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Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device

Caoutchouc vulcanisé ou thermoplastique — Détermination de la résistance à l'abrasion à l'aide d'un dispositif à tambour tournant

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Foreword

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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 document 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 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 fifth edition cancels and replaces the fourth edition (ISO 4649:2017), which has been technically revised.

The main changes are as follows:

— Addition of requirement to report the abrasive sheet cleaning method used.

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

Various types of laboratory test equipment for wear resistance of rubber compound have been developed depending on the products to which rubber compounds have been applied in the past. Methods and equipment are briefly introduced in ISO 23794 and the test method using a rotating cylindrical drum device is described in detail in this document.

Because factors such as the grade of abrasive sheet, the type of adhesive used in the manufacture of the sheet and contamination and wear caused by previous testing lead to variations in the absolute values of abrasion loss, all tests are comparative. Runs with a reference compound are included so that the results can be expressed either as a relative volume loss compared to a calibrated abrasive sheet or as an abrasion resistance index compared to a reference compound.

This document describes two methods and specifies two standard reference compounds that can be chosen freely, although some combinations are more frequently used in practice. Considerable experience has been accumulated using the relative volume loss calculation in 10.2 for method A with reference compound no. 1 and method B with reference compounds no. 1 and no. 2.

When using standard reference compound no. 1 with a non-rotating test piece, a very important part of the method is the preparation of the abrasive sheet and its calibration.

Relative volume loss can be calculated for either test method with another reference compound, if the defined mass loss is known.

Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device

WARNING 1 — 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.

WARNING 2 — Certain procedures specified in this document might involve the use or generation of substances or the generation of waste, that could constitute a local environmental hazard. Reference should be made to appropriate documentation on safe handling and disposal after use.

1 Scope

This document specifies two methods for the determination of the resistance of rubber to abrasion by means of a rotating cylindrical drum device.

The methods involve determination of the volume loss due to the abrasive action of rubbing a test piece over a specified grade of abrasive sheet. Method A is for a non-rotating test piece and method B is for a rotating test piece. For each method, the result can be reported as a relative volume loss or an abrasion resistance index.

These test methods are suitable for comparative testing, quality control, specification compliance testing, referee purposes and research and development work. No close relation between the results of this abrasion test and service performance can be inferred.

NOTE The abrasion loss is often more uniform using the rotating test piece because the whole surface of the test piece is in contact with the abrasive sheet over the duration of the test. However, there is considerable experience using the non-rotating test piece.

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 48-4, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 4: Indentation hardness by durometer method (Shore hardness)*

ISO 2230, *Rubber products — Guidelines for storage*

ISO 2393, *Rubber test mixes — Preparation, mixing and vulcanization — Equipment and procedures*

ISO 2781, *Rubber, vulcanized or thermoplastic — Determination of density*

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 following terms and definitions apply.

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

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

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

3.1
abrasion resistance
resistance to wear by mechanical action upon a surface

Note 1 to entry: For the purposes of this document, the abrasion resistance is expressed either as a *relative volume loss* (3.2) compared to an abrasive sheet calibrated using a standard reference compound or as an *abrasion resistance index* (3.3) compared to a reference compound.

3.2
relative volume loss
ΔV_{rel}
volume loss of the test rubber after being subjected to abrasion by an abrasive sheet which will cause a reference compound to lose a defined mass under the same specified conditions of test

Note 1 to entry: Relative volume loss is expressed in cubic millimetres.

3.3
abrasion resistance index
ARI
I_{AR}
ratio of the volume loss of a reference compound to the volume loss of the test rubber, measured under the same specified conditions of test

Note 1 to entry: A smaller number indicates a lower *abrasion resistance* (3.1).

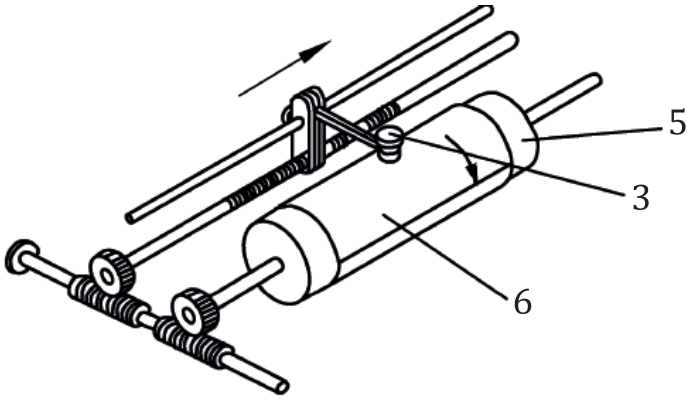
Note 2 to entry: The abrasion resistance index is expressed as a percentage.

4 Principle

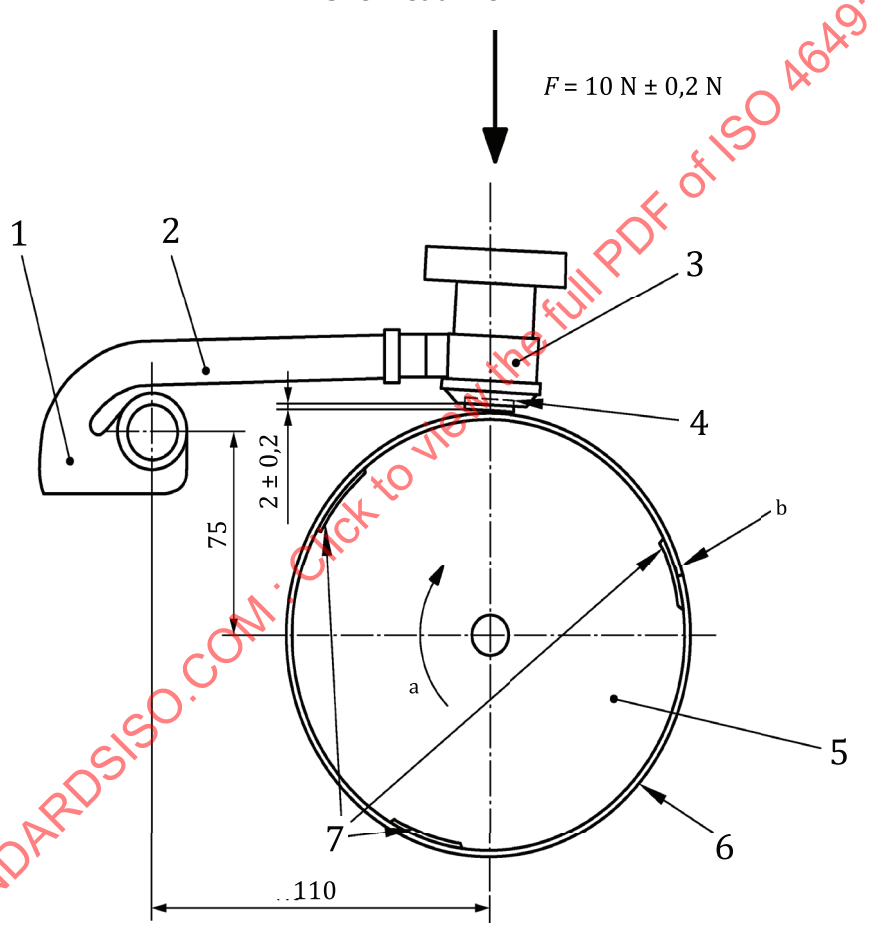
A cylindrical rubber test piece is made to slide over an abrasive sheet of specified abrasive grade under a specified pressure over a given distance. The test piece may be rotating or non-rotating during the test. The abrasive sheet is attached to a rotating cylindrical rotating drum against which the test piece is held and across which it traverses.

The loss of mass of the test piece is determined and used together with the density of the test piece material to calculate the volume loss. The volume loss of the test piece is compared to that of a reference compound tested under the same conditions.

Dimensions in millimetres



Overhead view



Key

1 sledge
2 swivel arm
3 test piece holder
4 test piece
5 cylinder, diameter 150 mm ± 0,2 mm, length 500 mm
6 abrasive sheet
7 double-sided adhesive tape
F vertical force
[a] Rotational speed 40 r/min ± 1 r/min.
[b] Gap of size ≤2 mm.

Figure 1 — Schematic illustration of apparatus

5 Apparatus and materials

5.1 Abrasion machine.

The test apparatus (see Figure 1) consists of a laterally movable test piece holder and a rotatable cylinder to which the abrasive sheet (5.2) is fixed.

The cylinder shall have a diameter of 150 mm ± 0,2 mm and a length of about 500 mm and shall be rotated at a speed of 40 r/min ± 1 r/min, the direction of rotation being as indicated in Figure 1.

The test piece holder shall have a cylindrical opening, the diameter of which can be adjusted from 15,5 mm to 16,3 mm and a device for adjusting the length of the test piece protruding from the opening to 2 mm ± 0,2 mm. The holder shall be mounted on a swivel arm that, in turn, is attached to a sledge that can be moved laterally on a spindle. The lateral displacement of the holder shall be 4,20 mm ± 0,04 mm per revolution of the drum (see Note 1). Suitable attachments may be provided to rotate the test piece during the test run by rotation of the test piece holder (method B), preferably at the rate of 1 revolution per 50 revolutions of the drum.

NOTE 1 With this lateral movement, the test piece passes over any one area of the abrasive sheet four times.

The swivel arm and test piece holder shall be free from vibration during operation and so disposed that the test piece is pressed against the drum with a vertical force of 10 N ± 0,2 N. For investigation of extremely soft or hard materials, the force may be changed to 5 N ± 0,1 N or 20 N ± 0,4 N, respectively (see Note 2). The force is generated by adding masses to the top of the test piece holder.

NOTE 2 A force of 5 N is typically used for rubbers softer than approximately 40 IRHD and a force of 20 N is used for hard rubbers of 80 IRHD and above.

The abrasive sheet shall be attached to the drum using three evenly spaced strips of double-sided adhesive tape extending along the complete length of the drum. The width of the margins that are not touched by the test piece shall be equal. Care shall be taken to ensure that the abrasive sheet is firmly held so as to present a uniform abrasive surface over the whole area of the cylinder. One of the strips shall be placed where the ends of the abrasive sheet meet. Ideally, the ends should meet exactly, but any gap left between them shall not exceed 2 mm. The adhesive tape shall be about 50 mm wide and not more than 0,2 mm thick.

The abrasion run starts by bringing the test piece into contact with the abrasion sheet.

Placement of the test piece on the sheet at the beginning of a test run and its removal after an abrasion run of 40 m ± 0,2 m (equivalent to 84 revolutions) shall be automatic. In special cases of very high volume loss of the test piece, the abrasion distance may be reduced to 20 m ± 0,1 m (equivalent to 42 revolutions). In that case, a revolution counter or automatic stopping device should preferably be used.

NOTE 3 For rubbers with very high mass loss, a distance of 10 m has been used.

To protect the abrasive sheet from damage by the test piece holder, a device for switching off the apparatus just before the lower edge of the test piece holder touches the sheet is recommended.

The test machine may be equipped with a vacuum hose and a brush to aid in the removal of debris from the machine.

5.2 Abrasive sheet.

An abrasive sheet made with aluminium oxide (corundum) of grain size 60, at least 400 mm wide, 474 mm ± 1 mm long and 1 mm average thickness, shall be used as the abrasive medium. The characteristics of a suitable abrasive sheet are given in Annex A.

In a test using a non-rotating test piece (method A) of standard reference compound no. 1 (see Table B.1), this abrasive sheet shall cause a mass loss of between 180 mg and 220 mg for an abrasion distance of 40 m. To achieve this, the sheet shall be prepared in accordance with Annex A.

When each new sheet is first used, the direction of motion shall be indicated on the sheet, as it is important that the same direction be used for all subsequent test runs.

5.3 Hollow drill.

The drill shown in Figure 2 is an example of a tool suitable for the preparation of test pieces that are not moulded (see 7.1). The speed of rotation of the drill needs to be at least 1 000 r/min for most rubbers, and even higher for rubbers with a hardness of less than 50 IRHD. A sufficient cooling of the tool is necessary to prevent an undesired heating of the drill.

Dimensions in millimetres

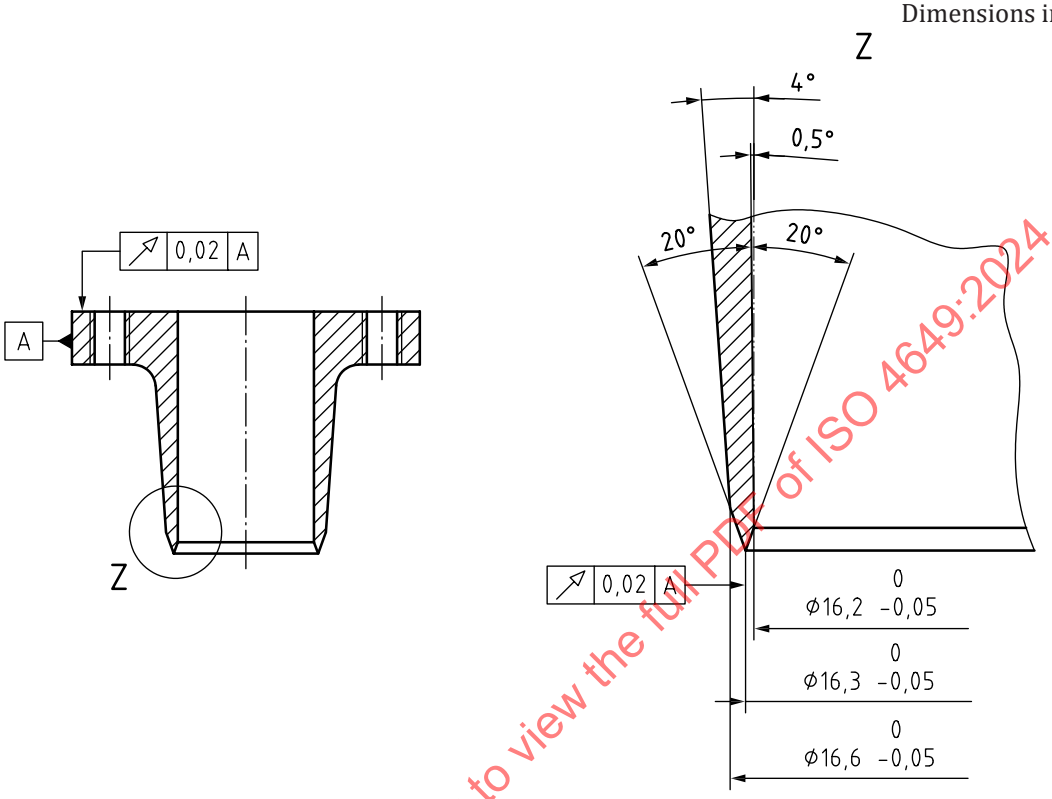


Figure 2 — Example of a hollow drill for test piece preparation

5.4 Balance.

The balance shall be of sufficient accuracy to enable the mass loss of a test piece to be determined to ±1 mg.

5.5 Standard reference compounds.

Specifications for standard reference compounds are given in detail in Annex B.

6 Calibration

The test apparatus shall be calibrated in accordance with the schedule given in Annex C.

7 Test pieces

7.1 Type and preparation

The test pieces shall be cylindrical in shape, of diameter 16 mm ± 0,2 mm, with a minimum height of 6 mm.

Test pieces are normally prepared from moulded sheets using the hollow drill (5.3) or other rotating cutting tools. During cutting, the cutting edge shall be lubricated with water to which a wetting agent has been added. Punching of the test pieces is not permitted.

NOTE 1 If the cut sample is not satisfactory, cylinder vibration occurs.

Alternatively, test pieces may be vulcanized or formed in a mould.

NOTE 2 It is sufficient to rub off only one side of the test piece.

If test pieces of the required thickness are not available, the necessary thickness may be obtained by bonding a piece of the test rubber to a base element of hardness not less than 80 IRHD. The thickness of the test rubber shall be not less than 2 mm.

7.2 Number

A minimum of three test runs shall be carried out for each rubber being tested. A new test piece shall be used for each test run. For referee purposes, use 10 test pieces.

In the case of the standard reference compounds no. 1 (see Table B.1) and no. 2 (see Table B.4), three test runs may be carried out on one test piece in order to reduce wastage.

7.3 Time interval between vulcanization or forming and testing

Unless otherwise specified, the time interval between the date the material was formed and testing shall be in accordance with ISO 23529.

7.4 Conditioning

Condition all test pieces at standard laboratory temperature, in accordance with ISO 23529, for a minimum period of 16 h immediately before testing.

For rubbers which are sensitive to moisture, the humidity should also be controlled.

8 Test temperature

The test shall be carried out at standard laboratory temperature (see ISO 23529).

During a test run, there can be a considerable increase in temperature at the abrading interface, which can lead to temperature rises within the test piece. For the purposes of this document, such temperature rises are to be disregarded, the temperature of test being that of the ambient atmosphere and of the test piece before commencing the test.

9 Procedure

9.1 General test procedure

Before each test, any rubber debris left on the abrasive sheet from a previous abrasion test shall be removed. The method of cleaning the abrasive sheet can have an influence on the measurement result. For measurements in arbitration cases, the cleaning method shall be agreed between the interested parties. The traditionally recommended method is with a brush of about 55 mm diameter with hard nylon or similar bristles and about 70 mm in length. Alternative methods are with a brush attached to a vacuum cleaner or using compressed air. In some cases, a blank test with a reference compound (see Note 1) will effectively clean the abrasive sheet (see Note 2).

Brushes with metal bristles are not recommended as they shorten the life of the abrasive sheet.

NOTE 1 The reference compound used only for cleaning purposes does not necessarily have to meet the stringent requirements of the reference compound used for test purposes.

NOTE 2 Some laboratories have found that blowing removes the debris left by some test rubbers better than brushing. Safety blow guns which give a maximum pressure of 0,2 MPa at the nozzle when the nozzle is blocked off, used with a supply air pressure between 0,5 MPa and 0,9 MPa, have given good results.

For method A, the non-rotating test piece shall be used. For method B, the rotating test piece shall be used. Standard reference compound no. 1 (see Table B.1) or no. 2 (see Table B.4) or a user-defined reference compound shall be used as the reference compound. The method and the reference compound used shall be stated in the test report because the results obtained can differ. For measurements intended to be comparable, the same conditions shall be used for all test rubbers and the reference compound.

Weigh the test piece to the nearest 1 mg. Fix the test piece in the test piece holder in such a way that a length of 2,0 mm ± 0,2 mm protrudes from the opening. This length shall be checked by means of a gauge.

The test piece shall normally be pressed against the drum with a vertical force of 10 N ± 0,2 N. If, for special cases, the vertical force is reduced to 5 N ± 0,1 N or increased to 20 N ± 0,4 N, this shall be stated in the test report.

Turn on the suction, if it is provided. Move the test piece holder and sledge to the starting point and start the automatically controlled test run. Check for vibration in the test piece holder. This test method does not yield meaningful results if there is abnormal vibration in the test piece holder. The test run is stopped automatically after an abrasion distance of 40 m. When relatively large mass losses (usually more than 400 mg in 40 m) occur, the test run may be stopped after 20 m and the length of exposed test piece reset to 2,0 mm ± 0,2 mm so that the remaining 20 m of the run can be completed. At no time shall the height of the test piece be less than 5 mm. If the mass loss is greater than 600 mg in 40 m, the abrasion distance shall be reduced to 20 m and this shall be stated in the test report. The results shall be multiplied by 2 so that the mass loss can still be given for an abrasion distance of 40 m.

For non-rotating test pieces that are removed during the test, care shall be taken to ensure that the test piece is always replaced in the test piece holder in the same way.

For bonded test pieces, care shall be taken that the test pieces are not abraded down to the bond line or if a sample with a fabric reinforcement is used in fabric line (if necessary, use a 20 m run).

Weigh the test piece to the nearest 1 mg after the test run. Sometimes a small edge hanging from the test piece has to be pulled off before weighing, especially if a non-rotating test piece is used.

Carry out all test runs on the same rubber consecutively.

9.2 Comparison against standard reference compounds or user-defined reference compounds

The test rubbers are compared against one of the two standard reference compounds specified in Annex B or a user-defined reference compound.

The mass loss of the reference compound shall be determined by carrying out a minimum of three test runs both before and after each test series with the test rubber following the procedure in 9.1. There shall be a maximum of 10 runs of test rubber test pieces in each test series. Do not split the runs on a test rubber between series. When repeat runs are made on the same test piece of one of the standard reference compounds, allow sufficient time between such runs for the temperature of the whole of the test piece to return to standard laboratory temperature.

For rubbers which have a tendency to smear, determine the mass loss of the reference compound after each run with the test rubber. In extreme cases of smearing, there is a considerable reduction in mass loss of the reference compound measured after the test run compared to that measured before the test run. This is due to the fact that the abrasive sheet is being “cleaned” by the reference compound, as opposed to the reference compound being abraded by the sheet. If the reduction in mass loss of the reference compound is greater than 10 %, then the method is not valid.

Variations in the test method have been proposed to overcome this problem, including the use of a 40 grit abrasive sheet. Any such variations used shall be agreed upon by all parties involved and carefully noted in the test report [see Clause 12, c) 3)].

9.3 Density

Determine the density of the test material in accordance with one of the methods specified in ISO 2781.

10 Expression of results

10.1 General

The results may be expressed either as a relative volume loss or as an abrasion resistance index.

Calculate the mean value of the mass losses of the test rubber, Δm_t, and of the reference compound, Δm_r, from the separate determinations. The mass loss of the reference compound is the mean of all 6 runs (3 before and 3 after the test series).

A value for Δm_{const} of 200 mg has been established as the mid-point of the calibration range (see B.2.4.3) for the abrasive sheet (see Annex A) using method A with standard reference compound no. 1 and a value of 250 mg using method B with standard reference compound no. 1. Considerable experience has been accumulated using the relative volume loss calculation. 138 mg has been indicated as a possible value for method A with standard reference compound no. 2, using abrasive sheet (see Annex A), and 150 mg has been indicated as a possible value for method B with standard reference compound no. 2, but its accuracy has not been documented to the degree of the value 200 mg using method A with standard reference compound no. 1.

NOTE For standard reference compounds no. 1 and no. 2, see Table B.1 and Table B.4, respectively.

10.2 Relative volume loss, ΔV_{rel}

The relative volume loss (see 3.2), ΔV_{rel}, in cubic millimetres, is given by Formula (1):

$$\Delta V_{rel} = \frac{\Delta m_t \, \Delta m_{const}}{\rho_t \, \Delta m_r} \quad (1)$$

where

Δm_t is the mass loss, in milligrams, of the test rubber test piece;

Δm_{const} is the defined value of the mass loss, in milligrams, of the reference compound test piece tested with the same method (see 10.1);

ρ_t is the density, in milligrams per cubic millimetre, of the test rubber;

Δm_r is the mass loss, in milligrams, of the reference compound test piece tested with the same method.

NOTE Standard reference compound no. 1 is usually used with this method of expression of results.

Calculate the mean value of the relative volume loss.

10.3 Abrasion resistance index

The ARI (see 3.3), I_{AR}, as a percentage, is given by Formula (2):

$$I_{AR} = \frac{\Delta m_r \, \rho_t}{\Delta m_t \, \rho_r} \times 100 \quad (2)$$

where

Δm_r is the mass loss, in milligrams, of the reference compound test piece;

ρ_r is the density, in milligrams per cubic millimetre, of the reference compound;

Δm_t is the mass loss, in milligrams, of the test rubber test piece;

ρ_t is the density, in milligrams per cubic millimetre, of the test rubber.

Calculate the mean value of the abrasion index.

11 Precision

See Annex D.

12 Test report

The test report shall include at least the following information:

a) sample details:
   1) full description of the sample and its origin,
   2) compound details and curing or forming conditions, if known,
   3) method of preparation of the test pieces from the sample, i.e. whether cut or moulded;

b) test method:
   1) full reference to the test method used, i.e. reference to this document (ISO 4649:—),
   2) method used (A or B);

c) test details:
   1) standard laboratory temperature used,
   2) whether standard reference compound no. 1 (see Table B.1) or no. 2 (see Table B.4) or a user-defined reference compound was used,
   3) any deviations from the normal test procedure, especially if the test run comprised only half the abrasion distance or if half the vertical force was used (see last paragraph in 9.2);

d) test result:
   1) mean value of the relative volume loss and the abrasion resistance index,
   2) densities of the reference compound and of the test rubber;
   3) the method used to clean the abrasive sheet;

e) date of the test.

Annex A
(normative)

Suitable abrasive sheet

A suitable abrasive sheet comprises corundum particles of grain size 60, i.e. passing through a 60 mesh sieve, bonded to a twill sheet with a phenolic resin. As produced, the abrasive sheet causes an abrasion loss of more than 300 mg when standard reference compound no. 1 specified in Table B.1 is tested using a non-rotating test piece. It is necessary to perform one or two runs with a steel test piece to reduce the abrasion loss to between 200 mg and 220 mg. This is checked by single runs with two test pieces. The direction of motion shall be indicated on the sheet, as it is important that the same direction be used for all subsequent test runs.

Experience has shown that a minimum of a few hundred runs with standard reference compound no. 1 (see Table B.1) can be carried out with this type of sheet before the abrasion loss comes down to 180 mg, after which the sheet shall be discarded.

Abrasive sheet produced and standardized in this manner is available commercially.

NOTE Abrasive paper can be used instead of cloth, if it provides comparable results.

Annex B
(normative)

Standard and user-defined reference compounds

B.1 Purpose

Reference compounds are necessary because these abrasion tests are comparative tests. The quality of the reference compounds significantly influences the repeatability and reproducibility of the tests.

The standard reference compound described in B.2 shall be used for the calibration of the abrasive sheet (5.2) using method A because of the considerable experience already gained using it for this purpose. It may also be used as the comparative standard reference compound in test methods A and B. Standard reference compound no. 1 may be obtained commercially.

The compound described in B.3 is representative of a simple tyre tread compound and has had some previous use as a standard reference compound, including use in the international interlaboratory test programme described in Annex D. Standard reference compound no. 2 would normally be prepared by the user. There is a possibility of obtaining it commercially for those users who do not have their own facilities for preparing it.

Users may define other reference compounds as needed for their own use, noting the degree of care in preparation needed for repeatable and reproducible results. Care shall also be taken not to confuse user-defined reference compounds with standard reference compound no. 1 or no. 2 in test reports.

B.2 Standard reference compound no. 1 for the calibration of the abrasive sheet and for use as a comparative standard reference compound

B.2.1 Composition

Table B.1 — Composition of standard reference compound no. 1

Ingredient	Parts by mass
Natural rubber (TSR L)	100,0
Zinc oxide, class B4c (see ISO 9298:2017, Annex D)[a]	50,0
N-Isopropyl-*N*′-phenyl-*p*-phenylenediamine (IPPD)[b]	1,0
Benzothiazyl disulfide (MBTS)[c]	1,8
Carbon black N330[d]	36,0
Sulfur	2,5
Total	191,3

[a] Zinkweiss Pharma 8 is the trademark of a product supplied by Grillo Zinkoxid GmbH.

[b] Vulkanox 4010NA® is the trademark of a product supplied by Lanxess AG.

[c] Vulkacit DM/C® is the trademark of a product supplied by Lanxess AG.

[d] Corax N330® is the trademark of a product supplied by Orion Engineered Carbons GmbH.

This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the products named. Equivalent materials may be used provided that the resulting standard sheets meet the requirements of B.2.4.

B.2.2 Recommended mixing procedure

The following mixing procedure has been found to be suitable to meet the requirements. Other procedures may be used provided that a good dispersion is obtained and that the properties meet the requirements of B.2.4.

Use an internal mixer to mix all ingredients, following the procedure specified in Table B.2. Subsequently, homogenize the batch using a roll mill, as specified in Table B.3.

Table B.2 — Mixing procedure using an internal mixer

Mixing chamber volume: 4,6 l (determined by means of wheat grains or another suitable methods) Chamber filled to: (65 ± 5) % Speed: 30 r/min Cooling fully operative Mass of rubber: 2 000 g	
Mixing step	**Elapsed time,** min
Add rubber	0
Add zinc oxide, antioxidant, and accelerator, well premixed	7,5
Add carbon black	11
Add sulfur	14
Dump	18
Final temperature of batch: 100 °C to 110 °C	

Table B.3 — Homogenization of batch using a roll mill

Roll diameter: 250 mm Working width: 400 mm Surface temperature of rolls: 50 °C ± 5 °C Speeds of rolls: approximately 12,4 r/min and 18,1 r/min		
Milling step	**Elapsed time,** min	**Nip opening**, mm
Band hot masterbatch	0	
Make 3 to 4 cuts	1	0,5
Turn the rolled sheet	5	
Sheet off	10	5,0
Final temperature of sheet: approximately 70 °C		

B.2.3 Vulcanization

Ply up enough milled sheets to give a minimum thickness of 6 mm. Insert the blank into a mould preheated to 150 °C ± 2 °C. Place the mould in a press and subject to several bumping cycles. Slowly apply a pressure of at least 3,5 MPa and vulcanize for 25 min ± 1 min.

The recommended dimensions of the vulcanized sheet are 8 mm × 181 mm × 181 mm which yields approximately 90 test pieces.

B.2.4 Quality control

B.2.4.1 General

The procedure for quality control specified in B.2.4.2, B.2.4.3, and B.2.4.4 has been found to be suitable to achieve a consistent level of abrasion loss.

Tests shall be carried out not earlier than 16 h and not later than 7 days after vulcanization.

B.2.4.2 Reference test pieces

From a sufficient number of sheets, cut, as specified in 7.1, one test piece from each sheet to provide reference test pieces for quality control of further test piece production. These test pieces can be stored in accordance with B.2.5 for up to three years.

B.2.4.3 Mass loss

All measurements of mass loss for quality control shall be made with a separate abrasive sheet that is only used for this purpose. This abrasive sheet is checked using 15 reference test pieces. With each test piece, the mass loss is measured with three runs with a non-rotating test piece and the median reported. The mean, Δm_{Ref}, of the 15 median values shall be between 180 mg and 220 mg.

This procedure is carried out for every fifth "production run", which may include several batches produced under the same conditions by the same operator over a period of 1 day or 2 days.

The mass loss, Δm_{Prod}, of a production run is determined using a representative sheet from each production run. From this sheet, cut out 15 test pieces as specified in 7.1 and for each test piece, measure the mass loss, Δm, with three runs using a non-rotating test piece and report the median value. From these 15 median values, calculate the mean, Δm_{Prod}, and the standard deviation. The difference between Δm_{Prod} and the last Δm_{Ref} shall be not more than 15 mg.

In order to ensure uniform quality, it is strongly recommended that reference test pieces obtainable commercially be used for the first check, and occasionally later. The difference between Δm_{Ref} for test pieces produced in-house and the Δm_{Ref} for test pieces obtained commercially shall be not more than 10 mg.

B.2.4.4 Hardness

Measure the Shore hardness in accordance with ISO 48-4 at a minimum of four places on each sheet and report the median value for each sheet.

The mean for all sheets (i.e. all the median values) in a production run shall be (60 ± 3) Shore A.

B.2.5 Storage

Test sheets shall be stored in accordance with ISO 2230. Wrap the sheets with a material (e.g. polyethylene) which protects the sheets from atmospheric attack and store them in a cool, dark place.

B.3 Standard reference compound no. 2 (representative of a simple tyre tread rubber) for use as a comparative standard reference compound

B.3.1 Composition

Table B.4 — Composition of standard reference compound no. 2

Ingredient	Parts by mass
Natural rubber (TSR L)	100,0
Stearic acid	2,0
Zinc oxide	5,0
Carbon black N330	50,0
N-Isopropyl-*N*′-phenyl-*p*-phenylenediamine (IPPD)	1,0
N-Cyclohexylbenzothiazole-2-sulfenamide (CBS)	0,5
Sulfur	2,5
Total	161,0

B.3.2 Mixing and vulcanization

The equipment and procedure used for preparation, mixing and vulcanization shall be in accordance with the relevant requirements of ISO 2393. An internal mixer or a mixing mill may be used. Sheets shall be vulcanized at 140 °C for 60 min.

B.3.3 Storage

Wrap the sheets with a material that protects the sheets from attack by ozone (e.g. polyethylene) and store them in a cool, dark place.

B.3.4 Quality

The mass losses for two different batches of standard reference compound, determined in accordance with Clause 9, shall agree to within ±10 %.

NOTE It has been found that the standard rubber gives an abrasion loss of about 150 mg when tested in accordance with Clause 9 using a rotating test piece. The value of abrasion loss for compound no. 2 depends to some extent on the exact mixing procedure and the variation in the natural rubber. This rubber is intended as an in-house standard rather than being a universal certified reference material.