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Rubber — General procedures for preparing and conditioning test pieces for physical test methods

Caoutchouc — Procédures générales pour la préparation et le conditionnement des éprouvettes pour les méthodes d'essais physiques

Reference number
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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 on 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.

The committee responsible for this document is ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This third edition cancels and replaces the second edition (ISO 23529:2010), which has been technically revised as follows.

— Clause 2 and Clause 3 have been added.

— Rubber solvent has been added as a textile-removing liquid (7.2.2.1).

— Description on preparation of unvulcanized test pieces has been added (7.6).

— 7.3.1 and 7.3.2 have been modified.

— Information on suitable callipers has been added (Note to 9.2).

— The format of Table A.1, Table A.2 and Table A.3 has been improved.

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Rubber — General procedures for preparing and conditioning test pieces for physical test methods

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 ensure compliance with any national regulatory conditions.

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 general procedures for the preparation, measurement, marking, storage, and conditioning of rubber test pieces for use in physical tests specified in other International Standards, and the preferred conditions to be used during the tests. Special conditions, applicable to a particular test or material or simulating a particular climatic environment, are not included, nor are special requirements for testing whole products.

This document also specifies the requirements for the time interval to be observed between forming and testing of rubber test pieces and products. Such requirements are necessary to obtain reproducible test results and to minimize disagreements between customer and supplier.

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 1795, *Rubber, raw natural and raw synthetic — Sampling and further preparative procedures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1382 apply.

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

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

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

4 Identification and record keeping

Records shall be kept of the identity of each test piece so that it is identifiable with the sample supplied and such that all the relevant details of preparation, storage, conditioning and measurement are traceable to each individual test piece.

Each sample or test piece shall be individually identifiable by marking or segregation at each stage of its preparation and testing. Where marking is used as the method of identification, the markings shall be sufficiently durable to ensure that the test piece or sample remains identifiable until discarded. Where grain effects can be significant, the direction of the grain shall be identified on each sample or test piece.

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The method of marking shall not affect the properties of the sample or test piece and shall avoid significant surfaces, i.e. surfaces which are to be directly tested (e.g. in abrasion tests) or surfaces at which a fracture terminates in the test (e.g. tear or tensile tests).

5 Standard laboratory conditions

5.1 Standard laboratory temperature

The standard laboratory temperature shall be either (23 ± 2) °C or (27 ± 2) °C in accordance with national practice. If a closer tolerance is required, it shall be ±1 °C.

NOTE The temperature 23 °C is normally the standard laboratory temperature in temperate countries and 27 °C is normally the standard laboratory temperature in tropical and subtropical countries.

5.2 Standard laboratory humidity

If control of both temperature and humidity is necessary, they shall be selected from Table 1.

Table 1 — Preferred relative humidity

Temperature °C	**Relative humidity** %	**Tolerance on humidity** %
23	50	±10[a]
27	65	

[a] If a tighter tolerance is needed, ±5 % can be specified.

5.3 Other conditions

When control of temperature and humidity is not necessary, the prevailing ambient temperature and humidity can be used. The latter conditions shall be used where standard laboratory conditions cannot easily be achieved.

6 Storage of samples and test pieces

6.1 Samples awaiting the preparation of test pieces and test pieces prior to conditioning shall be stored under conditions which minimize the possibility of degradation by ambient conditions, such as heat or light, or of contamination, e.g. cross-contamination from other samples.

6.2 For all tests, the minimum time between forming the material and testing shall be 16 h. When test pieces are cut from a product or where a whole product, e.g. bridge bearings, is tested, considerably more time than 16 h between forming the material and testing can be necessary. In these cases, the minimum time shall be as given in the product specification or relevant test method.

6.3 For non-product tests, the maximum time between forming the material and testing shall be 4 weeks and, for evaluations intended to be comparable, the tests shall be carried out, as far as possible, after the same time interval.

6.4 For product tests, whenever possible, the time between forming the product and testing shall not exceed 3 months. In other cases, tests shall be made within 2 months of the date of receipt of the product by the customer.

6.5 These requirements relate only to initial rubber material tests and to product tests at both the initial and delivery stage. Special tests for other purposes can be carried out at any time, e.g. for the

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purposes of process control or to evaluate the influence of abnormal storage conditions on a product. Such reasons shall be clearly stated in the test report.

6.6 In the case of unvulcanized compound, batches shall be conditioned for between 2 h and 24 h at one of the standard laboratory temperatures specified in 5.1, preferably in a closed container to prevent absorption of moisture from the air, or in a room in which the relative humidity is controlled at (50 ± 5) %.

7 Preparation of test pieces

7.1 Test piece thickness

The test piece thickness shall be as specified in the relevant test method. However, the test piece thicknesses other than those in Table 2 may be specified where it is necessary to retain the original surface of the sample.

Table 2 — Preferred test piece thicknesses

Test piece thickness mm	**Tolerance** mm
1,0	±0,1
2,0	±0,2
4,0	±0,2
6,3	±0,3
12,5	±0,5

7.2 Thickness adjustment

7.2.1 General

When material, particularly from products, requires testing, but is not available in a thickness recommended in Table 2, procedures are required to adjust the thickness to within the prescribed limits. Recommended procedures are given in 7.2.2. In most cases, thickness adjustments shall be made on the material before the cutting of the test pieces.

For most rubbers, splitting or buffing modifies the surface. Hence, when a surface-dependent property is being measured, thicknesses other than those in Table 2 might need to be specified in order to retain the original surface.

7.2.2 Techniques

7.2.2.1 Removal of textiles combined with the rubber

The separation shall preferably avoid the use of a liquid, which causes swelling. If this is not possible, a nontoxic liquid of low boiling point, such as isooctane (2,2,4-trimethylpentane) or rubber solvent (gasoline), can be used to wet the contacting surfaces. Care shall be taken to avoid excessive stretching of the rubber by separating a little at a time while the rubber is gripped near the point of separation. If a liquid is used, the rubber shall be placed so as to permit free evaporation of the liquid, and time shall be allowed for the complete evaporation of the liquid, preferably at least 16 h, before the test pieces are cut and tested.

7.2.2.2 Cutting techniques

When it is necessary to remove a considerable thickness of rubber or to produce a number of slices from a thick piece of rubber, cutting equipment such as that specified in 7.2.3.1 and 7.2.3.2 shall be used.

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7.2.2.3 Abrading techniques

When it is necessary to remove surface unevenness, such as fabric impressions or corrugations caused by contact with fabric components or with cloth wrappings used for vulcanization, or unevenness caused by cutting, this shall be done using the equipment specified in 7.2.3.3 or 7.2.3.4.

7.2.3 Equipment for test piece preparation

7.2.3.1 Rotating-blade equipment

This equipment is based on commercial slicing machines. The machine consists of a motor- or hand-driven disc cutter of suitable diameter with a movable cutting table which transports the sample to the cutting edge.

An adjustable slow-feed mechanism fitted to the cutting table feeds the rubber forward to the line of cut, and controls the thickness of the slice. Clamping devices shall be available to secure the rubber. The blade shall preferably be lubricated with a dilute aqueous detergent solution to ease the cutting operation.

7.2.3.2 Skiving machines

This equipment is based on commercial leather-slitting machinery, and convenient types are available for cutting strips about 50 mm wide with thicknesses up to about 12 mm. Adjustment shall be possible to vary the thickness of cut, and feed rollers shall be provided to transport the material past the knife. Provision shall be made for maintaining the cutting edge in a sharp condition. Attachments are available for splitting and cutting sections from cable sheathing.

7.2.3.3 Abrasive wheels

The abrading apparatus shall consist of an abrader with a motor-driven abrasive wheel. It is important that the wheel runs true without vibration, and that the abrasive surface, of aluminium oxide or silicon carbide, is true and sharp. The abrader can be equipped with a slow-feed mechanism so that very light cuts can be made to avoid overheating of the rubber. Suitable means shall be provided for securing the rubber to prevent excessive deformation and for controlled traversing of the rubber against the abrasive wheel.

NOTE Wheels of diameter 150 mm operating at a surface speed in the range of 10 m/s to 12 m/s, designated C-30-P-4-V for roughing and designated C-60-P-4-V for finishing (see ISO 525[1]), have been found suitable.

The depth of cut produced in the first pass shall not exceed 0,2 mm. Successive cuts shall be progressively less deep to avoid overheating. Buffing shall not be carried out beyond the point where unevenness in the thickness has been eliminated. For removal of greater thicknesses of rubber, cutting equipment as specified in 7.2.3.1 or 7.2.3.2 shall be used.

7.2.3.4 Flexible abrasive belts

The apparatus shall consist of either a motor-driven drum on which a helical strip of the abrasive belt is secured, or of two pulleys, one motor-driven and the other adjustable, to tension and align the belt. The abrasive belt shall be of textile or paper or a combination of the two, with the abrasive, of aluminium oxide or silicon carbide, bonded to the surface with a resin which is unaffected by water. Equipment shall be provided for slow feeding of the material to the abrasive belt and for securing the material without excessive deformation.

NOTE A surface speed of the band of (20 ± 5) m/s has been found suitable.

With this apparatus, cuts removing several tenths of a millimetre of rubber are practicable as much less heat is produced than with the equipment specified in 7.2.3.3. Abrasion can be carried out against the drum, against one of the pulleys or against the taut belt between the pulleys.

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7.3 Test piece cutters

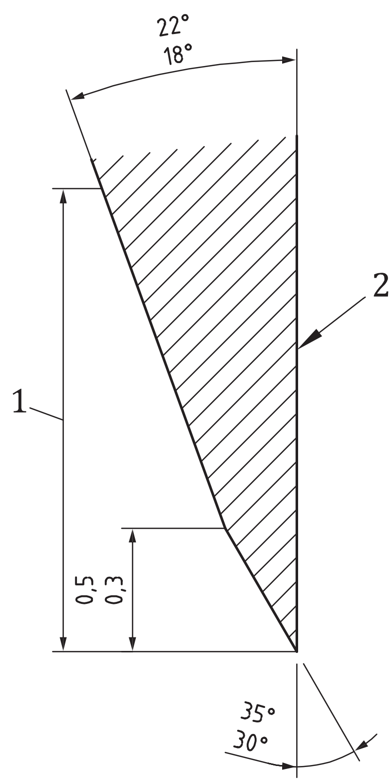
7.3.1 General

The design and type of cutter or die employed depends on the thickness and hardness of the material under test. In the case of thin materials, punching or rotary cutting techniques shall be used as specified in 7.3.2, 7.3.3 or 7.3.4. For thicker materials, usually above 4 mm, a rotary cutting technique as specified in 7.3.4 is desirable to reduce the degree of dishing of the cut edge resulting from compression of the rubber during cutting.

7.3.2 Fixed-blade cutters

For cutters which do not have replaceable blades, an example of a suitable cutting edge is shown in Figure 1. These shall be made from high-quality tool steel and can be of either one-piece (solid metal) or two-piece construction. They can be designed to punch out single or multiple test pieces. It is essential that the design ensures sufficient rigidity to prevent distortion of the cutting shape, and the cutter shall preferably be fitted with an ejection system to release the test piece. If fitted, such a system shall be designed to accommodate material up to the maximum thickness to be cut, normally 4,2 mm. If an ejection system is not fitted, access shall be available from the rear to permit release of the test piece by the operator without damaging the cutting edge. The cutting edge shall be kept sharp and free from nicks, as specified in 7.4, to prevent the formation of ragged edges on the test pieces.

Dimensions in millimetres



Key

1 ground area approximately 6 mm wide

2 inside surface of cutter

Figure 1 — Example of suitable cutting edge

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7.3.3 Replaceable-blade cutters

These shall use sharpened, high-carbon-steel strips, such as single-edged razor blades, which are sufficiently flexible to conform to the shape of the cut required. The cutting edge shall be securely clamped between shaped metal spacers and shaped blocks which conform to the specified cut shape. The spacers and shaped blocks shall be of sufficient thickness to support the cutting blade so that under normal circumstances, not more than 2,5 mm of the blade protrudes from the surface. The back of the cutting blade shall bed firmly on a solid metal base. The cutter shall preferably be fitted with an ejection system to release the test piece. If fitted, such a system shall be designed to accommodate material up to the maximum thickness to be cut, normally 2,2 mm. If an ejection system is not fitted, access shall be available from the rear to permit release of the test piece by the operator without damaging the cutting edge. Checks shall be made to ensure that the blade is not significantly deformed during the cutting operation, particularly with rubbers of high hardness.

7.3.4 Rotary cutters

Either annular or arc-shaped knives or razor blades, held in a suitable adapter permitting them to be fitted in a drilling machine, shall be used. Means shall be provided for holding the rubber in place during the cutting operation. This can consist of a combination of a plunger with a presser foot incorporated in the adapter to secure the central portion of the rubber and a metal pressure plate having a central hole larger than the size of the test piece to be cut out, or it can consist of a vacuum-type holder which applies suction to the lower surface of the rubber. Means can be provided for lubricating the surface of the rubber during the cutting operation. To assist in obtaining a perpendicular cut, a second annular blade of larger diameter, working at the same time as the test piece cutting blade, has been found effective. The size of the blades and the movement of the drill head shall be sufficient to accommodate the thickness of rubber to be cut. The leading edge of an arc-shaped blade shall be angled and sharpened to facilitate entry into the rubber. It is important that the cutting area be adequately guarded with a transparent shield permitting examination of the cutting operation. Other techniques in which the rubber is rotated against a stationary knife or razor blade can also be used.

7.4 Maintenance of cutters

Care shall be exercised at all times to protect and maintain the cutting edges of cutting equipment, as any dulling, nicking or bending of the cutting edge can lead to defective test pieces which give atypical results.

During storage, cutters shall be placed either in such a way that the cutting edge is resting on a soft surface such as foamed rubber or, preferably, that the cutting edge does not contact any surface.

7.5 Preparation of test pieces by moulding

7.5.1 Test sheets

When test sheets are prepared by mould cure (see Note), vulcanize them to reproduce as closely as possible the state of vulcanization of the product. First, press-cure the sheets to the thickness specified in the relevant test method, then cut out test pieces using cutters.

NOTE Suitable procedures for moulding test sheets and test discs are specified in ISO 2393[3].

7.5.2 Test pieces

When test pieces, e.g. in the form of discs, are prepared directly by mould cure, vulcanize them to reproduce as closely as possible the state of vulcanization of the product.

7.5.3 Thermoplastic materials

Samples of thermoplastic materials shall be moulded in accordance with the manufacturer's instructions for the material, application and type and size of moulding.

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7.6 Preparation of unvulcanized test pieces

Test pieces of unvulcanized rubbers or compounds shall be prepared in accordance with ISO 1795.

8 Conditioning

8.1 General

When both temperature and humidity are specified, the conditioning time shall be a period of not less than 16 h, immediately before testing.

When a standard laboratory temperature is specified without the need to control the humidity, the conditioning time shall be a period of not less than 3 h, immediately before testing.

When a temperature other than a standard laboratory temperature is specified without the need to control the humidity, the conditioning time shall be a period sufficient for the rubber to reach temperature equilibrium with the environment or the period required by the specification covering the material or product being tested.

Test pieces prepared from buffed samples shall be conditioned before testing.

8.2 Conditioning times for subnormal or elevated temperatures

Annex A gives calculated times for the centre of a test piece to reach a temperature within 1 °C of a set conditioning temperature, starting from an initial temperature of 20 °C. The time depends on the geometry and size of test piece, the material and the type of heat-transfer medium used.

9 Measurement of the dimensions of test pieces

NOTE For the measurement of the dimensions of products for control purposes, the reader is referred to ISO 3302-1[4].

9.1 Method A — For dimensions less than 30 mm

This method is applicable where the dimension to be measured is less than 30 mm, with the test piece lying between two flat parallel surfaces, and where the other dimensions are such that the application of pressure does not cause any appreciable buckling.

The apparatus used shall consist of a flat rigid base plate, on which the test piece or product rests, and a gauge having a flat circular foot of diameter between 2 mm and 10 mm that is applied to the test piece or product, exerting a specified pressure.

The gauge shall be capable of measuring the thickness with an error of not more than 1 % or 0,01 mm, whichever is the smaller. It is recommended that a digital gauge with a resolution of 0,001 mm be used.

The circular foot shall not extend over the edge of the test piece or product and shall exert a pressure of (22 ± 5) kPa for solid rubber of hardness equal to or greater than 35 IRHD, or a pressure of (10 ± 2) kPa if the hardness is less than 35 IRHD. The normal masses required to give the specified pressures of (10 ± 2) kPa and (22 ± 5) kPa are given, for different foot diameters, for reference purposes in Table 3.

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Table 3 — Surface pressure as a function of foot diameter

Foot diameter mm	Mass, in grams, required to give a pressure of (10 ± 2) kPa	 (22 ± 5) kPa
2	3	7
3	7	16
4	13	28
5	20	44
6	29	63
8	51	113
10	80	176

If the measuring device is capable of adjusting the pressure to suit the test piece or product geometry, the requirement for the foot to not extend over the edge can be ignored. Throughout the test, the test piece or product shall lie flat against the foot.

NOTE Other standards specify this apparatus for test pieces not having flat, parallel faces. In these cases, the measurement conditions are given in the relevant standard.

At least three measurements shall be made of each dimension to be determined, and the median value of each dimension reported.

9.2 Method B — For dimensions of 30 mm and up to and including 100 mm

The measurement shall be made by means of a vernier calliper capable of measuring the dimension with an error of not more than 1 %. Each measurement shall be made along a line perpendicular to the opposite faces of the test piece or product defining the dimension to be measured. The measurement shall be made with the test piece or product supported, so that the dimension measured is not affected by strain in the test piece or product.

The calliper shall be adjusted so that the faces which contact the surfaces of the test piece or product do not compress them.

NOTE Suitable callipers are specified in ISO 13385-1[5].

At least three measurements shall be made of each dimension to be determined, and the median value of each dimension reported.

9.3 Method C — For dimensions over 100 mm

The measurement shall be made by means of a graduated ruler or tape with an error of not more than 1 mm.

Each measurement shall be made along a line perpendicular to the opposite faces of the test piece or product defining the dimension to be measured.

At least three measurements shall be made of each dimension to be determined, and the median value of each dimension reported.

9.4 Method D — Non-contact method

This method, which does not involve any contact with the rubber, can be required when the test piece or product has a special shape (e.g. O-rings or test pieces taken from hoses). Various types of optical apparatus can be used, e.g. a travelling microscope, projection microscope or shadowgraph.

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The gauge shall be capable of measuring the thickness with an error of not more than 1 % or 0,01 mm, whichever is the smaller.

At least three measurements shall be made of each dimension to be determined, and the median value of each dimension reported.

10 Conditions of test

10.1 Duration of test

The period required to obtain any given degree of change in a test piece (e.g. during ageing) depends largely upon the type of rubber, its composition and state of cure, and the nature and severity of the test environment. When an extensive investigation is required, changes are usually monitored by testing at set time intervals. For control purposes, such a procedure is not usually necessary and a single test period can be sufficient. In both cases, it is recommended that the test period(s) be selected from Table 4.

Table 4 — Preferred test periods

<table>
<tr><th>Test period
h</th><th>Tolerance
h</th></tr>
<tr><td>8</td><td rowspan="2">±0,25</td></tr>
<tr><td>16</td></tr>
<tr><td>24</td><td rowspan="2">0
−2</td></tr>
<tr><td>48</td></tr>
<tr><td>72</td><td rowspan="3">±2</td></tr>
<tr><td>168</td></tr>
<tr><td>Multiples of 168</td></tr>
<tr><td colspan="2">NOTE The tolerances are not uniform in percentage terms, but have been used traditionally, in part due to the need to take account of the normal working day.</td></tr>
</table>

In cases where, for technical reasons, closer tolerances are necessary, they shall be as specified in the test method.

10.2 Temperature and humidity

10.2.1 Standard laboratory temperature and humidity

The standard conditions of temperature and humidity shall be those defined in Clause 5.

10.2.2 Other test temperatures

When a subnormal or an elevated temperature is necessary, this temperature shall be selected from the values in Table 5, unless technical reasons dictate otherwise.

Closer tolerances may be specified where they have been shown to be necessary in order to obtain reproducible test results.

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Table 5 — Test temperatures

Test temperature °C	Tolerance °C
−85 −70 −55 −40 −25 −10 0	±2
40 55 70 85 100	±1[a]
125 150 175 200 225 250 275 300	±2

[a] Where the use of a glove box is necessary, the tolerance is relaxed to ±2 °C.

11 Test chambers

11.1 General requirements for temperature-controlled chambers

The immersion medium in the chamber shall have no significant effects on the properties of the rubber test pieces. The temperature of the part of the chamber in which the test pieces are placed shall be controlled to within the tolerances specified by the relevant method of test. The immersion medium shall be circulated thoroughly throughout the chamber. Automatic temperature control is preferred. Recovery to the set temperature after the introduction of test pieces or test apparatus shall be as rapid as possible, consistent with minimal overshoot or undershoot, but in any case shall not exceed 15 min, particular care being required with gaseous media.

The chamber shall be thermally insulated to prevent condensation on exterior surfaces when testing at subnormal temperatures, and to prevent discomfort to the touch when testing at elevated temperatures. If a window is needed to observe the test equipment, e.g. to read meters, it shall be constructed so as to ensure adequate thermal insulation and to prevent condensation.

For liquid media, the temperature can be controlled by elements immersed in the medium or by circulating the medium through a heat-exchange system outside the chamber.

The construction of the chamber depends on the type of immersion medium. For gaseous media, a side entrance for introducing test pieces is convenient, and is necessary where the test equipment is operated from the side. The interior walls of the chamber shall be made of a good thermal conductor, preferably aluminium or tin-plated copper, to ensure uniform temperature and minimize radiant effects. When manual operation of equipment (except for mounting and removal of test pieces) inside

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the chamber is necessary, hand-holes equipped with gloves and insulated sleeves shall be installed in the walls of the chamber wherever possible.

11.2 Chambers operating at elevated temperatures

11.2.1 Chambers with gaseous heat-transfer media

The gaseous medium shall be heated by means of suitable electric heating elements, a fan or blower being provided to ensure adequate circulation of the gas. The heating elements shall be shielded to avoid thermal radiation falling directly onto the test pieces.

To obtain the necessary precision of temperature control, the heating system shall:

a) use a recirculating gas system;

b) be designed so that most of the heat required is supplied continuously and the remainder intermittently for temperature control or with proportionating devices in the heat supply that prevent large cyclic variations in temperature.

11.2.2 Chambers with liquid heat-transfer media

Such chambers shall preferably follow the same principles as in 11.2.1, using an immersion heater instead of the heating elements used in 11.2.1, and a stirrer or pump instead of the fan or blower.

11.2.3 Fluidized beds

Such chambers shall preferably utilize a bed of inert material which can be “fluidized” by passing a suitable gas through the bed at a suitable speed.

11.3 Chambers operating at subnormal temperatures

11.3.1 Mechanically refrigerated units

In general, mechanically refrigerated low-temperature chambers have a multi-stage compressor and suitable cooling coils which surround the test chamber.

11.3.2 Solid carbon dioxide units (direct-cooling type)

In the direct-cooling type of solid carbon dioxide cooled low-temperature chamber, a suitable fan or blower, located in the solid carbon dioxide compartment, circulates the carbon dioxide vapour from the solid carbon dioxide compartment into the test piece compartment and back.

11.3.3 Solid carbon dioxide units (indirect-cooling type)

In the indirect-cooling type of solid carbon dioxide cooled low-temperature chamber, air is used as the heat-transfer medium and no carbon dioxide vapour comes into contact with the test pieces.

11.3.4 Packaged refrigeration units

It is frequently desirable to house the test equipment in the test chamber and circulate temperature-regulated cold air or carbon dioxide vapour from a separate refrigeration unit to the test chamber and back through insulated ducts or pipes.

11.3.5 Liquid nitrogen

Liquid nitrogen can be injected into the chamber as required to control the temperature or, alternatively, a sufficient volume of the gas in the chamber to give the required temperature can be circulated through a liquid-nitrogen vessel outside the chamber. When liquid nitrogen is injected, it

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shall be completely vaporized and the nitrogen gas shall have reached the test temperature before it contacts the test equipment or test pieces.

12 Test report

The test report shall include at least the following information:

a) a reference to this document, i.e. ISO 23529;

b) moulding conditions and the date of moulding (if applicable);

c) methods used for sample and test piece preparation;

d) details of test piece conditioning;

e) method(s) used to measure the test piece dimensions and the results of the measurements;

f) test temperature and, if appropriate, humidity.

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Annex A
(normative)

Conditioning times for rubber test pieces

Tables A.1 to A.3 give calculated times for the centre of a test piece to reach a temperature within 1 °C of a set conditioning temperature, starting from an initial temperature of 20 °C. The time depends on the geometry and size of test piece, the material and the type of heat-transfer medium used.

To make individual calculations for every test piece in current use would be impractical. Fortunately, nearly all test pieces fall into three geometrical categories: discs, flat sheets and flat strips. Dumb-bell test pieces used in tensile tests can be considered as flat strips.

The conditioning time depends on the thermal properties of the sample material. For rubber, the thermal diffusivity can be taken as 0,1 mm^2/s and the thermal conductivity as 0,2 W/(m·K).

The majority of temperature-controlled chambers use either air or a liquid as the heat-transfer medium. To generate the tables, a heat-transfer coefficient for air of 20 $W/(m^2·K)$ was assumed. Different liquids have various heat-transfer coefficients, but for most purposes, a value of 750 $W/(m^2·K)$ can be assumed.

The conditioning time is not critical to the nearest minute, although it is essential that the test piece be given sufficient time to reach equilibrium. All times in the tables have been rounded up to the next highest multiple of 5 min.

Table A.1 — Discs

Test piece dimensions		Time to 1 °C off equilibrium min													
		Air medium							Liquid medium						
		Temperature °C							Temperature °C						
Diameter mm	Height mm	−50	0	50	100	150	200	250	−50	0	50	100	150	200	250
64	38	130	95	105	130	145	155	160	75	60	65	80	85	90	90
40	30	75	55	60	75	85	90	95	35	30	30	35	40	45	45
37	10,2	35	25	30	35	40	40	45	10	10	10	10	10	10	15
32	16,5	45	35	35	45	50	55	55	15	15	15	20	20	20	20
29	25	50	40	45	55	60	65	65	20	15	20	25	25	25	25
	12,5	35	25	30	35	40	45	45	10	10	10	15	15	15	15
25	20	40	30	35	45	45	50	50	15	15	15	15	20	20	20
	10	25	20	20	25	30	30	30	5	5	5	5	10	10	10
	6,3	20	15	20	20	25	25	25	5	5	5	5	5	5	5
13	12,6	20	15	20	20	25	25	25	5	5	5	5	10	10	10
	6,3	15	10	15	15	20	20	25	5	5	5	5	5	5	5
9,5	9,5	15	10	15	15	20	20	20	5	5	5	5	5	5	5

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Table A.2 — Flat sheets

Test piece dimension Thickness mm	Time to 1 °C off equilibrium min													
	Air medium							Liquid medium						
	Temperature °C							Temperature °C						
	−50	0	50	100	150	200	250	−50	0	50	100	150	200	250
25	135	95	110	140	155	160	170	90	75	80	90	95	100	105
15	70	50	60	75	80	85	90	35	30	30	35	40	40	40
10	45	30	35	45	50	55	55	15	15	15	20	20	20	20
8	35	25	30	35	40	40	45	10	10	10	10	10	15	15
5	20	15	20	20	25	25	25	5	5	5	5	5	5	5
3	15	10	10	15	15	15	15	5	5	5	5	5	5	5
2	10	10	10	10	10	10	10	5	5	5	5	5	5	5
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5
0,2	5	5	5	5	5	5	5	5	5	5	5	5	5	5

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Table A.3 — Flat strips

Test piece dimensions		Time to 1 °C off equilibrium min													
		Air medium							Liquid medium						
Width mm	Thickness mm	Temperature °C							Temperature °C						
		−50	0	50	100	150	200	250	−50	0	50	100	150	200	250
25,4	12,7	45	30	35	45	50	50	55	15	10	15	15	15	15	15
	10,0	35	25	30	35	40	40	45	10	10	10	10	10	10	10
	9,5	35	25	30	35	40	40	40	10	10	10	10	10	10	10
	6,5	25	20	20	25	30	30	30	5	5	5	5	5	5	5
	5,0	20	15	15	20	20	20	25	5	5	5	5	5	5	5
	3,0	15	10	10	15	15	15	15	5	5	5	5	5	5	5
	2,0	10	10	10	10	10	10	10	5	5	5	5	5	5	5
	1,0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
15,0	15,0	35	30	30	40	40	45	45	10	10	10	10	15	15	15
12,7	12,7	30	25	25	30	35	35	40	10	10	10	10	10	10	10
	10,0	25	20	20	30	30	30	35	10	5	5	10	10	10	10
	9,5	25	20	20	25	30	30	35	10	5	5	10	10	10	10
	6,5	20	15	15	20	25	25	25	5	5	5	5	5	5	5
	5,0	15	15	15	20	20	20	20	5	5	5	5	5	5	5
	3,2	15	10	10	15	15	15	15	5	5	5	5	5	5	5
	3,0	10	10	10	10	15	15	15	5	5	5	5	5	5	5
	2,0	10	5	10	10	10	10	10	5	5	5	5	5	5	5
	1,0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6,35	12,7	20	15	15	20	25	25	25	5	5	5	5	5	5	5
	10,0	20	15	15	20	20	20	25	5	5	5	5	5	5	5
	6,5	15	10	15	15	15	20	20	5	5	5	5	5	5	5
	5,0	15	10	10	15	15	15	15	5	5	5	5	5	5	5
	3,0	10	10	10	10	10	10	10	5	5	5	5	5	5	5
	2,0	10	5	5	10	10	10	10	5	5	5	5	5	5	5
	1,5	5	5	5	5	10	10	10	5	5	5	5	5	5	5
	1,0	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4,0	12,7	15	10	10	15	15	15	20	5	5	5	5	5	5	5
	10,0	15	10	10	15	15	15	15	5	5	5	5	5	5	5
	6,5	10	10	10	10	15	15	15	5	5	5	5	5	5	5
	5,0	10	10	10	10	10	15	15	5	5	5	5	5	5	5
	3,0	10	5	10	10	10	10	10	5	5	5	5	5	5	5
	2,0	5	5	5	10	10	10	10	5	5	5	5	5	5	5
	1,0	5	5	5	5	5	5	5	5	5	5	5	5	5	5

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