protection offered by the protective clothing.

It is emphasized that these tests do not necessarily simulate conditions to which clothing materials are likely to be exposed in practice. The use of test data should therefore be restricted to broad comparative assessment of such material according to their permeation-resistance characteristics.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*

ISO 2286-2, *Rubber- or plastics-coated fabrics — Determination of roll characteristics — Part 2: Methods for determination of total mass per unit area, mass per unit area of coating and mass per unit area of substrate*

ISO 2286-3, *Rubber- or plastics-coated fabrics — Determination of roll characteristics — Part 3: Method for determination of thickness*

ISO 3801, *Textiles — Woven fabrics — Determination of mass per unit length and mass per unit area*

ISO 5084, *Textiles — Determination of thickness of textiles and textile products*

3 Terms and definitions

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

3.1
analytical technique
procedure whereby the concentration of a chemical in a collection medium is quantitatively determined

NOTE These procedures are often specific to individual chemical and collection-medium combinations.

EXAMPLES Applicable analytical techniques can include ultraviolet (UV) and infrared (IR) spectrophotometry, gas and liquid chromatography, pH measurement, ion chromatography, conductimetry, colorimetry, atmospheric analytical detector tubes and radionuclide tagging/detection counting.

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

See Figure 1.

NOTE The breakthrough detection time is dependent on the sensitivity of the method and the frequency of sampling (the interval between sampling times).

3.3
closed-loop
refers to a testing mode in which the collection medium volume is fixed

NOTE The collection medium volume may change slightly from sampling without replacement of the sampled collection medium.

3.4
collection medium
liquid or gas that does not affect the measured permeation and in which the test chemical is freely soluble or adsorbed to a saturation concentration greater than 0,5 % by mass or by volume

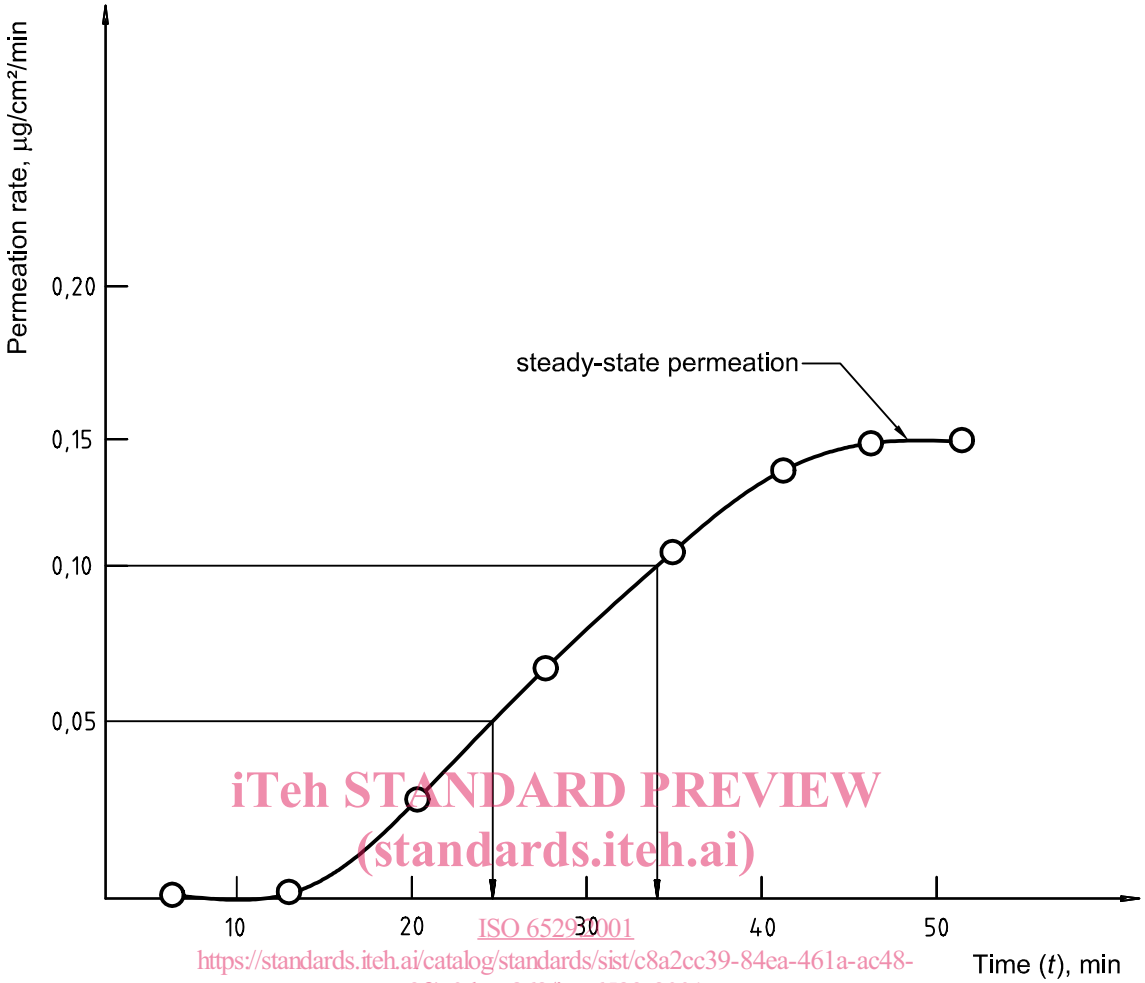
3.5
contact time
in an intermittent contact test, the duration that the challenge-side chamber of the permeation cell contains test chemical during each cycle

3.6
cumulative permeation mass
total amount of chemical that permeates during a specified time from the time the clothing material specimen is first contacted with the test chemical

NOTE 1 Quantification of cumulative permeation enables the comparison of permeation behaviour under different intermittent and continuous-contact conditions.

NOTE 2 The measurement of cumulative permeation may depend on the sensitivity of the permeation-test system.

3.7
cycle time
in an intermittent contact permeation test, the interval of time from the start of one contact period to the start of the next contact period



NOTE The breakthrough detection time for a method sensitivity of 0,05 µg/cm²/min is 23 min but would be reported at 20 min, which corresponds to the last sampling time preceding the test. The normalized breakthrough detection time at a normalization permeation rate of 0,1 µg/cm²/min is 33 min, but similarly would be reported at 28 min, which corresponds to the preceding sampling time. The steady-state permeation rate is approximately 0,15 µg/cm²/min.

Figure 1 — Breakthrough detection time

3.8
degradation
deleterious change in one or more physical properties of a protective clothing material

3.9
minimum detectable mass permeated
smallest mass of test chemical that is detectable with the complete permeation-test system

NOTE This value is not necessarily the intrinsic limit of detection for the analytical instrument.

3.10
minimum detectable permeation rate
lowest rate of permeation that is measurable with the complete permeation-test system

NOTE This value is not necessarily the intrinsic limit of detection for the analytical instrument.

3.11
normalization permeation mass
permeation mass used for determining the normalized breakthrough detection time in a closed-loop permeation test

NOTE This test method provides two choices of normalization permeation mass at 0,25 μg/cm^2 or 2,5 μg/cm^2.

3.12
normalization permeation rate
permeation rate used for determining the normalized breakthrough detection time in an open-loop permeation test

NOTE This test method provides two choices of normalization permeation rates: 0,1 μg/cm^2/min or 1,0 μg/cm^2/min.

3.13
normalized breakthrough detection time
⟨open-loop system⟩ time at which the permeation rate reaches the normalization permeation rate

See Figure 1.

3.14
normalized breakthrough detection time
⟨closed-loop test⟩ time at which the mass of chemical permeated reaches the normalization permeation mass

3.15
open-loop
testing mode in which fresh collection medium flows continuously through the collection chamber of the test cell and is not reused or recycled

3.16
penetration
flow of a chemical through closures, porous materials, seams and holes or other imperfections in a protective clothing material on a non-molecular level

3.17
permeation
process by which a chemical moves through a protective clothing material on a molecular level

NOTE Permeation involves

a) sorption of molecules of the chemical into the contacted (outside) surface of a material,

b) diffusion of the sorbed molecules in the material, and

c) desorption of the molecules from the opposite (inside) surface of the material into the collection medium.

3.18
permeation mass
quantity of test chemical that passes through the protective clothing material within a given time

3.19
permeation rate
quantity of test chemical that passes through the protective clothing material for a given exposed surface area per unit time

3.20
protective clothing material
any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from a potential hazard

3.21
purge time
⟨intermittent contact test⟩ time immediately following the termination of the contact time when the test chemical is removed from the challenge-side chamber and air or nitrogen is blown over the outside surface of the protective clothing material

3.22
steady-state permeation rate
constant rate of permeation that occurs after breakthrough when the chemical contact is continuous and all forces affecting permeation have reached equilibrium

NOTE Steady-state permeation may not be achieved during the period for which permeation testing is conducted.

3.23
test chemical
liquid or gas that is used to challenge the protective clothing material specimen

NOTE The liquid or gas may be either one component (i.e. a neat liquid or gas) or have several components (i.e. a mixture).

4 Principle

The protective clothing material specimen acts as a partition between one chamber of a permeation test cell, which contains the test chemical, and another chamber, which contains the collection medium.

The test chemical may be either a liquid or a gas. The protective clothing material specimen may contact the test chemical either continuously or intermittently depending on the choice of the method used.

The collection medium, which may be liquid or gas, is analysed quantitatively for its concentration of the chemical and thereby the amount of that chemical that has permeated the partition as a function of time after its initial contact with the material.

Several different test configurations may be used depending on the choice of the test chemical, collection medium and conditions of the test.

By either graphical representation or appropriate calculations, or both, the breakthrough detection time, normalized breakthrough detection time, permeation rate, and cumulative permeation of the test chemical are determined.

A group of chemicals, representing a range in chemical properties, which can be used to compare the permeation resistance is given in annex A.

Interlaboratory data for this test method are provided in annex B.

5 Choice of analytical technique and collection medium

5.1 General

The combination of the analytical technique and the collection medium shall be selected to maximize sensitivity for the detection of the test chemical and represent actual occupational conditions as closely as possible.

5.2 Gaseous collection medium

The gaseous collection medium shall be either dry air or a dry, non-flammable inert gas, or other gases which do not interfere with the detection of the test chemical and are of sufficiently high purity as not to interfere with the permeation process or analytical procedure.

EXAMPLES Nitrogen or helium.

NOTE This gas is used, under continuous flow conditions, for the collection of permeating molecules that are capable of vaporizing from the test liquid under the conditions of the test in sufficient quantities for analysis.

5.3 Liquid collection medium

The liquid collection medium shall be either water or another liquid which does not influence the resistance of the protective clothing material to permeation.

NOTE This liquid is used for the collection of diffused molecules of low volatility that are soluble in the collecting medium under the conditions of the test in sufficient quantities for analysis.

5.4 Other collection medium

Other collection medium such as solid sorbents may be used when suitable collection efficiencies are demonstrated for the test chemical being used.

6 Apparatus

6.1 Thickness gage, suitable for measuring thickness to the nearest 0,02 mm, as specified in ISO 2286-3 or ISO 5084, and used to determine the thickness of each protective clothing material specimen tested.

6.2 Analytical balance, capable of being read to the nearest 0,01 g.

6.3 Permeation test cell, consisting of a two-chambered cell for contacting the specimen with the test chemical on the specimen's normal outside surface (clothing exterior) and with a collection medium on the specimen's normal inside surface (clothing interior).

NOTE Permeation test cells may be designed for testing either liquid test chemicals or gaseous test chemicals. However, alternative permeation test cells may also be used.

6.3.1 Permeation test cell for liquid test chemicals, capable of accommodating liquid chemicals, constructed from two end-fitting sections of straight glass pipe, each nominally sized to either a 25 mm or 51 mm diameter (see Figure 2).

Materials other than glass may be used for tests involving chemicals incompatible with glass (e.g. hydrofluoric acid).

Permeation test cells made from glass shall be arranged as follows.

— One end of each glass section shall be sealed closed (for example, with a glass disk equivalent in quality to that of the glass of the original sections).

— The opposite end of each glass section shall retain the “as-manufactured” flared end.

— Inlet and outlet ports with appropriate stopcock valves shall be added to each glass section as shown.

— When assembled, the two glass sections shall be joined horizontally by flanges and a gasket shall be used at the joint. A second gasket may be used on the other side of the test specimens if necessary, to obtain a proper seal.

EXAMPLE PTFE gasket material.

— In closed-loop tests where increased analytical sensitivity is required, a shorter length of glass pipe may be used to contain the collection medium. This reduces the contained volume and increases the ratio of material specimen area to the collection medium volume. In open-loop tests, lower collection medium flow rates will increase the system sensitivity by lowering the minimum detectable permeation rate.

The challenge-side chamber may be modified to include an additional outlet port (with stopcock) positioned downward, opposite the liquid chemical inlet port. Such a modification will facilitate the repeated addition and removal of liquid test chemicals during intermittent testing.