BS EN 16523-2:2015

BSI Standards Publication

# Determination of material resistance to permeation by chemicals

## Part 2: Permeation by gaseous chemical under conditions of continuous contact

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## National foreword

This British Standard is the UK implementation of EN 16523-2:2015.

BSI, as a member of CEN, is obliged to publish EN 16523-2:2015 as a British Standard. However, attention is drawn to the fact that during the development of this European Standard, the UK committee voted against its approval as a European Standard.

The following opinions regarding this standard and EN 16523-1 have been expressed by the UK committee:

- EN 16523-1 and EN 16523-2 were drafted with the intention of having one test method that can be applied to gloves, footwear and clothing. However, as written, these standards do not align with clause 4.3, Permeation test, from the chemical-protective footwear standard, EN 13832-1:2006.
- The dimensions outlined for the design of the permeation cells in clause 6.1 are unnecessarily restrictive. The inter-laboratory trial inadvertently showed that the size of the test cell does not have a significant effect on the result while benefits can be gained by using different sized cells for closed loop and open loop testing, including maximized sensitivity and minimized uncertainty of measurement.
- The test methods described in EN 16523-1 and EN 16523-2 do not consider cumulative permeation. It is increasingly recognized that breakthrough time alone is a poor indicator of chemical protection, especially when considering the latest generation of barrier-laminate materials. ISO 6529 is available for readers to refer to as an alternative standard test method.

Further commentary on EN 16523-1 and EN 16523-2 from UK Technical Committee PH/3/3 can be found in National Annex NA of this document.

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

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

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# Determination of material resistance to permeation by chemicals - Part 2: Permeation by gaseous chemical under conditions of continuous contact

Détermination de la résistance des matériaux à la perméation par des produits chimiques - Partie 2: Perméation par un produit chimique gazeux dans des conditions de contact continu

Bestimmung des Widerstands von Materialien gegen die Permeation von Chemikalien - Teil 2: Permeation durch eine gasförmige Chemikalie unter Dauerkontakt

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# Foreword

This document (EN 16523-2:2015) has been prepared by Technical Committee CEN/TC 162 “Protective clothing including hand and arm protection and lifejackets”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2015 and conflicting national standards shall be withdrawn at the latest by August 2015.

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

EN 16523, *Determination of material resistance to permeation by chemicals*, is composed of the following parts:

— *Part 1: Permeation by liquid chemical under conditions of continuous contact*;

— *Part 2: Permeation by gaseous chemical under conditions of continuous contact* [the present document].

NOTE CEN/TC 162 WG 13 has foreseen to work on other test methods in the future that will spread in several standard parts:

— *Permeation by solid chemical under conditions of continuous contact;*

— *Permeation by chemical under conditions of intermittent contact;*

— *Permeation by chemical of seams, joins, assemblages and closers;*

— *Permeation by chemical in a form of droplets;*

— *Guide on testing and interpretation.*

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

# Introduction

This European Standard is used in conjunction with EN 16523-1. A future part of EN 16523 will explain the use of the series of standards EN 16523.

This standard includes only the specific aspects linked with the testing with gaseous challenge chemicals.

# 1 Scope

This European Standard specifies a test method for the determination of the resistance of protective clothing, gloves and footwear materials to permeation by potentially hazardous gaseous chemicals under the condition of continuous contact.

This test method is applicable to the assessment of protection against gazeous chemicals that can be collected only by liquid or gaseous collecting media.

This test method is not adapted for the assessment of gaseous chemical mixtures.

This test method describes the modifications to EN 16523-1 necessary to test against gaseous chemicals that can be collected by liquid or gaseous collecting media.

# 2 Normative references

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

EN 16523-1:2015, *Determination of material resistance to permeation by chemicals — Part 1: Permeation by liquid chemical under conditions of continuous contact*

# 3 Terms and definitions

For the purposes of this document, the terms and definitions in EN 16523-1:2015 together with the following apply.

**3.1**
**gaseous challenge chemical**
chemical that is gaseous at the test conditions (atmospheric pressure and 23 °C) and that is used to challenge the PPE (protective clothing, gloves and footwear) material specimen

Note 1 to entry: Annex A lists the most common gaseous challenge chemicals. Other gases may be tested.

Note 2 to entry: The gas may be either pure or diluted in air or in nitrogen.

# 4 Test principle

The resistance of a PPE (protective clothing, gloves and footwear) material to permeation by a gaseous chemical is determined by measuring the normalized breakthrough time (NBT).

In the permeation test apparatus, the PPE (protective clothing, gloves and footwear) material separates the challenge chemical from the collecting medium. The collecting medium, which can be a gas or, a liquid, is analysed quantitatively for its concentration of the chemical and thereby the amount of that chemical that has permeated the barrier as a function of time after its initial contact with the PPE (protective clothing, gloves and footwear) material.

# 5 Collecting media

See EN 16523-1:2015, Clause 5.

When selecting the collecting media, the following points should be taken in consideration:

a) oxidation;

b) solubility;

c) hydrolysis;

d) other items as appropriate.

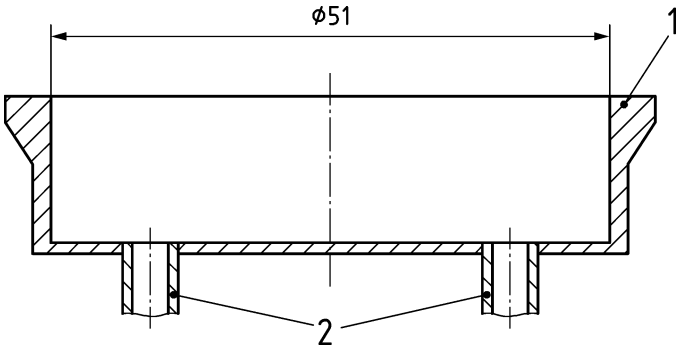
# 6 Apparatus

## 6.1 General

See EN 16523-1:2015, Clause 6, except for the sampling compartment of the challenge chemical.

## 6.2 Sampling compartment of the challenge chemical

The sampling compartment for the challenge chemical is described in Figure 1.




**Key**

1 sampling compartment for challenge chemical

2 pipe (in and out) for the gas setting, whose diameter shall be sufficiently large to avoid any deformation of the sample by the pressure of the incoming gas

**Figure 1 — Important dimensions for the sampling compartment for challenge chemical**

## 6.3 Challenge gas introduction system

The challenge gas shall be regulated to a pressure just above ambient. This pressure shall be sufficient to allow a flow of (5 ± 0,5) volumes of cell per minute without any significant deformation of the test piece.

# 7 Test specimens

See EN 16523-1:2015, Clause 7.

# 8 Procedure

## 8.1 Calibration

See EN 16523-1:2015, 8.1.

## 8.2 Preparation of test specimens and apparatus

See EN 16523-1:2015, 8.2.

### 8.3 Test procedure

The test temperature shall be (23 ± 1) °C. The challenge gaseous chemical entering in the permeation cell and the collecting medium shall be at (23 ± 1) °C.

Permeation is affected by temperature and so additional tests may be run at other temperatures if they are relevant to the use of the PPE (protective clothing, gloves and footwear).

The collecting medium is connected to the cell and the flow adjusted to the required rate (see EN 16523-1:2015, 6.3). Then the detection equipment (see EN 16523-1:2015, 6.5) is connected. The signal of the detector is observed to verify the blank steady-state. After a few minutes (between 1 min and 5 min) of blank steady-state, the following procedure shall be followed.

a) The flow of the test gas into the challenge chamber of the permeation test cell (the chamber to which the normal outside surface of the material specimen is facing) shall be commenced. Timing of the test begin once the equivalent of 5 chamber volumes of gas have passed through the chamber as determined by the mean of a rotameter or other monitoring device placed in the inlet stream of the chamber. The volumes of gas shall be passed through the chamber within approximately 1 min. Following this initial period, the gas flow may be reduced to a minimal level sufficient to ensure that the sample is always in contact with the test gas and that no air can leak-back into the challenge chamber.

   If the test is to be carried out at a non-ambient temperature, the challenge gas should be brought to the non-ambient temperature before it enters the test cell.

b) Care shall be taken so as not to pressurize the challenge or collection chamber. Overly high pressures may develop at high gas flow or as a result of attachments that restrict the flow of gas from the chamber. Tightly-packed activated carbon beds or highly restrictive sparger tubes are examples of such attachments.

The concentration of the chemical test in the collecting medium shall be measured periodically or continuously.

For periodical measurement, the number of measurement shall be sufficient to define the breakthrough time. The frequency of analysis of the collecting medium immediately before the time at which the NPR is measured shall be as listed in Table 1.

**Table 1 — Minimum sampling rates for collection medium**

| Final result | Minimum rate of sampling |
|---|---|
| ≤ 10 min | Every 75 s |
| > 10 min but ≤ 30 min | Every 150 s |
| > 30 min but ≤ 60 min | Every 150 s |
| > 60 min but ≤ 120 min | Every 6 min |
| > 120 min but ≤ 240 min | Every 6 min |
| > 240 min but ≤ 480 min | Every 11 min |
| > 480 min | At least one measurement after 8 h |

In cases where the result cannot reliably be estimated more frequent analysis may be prudent.

NOTE 1 The values of 75 s, 150 s, 6 min and 11 min are intended as maximum permissible values of nominal 60 s, 120 s, 5 min and 10 min sampling frequencies.

NOTE 2 For certain chemicals, the continuous analysis is not possible (complexity, specificity, use of complex detection techniques).

The NBT is deemed to have occurred when the permeation rates of the challenge chemical reaches the NPR; see EN 16523-1:2015, 8.5.1 and 8.5.2.

If required, continue the test until the permeation steady-state (see EN 16523-1:2015, Figure 1) has been reached.

The 3 test specimens shall be tested. Each visual change (with the naked eye optical devices,…) in the test specimen after the test shall be registered (see EN 16523-1:2015, Annex B).

The test can be stopped in case a severe degradation of the test specimen or saturation of the detector or any situation that damages the test equipment.

### 8.4 Calculation of results

See EN 16523-1:2015, 8.4.

### 8.5 Expression of results

See EN 16523-1:2015, 8.5.

### 8.6 Uncertainty of measurements

See EN 16523-1:2015, 8.6.

## 9 Test report

Apply EN 16523-1:2015, Clause 9, except for the indented line 2, the reference to this standard shall be made.

# Annex A
(informative)

# Example of appropriate technique for the detection of gaseous chemicals

Table A.1 gives information on the appropriate technique(s) for the detection of different chemicals.

**Table A.1 — Appropriate technique(s) for the detection of different gaseous chemicals**

| Usual chemical name | CAS NUMBER | Appropriate technique(s) for the detection |
|---|---|---|
| Ammonia $NH_3$ | 7664–41–7 | FTIR – PID – pH – conductivity - electrochemical detector |
| Hydrogen Chloride HCl | 7647–01–0 | FTIR – pH – conductivity - electrochemical detector |
| Chlorine $Cl_2$ | 7782–50–5 | Electrochemical detector - pH – conductivity |
| Ethylene oxide (oxirane) $C_2H_4O$ | 75–21–8 | PID – FID – FTIR |
| Methylchloride $CH_3Cl$ | 74–87–3 | FTIR – ECD – PID - FID |
| Hydrogen fluoride HF | 7664–39–3 | Selective electrode F |
| Phosphine $PH_3$ | 7803–51–2 | Electrochemical detector – FTIR |
| Phosgene $COCl_2$ | 75–44–5 | ECD - FTIR |
| Methylbromide $CH_3Br$ | 74–83–9 | FTIR – ECD – PID - FID |
| Carbon monoxide CO | 630–08–0 | FTIR |
| Nitrogen dioxide $NO_2$ | 10102–44–0 | Chemiluminescence - pH - conductivity |
| Sulfur dioxide $SO_2$ | 7446–09–5 | pH – conductivity - FTIR |
| Sulfuryl difluoride $SO_2F_2$ | 2699–79–8 | GC-MS or FTIR |
| 1,3-butadiene | 106–99–0 | PID – FID – FTIR |
| Ozone $O_3$ | 10028–15–6 | Chemiluminescence - Electrochemical detector |
| Cyanogen chloride ClCN | 506–77–4 | ECD - FTIR |

FTIR Fourier transform infrared spectroscopy
PID Photo-ionization detector
FID Flame-ionization detector
ECD Electron capture detector

# Annex ZA
(informative)

## Relationship between this European Standard and the Essential Requirements of EU Directive 89/686/EEC on PPE

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 89/686/EEC on PPE.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard, together with the requirements in the product standard, confers, within the limits of the scope of both standards, a presumption of conformity with the Essential Requirement 3.10.2 of that Directive and associated EFTA regulations.

**WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.**

# Bibliography

[1] EN 374-1, *Protective gloves against chemicals and micro-organisms - Part 1: Terminology and performance requirements*

[2] EN 374-3, *Protective gloves against chemicals and micro-organisms - Part 3: Determination of resistance to permeation by chemicals*

[3] EN 13832-1, *Footwear protecting against chemicals - Part 1: Terminology and test methods*

[4] EN 13832-3, *Footwear protecting against chemicals - Part 3: Requirements for footwear highly resistant to chemicals under laboratory conditions*

[5] EN ISO 868, *Plastics and ebonite - Determination of indentation hardness by means of a durometer (Shore hardness) (ISO 868)*

[6] EN ISO 6530, *Protective clothing - Protection against liquid chemicals - Test method for resistance of materials to penetration by liquids (ISO 6530)*

[7] ISO 4648, *Rubber, vulcanized or thermoplastic - Determination of dimensions of test pieces and products for test purposes*

[8] ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

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

[10] ISO 13994, *Clothing for protection against liquid chemicals - Determination of the resistance of protective clothing materials to penetration by liquids under pressure*

[11] ISO/IEC Guide 98-3, *Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

# National Annex NA
# Further commentary from UK Technical Committee PH/3/3

Following a technical review of EN 16523-1 and EN 16523-2, the following comments have been provided by UK Technical Subcommittee PH/3/3, Chemical, Biological, Radioactive and Nuclear Personal Protective Equipment. The comments below apply to the clauses within EN 16523-1, however as EN 16523-2 refers largely to EN 16523-1 (since the difference lies only in testing a gaseous challenge chemical instead of a liquid) many of the points below are also relevant to EN 16523-2.

- In Figure 1, the normalized breakthrough time is not well explained for those unfamiliar with permeation. The unit for permeation rate is also incorrect in the key ($^{-1}$ missing from “min”), although it is correct further down the page. This could also lead to confusion.

- Clause 6.3 states that gaseous collection shall be 5 ± 0,5 volume changes per minute. However, higher and lower volume changes have been successfully reported in the past and may be useful for certain tests in controlling sensitivity or simply on saving gas. Furthermore, this standard volume change is on the high side and may cause pressure in gas chromatography (GC)-based systems where the gas flows through narrow 1/16” stainless steel tubing typically attached to the selection/sampling valves.

- Clause 6.4 – as long as the collection liquid is stirred, it should not need to be kept at a constant rate of ± 10%. This is an awkward control which has to be built into the experiment and properly measured throughout, for no real benefit.

- Clause 6.5 – identifying the chemical analysed using a mass spectrometer as suggested could be very expensive and without value when only one chemical is under test. Rare situations may occur whereby the detected chemical differs due to a reaction of the original permeant, but it could already be possible to confirm this using the original method of detection (i.e. different elution time for GC-FID).

- Clause 8.3 – the frequency of analysis is likely to be unrealistic in certain cases, for example when testing multiple cells using GC, every 75 seconds cannot be achieved.

  The nominal test time is stated as 8 hours, but once steady state is reached, there is no benefit to further testing with this standard, since cumulative permeation has anyway been omitted.

- Section 8.4, Calculation of results, might be confusing to some readers due to the use of equations. The complexity of this section is likely to have led to the problems with the cumulative measurement and, indeed, it was apparent in the inter-laboratory trial that many labs opted not to use the draft standard and conducted the tests according to their established processes.

- Clause 8.5 – There are likely to be situations where the NBT does not fall in the 20% margin simply due to the permeation profile, and not anything to do with inconsistency of the test. Enabling this to be explained in the test report would be more sensible than enforcing further samples to be tested. Furthermore, it is stated that if the second set of 3 tests results is not in the defined range (which is very likely in the situation mentioned above) that the tested product will be reported as inhomogeneous. This could be an incorrect conclusion to draw from such results.

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