
**Rubber, vulcanized or
thermoplastic — Determination of
permeability to gases —**

**Part 2:
Equal-pressure method**

*Caoutchouc vulcanisé ou thermoplastique — Détermination de la
perméabilité aux gaz —*

Partie 2: Méthode équi-pression

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 45, *rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This second edition cancels and replaces the first edition (ISO 2782-2:2012), of which it constitutes a minor revision with the following changes:

- the list of normative references have been updated in [Clause 2](#).

A list of all parts in the ISO 2782 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The measurement of the permeability of rubber to gases is important in the evaluation of compounds for products such as inner tubes, tubeless-tyre liners, hoses, balloons and other gas-containing products, as well as seals and diaphragms. The measurement is also of theoretical importance in the study of the characteristics of gas diffusion and gas solubility in relation to polymer structure.

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Rubber, vulcanized or thermoplastic — Determination of permeability to gases —

Part 2: Equal-pressure method

WARNING — Persons using this document should be familiar with normal laboratory practice. This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of any other restrictions.

1 Scope

This document specifies a method for the determination of the gas transmission rate and gas permeability coefficient of vulcanized or thermoplastic rubber under conditions in which the overall pressure on each side of the rubber test piece is the same, using gas chromatography to determine the quantity of gas that permeates through the rubber.

The method applies to vulcanized and thermoplastic rubbers of hardness not less than 35 IRHD (international rubber hardness degrees) and to both single gases and mixtures of gases.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2782-1:2016, *Rubber, vulcanized or thermoplastic — Determination of permeability to gases — Part 1: Differential-pressure methods*

ISO 18899:2013, *Rubber — Guide to the calibration of test equipment*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2782-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Principle

A test cell, maintained at constant temperature, is divided by a test piece into a gas supply side and a gas transmission side (see [Figure 1](#)). The test gas is supplied to the gas supply side and a carrier gas is passed through the gas transmission side. The pressure on both sides of the cell is equal (atmospheric pressure) but, since the partial pressure of the test gas is higher on the gas supply side, it diffuses through the test piece into the gas transmission side. The quantity of test gas passing through the test piece is measured using a gas chromatograph.

In this method, measurements are possible on test gases containing water vapour, and it is also possible to analyse mixtures of gases to determine the components.

5 Apparatus

The apparatus consists of the test cell, a gas chromatograph, test gas and carrier gas supply systems and associated tubing and valves. An example of a test apparatus is shown in [Figure 1](#).

5.1 Test cell, consisting of a gas supply side and a gas transmission side, such that, when a test piece is mounted in it, the gas transmission area is clearly defined. The gas supply side has a test gas inlet port and an exhaust port and the gas transmission side is connected to the carrier gas supply and, through a sampling loop, to the gas chromatograph. The material of the test cell shall be unreactive with regard to the test gas and shall not absorb the gas used. The surfaces of the two halves of the cell which make contact with the test piece shall be smooth and flat to prevent any leakage of gas. A seal such as an O-ring may be used between these areas and the test piece, in which case the gas transmission rate of the seal shall be considerably lower than that of the material being tested so that it does not affect the result of the test. The diameter of the gas transmission area shall be within the range 10 mm to 150 mm, depending on the gas transmission rate expected.

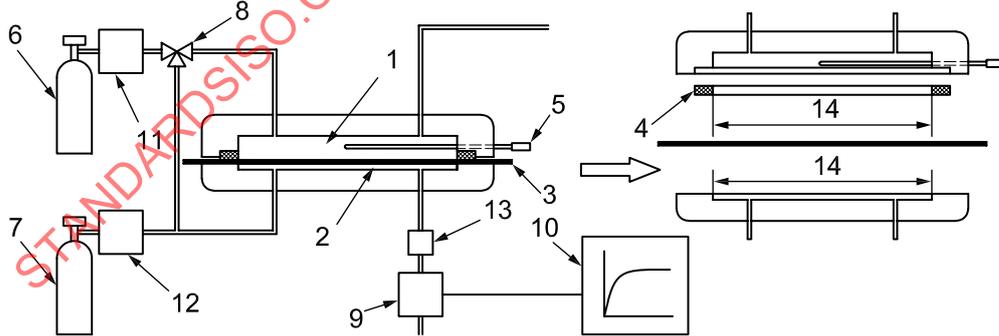
The cell shall be equipped with a heating system capable of raising the temperature to 80 °C. The temperature accuracy shall be ±1 °C for temperatures from 40 °C to 80 °C.

NOTE Examples of a heating system are an electric heating jacket and an oven designed to hold the test cell and test gas supply.

5.2 Gas chromatograph, having a detector such as a thermal conductivity detector (TCD) or a hydrogen flame ionization detector (FID). The detector and column shall be suitable for the test gas used and of the required sensitivity.

5.3 Test gas controller, in accordance with 7.1.4 of ISO 2782-1:2016.

5.4 Two temperature sensors, the first fitted in the test cell for measuring the test temperature and the second fitted in the flow of carrier gas to measure the temperature of the carrier gas. The sensors shall be capable of reading to within 0,1 °C or better.



Key

- | | | |
|-------------------------|-------------------------|-----------------------------------|
| 1 gas supply side | 6 test gas supply | 11 test gas controller |
| 2 gas transmission side | 7 carrier gas supply | 12 carrier gas controller |
| 3 test piece | 8 three-way valve | 13 sampling loop with thermometer |
| 4 sealing ring | 9 gas chromatograph | 14 gas transmission area |
| 5 temperature sensor | 10 data-processing unit | |

Figure 1 — Example of gas permeability measuring apparatus
(diagram at right shows an exploded view of the test cell)

6 Calibration

The test apparatus shall be calibrated in accordance with the schedule given in [Annex A](#).

7 Test gas

Use a single gas, such as nitrogen, oxygen or hydrogen, or a mixture of gases, such as air, liquefied petroleum gas (in gaseous form) or coal gas. The purity of a single gas or the purity of each component in a gas mixture shall be 99,5 % by volume or higher, unless otherwise agreed between the interested parties, in which case a gas of lower purity may be used. The test gas shall not include any impurity that might affect the measurement.

When using a gas mixture, the purity of each component shall be verified in advance with a suitable instrument, such as a gas chromatograph.

When using a toxic and/or flammable gas, all necessary precautions should be taken in its use and in its recovery or disposal.

8 Carrier gas

See 7.4 of ISO 2782-1:2016.

9 Test pieces

9.1 Shape and dimensions

See 5.4.1 of ISO 2782-1:2016.

9.2 Preparation

See 5.4.2 of ISO 2782-1:2016.

9.3 Number of test pieces

See 5.4.3 of ISO 2782-1:2016.

9.4 Measurement of thickness

See 5.4.4 of ISO 2782-1:2016.

9.5 Time interval between forming and testing

See 5.4.5 of ISO 2782-1:2016.

10 Conditioning

See 5.5 of ISO 2782-1:2016.

11 Test conditions

See 5.6 of ISO 2782-1:2016.

For the test gas and carrier gas, the standard pressure is atmospheric pressure.

12 Gas transmission area

See 5.7 of ISO 2782-1:2016.

13 Calibration curve

Inject a known quantity of the test gas into the gas chromatograph using a syringe or gas sampler. Determine the area of the peak in the chromatogram corresponding to the gas of interest. Repeat the above measurements with at least three different levels of concentration and prepare a calibration curve from the data obtained.

For a test gas mixture, a calibration curve for each component of the mixture shall be produced.

14 Procedure

14.1 Apply vacuum grease lightly and uniformly to the flat edges of the two halves of the test cell which will make contact with the test piece and mount the test piece in the lower part of the cell, without any wrinkling or sagging.

14.2 Place a sealing ring (if used) on the test piece, followed by the upper part of the cell. Clamp the two halves of the cell together with uniform pressure so that the test piece is completely sealed in place.

14.3 When making measurements at a temperature other than a standard laboratory temperature, bring the test cell to the test temperature.

14.4 Purge both the gas supply side and the gas transmission side with carrier gas by opening the three-way valve (8 in [Figure 1](#)) for a sufficient time, which will depend on the internal volume of the test cell and its connecting tubing. The flow rate is generally set at between 5 ml/min and 100 ml/min.

14.5 Inspect the apparatus for leaks, then continue purging the apparatus until the baseline, as measured by the recording device of the gas chromatograph, is stable. Record the carrier gas flow rate F and temperature T in the stable state.

14.6 Switch the three-way valve to let the test gas flow into the gas supply side of the cell only.

14.7 Adjust the test gas controller to give a constant flow rate, generally between 5 ml/min and 100 ml/min. The test gas diffusing through the test piece is carried by the carrier gas from the test cell into the sampling loop.

14.8 At fixed intervals of time, turn the switch valve of the sampling loop to collect a sample of this gas and then pass it through the column of the gas chromatograph.

14.9 Measure the area of the peak in the chromatogram corresponding to the test gas (or to each component of the test gas if the test gas is a mixture of gases). Determine the concentration of the test gas (or each component of the test gas) in the carrier gas by means of the calibration curve(s).

14.10 Repeat [14.8](#) and [14.9](#) until a constant value of the test gas concentration is obtained, and record the value w .

15 Calculation and expression of results

15.1 Gas transmission rate

NOTE The rubber industry uses the term equation for the relationships herein termed formula. The term formula is used to describe the table of ingredients in a rubber compound.

The gas transmission rate is determined from [Formula \(1\)](#):

$$\text{GTR} = \frac{T_0}{0,0227 \times A \times p_d \times T} \times F \times w \times 10^{-6} \quad (1)$$

where

GTR is the gas transmission rate [mol/(m²·s·Pa)];

A is the gas transmission area (m²);

p_d is the partial pressure of the test gas on the gas supply side (Pa);

T is the carrier gas temperature (K);

T_0 is the standard-state temperature, in K (= 273,15);

F is the carrier gas flow rate (m³/s);

w is the test gas concentration (ppm);

0,022 7 is the volume, in m³, of 1 mol of gas at a pressure of 0,1 MPa [the volume of 1 mol of gas at 1 atm and 0 °C is 0,022 4 m³ (22,4 l), but it is 0,022 7 m³ (22,7 l) at 0,1 MPa (1 bar)].

Express the gas transmission rate as the arithmetic mean of the results obtained for all the test pieces.

15.2 Gas permeability coefficient

NOTE The rubber industry uses the term equation for the relationships herein termed formula. The term formula is used to describe the table of ingredients in a rubber compound.

The gas permeability coefficient is determined from [Formula \(2\)](#):

$$Q = \text{GTR} \times d \quad (2)$$

where

Q is the gas permeability coefficient [mol·m/(m²·s·Pa)];

GTR is the gas transmission rate [mol/(m²·s·Pa)];

d is the thickness of the test piece (m).

Express the gas permeability coefficient as the arithmetic mean of the results obtained for all the test pieces.

16 Test report

The test report shall include the following information:

- a) a full description of the sample and its origin;
- b) a full reference to the test method used, i.e. the number of this document (ISO 2782-2:2018);

- c) test details:
 - 1) the type of test piece used,
 - 2) the method of preparation of the test pieces from the sample, for example moulded or cut,
 - 3) the laboratory temperature,
 - 4) the time and temperature of conditioning of the test pieces prior to testing,
 - 5) the number of test pieces tested,
 - 6) details of any procedures not specified in this document;
- d) test results:
 - 1) the individual test results,
 - 2) the arithmetic mean of the individual results;
- e) the date(s) of testing.

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