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Rubber — Determination of crystallization effects by hardness measurements

Caoutchouc — Détermination des effets de la cristallisation au moyen de mesurages de dureté

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Contents

Page

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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 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 fourth edition cancels and replaces the third edition (ISO 3387:2012), which has been technically revised.

The main changes compared to the previous edition are as follows.

— The normative references have been updated in Clause 2.

— How to select method and how to make measurement have been explained in more detail in 9.1.

— Information about original hardness measurement has been revised in 9.2.

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.

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Rubber — Determination of crystallization effects by hardness measurements

1 Scope

This document specifies a test based on hardness measurements for determining the progressive stiffening of rubber with time, caused by crystallization. It is limited to materials having an initial hardness at a test temperature of from 10 IRHD to 85 IRHD.

The method is applicable to raw, unvulcanized (compounded) and vulcanized rubber. It is mainly of interest for rubber with a marked crystallization tendency at temperatures experienced in cold climates, such as chloroprene and natural rubber.

The method is not applicable to fast-crystallizing materials which crystallize to a considerable degree within the timespan of 15 min used for conditioning at test temperature.

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 48-2:2018, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 2: Hardness between 10 IRHD and 100 IRHD*

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

No terms and definitions are listed in this document.

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

One or the other of the following measurements is made on a test piece stored at the desired temperature:

a) the increase in hardness after a specified storage time;

b) the time required for a specified increase in hardness to occur.

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5 Apparatus

5.1 Cold chamber, in accordance with ISO 23529, capable of being maintained within ±2 °C of the specified temperature and using a gaseous heat-transfer medium.

All final handling and measurements shall be made within the cold chamber while the test temperature remains within the permissible limits. This can be done by providing suitable equipment which permits manipulation of materials within the chamber from the outside (for example, by means of handholes and gloves through the door or wall of the cabinet).

5.2 Hardness gauges, in accordance with ISO 48-2. Lubricants, if used, shall be of a type not causing friction in the instrument at the test temperature.

The hardness gauge used in this test procedure is normally conditioned and operated inside the cold chamber. Alternatively, a special device may be used where the body of the hardness gauge is placed outside the cold chamber and connected with the indenter in the cold chamber by means of a rod with low heat-conductive capacity, and constructed to avoid the introduction of additional friction.

5.3 Tweezers or tongs, for handling the test pieces.

5.4 Gloves, for handling the test equipment.

5.5 Heated press, for the preparation of raw and unvulcanized (compounded) test pieces.

6 Calibration

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

7 Test pieces

7.1 Dimensions

Tests may be carried out on test pieces of different thicknesses. These do not necessarily give the same values of hardness readings. Tests intended to be comparable shall be made on test pieces of the same thickness.

The upper and lower surfaces of the test piece shall be flat, smooth and parallel to one another. The standard test piece shall be 8 mm to 10 mm thick. Non-standard test pieces may be either thicker or thinner, but in no case shall the test piece be thinner than 4 mm for hardness between 35 IRHD and 85 IRHD, or thinner than 6 mm for hardness between 10 IRHD and 35 IRHD. The lateral dimensions of both standard and non-standard test pieces shall be such that no test is made at a distance from the edge of the test piece less than the appropriate distance shown in Table 1.

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Table 1 — Dimensions of test pieces

Dimensions in millimetres

Total thickness of test piece	Minimum distance from point of contact to edge of test piece
4	7,0
6	8,0
8	9,0
10	10,0
15	11,5
25	13,0

7.2 Preparation

7.2.1 Vulcanized rubber

Test pieces of vulcanized rubber shall be prepared in accordance with ISO 23529. To obtain the necessary thickness, it is permissible to superimpose two pieces of rubber (but no more than two), provided that these have flat, parallel surfaces.

7.2.2 Raw and unvulcanized rubber

Test pieces of raw and of unvulcanized (compounded) rubber shall be prepared by placing a suitable quantity in a preheated mould and then applying heat and pressure (5.5) for a suitable time. The mould, still under pressure, shall be cooled to standard laboratory temperature (see ISO 23529). After 15 min, the pressure shall be released, and the test piece removed. It shall be free from blisters and porosity. Values of mould temperature and time of application of pressure required to produce a suitable test piece depend upon the type of rubber. A temperature of 150 °C applied for 3 min has been found suitable for many raw rubbers, while a temperature of 120 °C applied for 3 min has been found satisfactory for many compounded rubbers. However, for some materials, longer times or higher mould temperatures might be necessary to ensure a smooth and flat test piece surface. Under no circumstances shall conditions be used that cause incipient cure or degradation.

7.3 Conditioning

7.3.1 Time-interval between vulcanization and testing

When appropriate, the time interval between vulcanization and testing shall be in accordance with ISO 23529.

7.3.2 Decrystallization and conditioning

Test pieces of vulcanized rubber or test pieces moulded from raw or unvulcanized (compounded) rubber kept for more than 8 h after moulding before testing shall be decrystallized immediately before testing by heating them in an oven at 70 °C for 45 min. They shall then be conditioned at the standard laboratory temperature (see ISO 23529) for at least 30 min and no more than 60 min before testing.

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8 Temperature and duration of test

8.1 Temperature

The test shall be carried out at one of the following temperatures (see ISO 23529):

+ 23 °C ± 2 °C (standard laboratory temperature)

+ 27 °C ± 2 °C (standard laboratory temperature)

+ 10 °C ± 2 °C

0 °C ± 2 °C

− 10 °C ± 2 °C

− 25 °C ± 2 °C

− 40 °C ± 2 °C

− 55 °C ± 2 °C

− 70 °C ± 2 °C

If not specified for special reasons, the test shall be carried out at the temperature which is closest to the one where the crystallization rate is at its maximum whenever this is known.

NOTE Generally, crystallization rates are known to have their maxima at the following approximate temperatures:

Rubber polymer	Temperature of maximum crystallization rate °C
Chloroprene rubber	−10
Polyurethane rubber	−10
Natural rubber (1,4-*cis*-polyisoprene)	−25
Dimethyl silicone rubber	−55
1,4-*cis*-polybutadiene	−55

8.2 Duration

Hardness measurements are generally taken after $(24^{\ 0}_{-0,5})$ h and $(168^{\ 0}_{-2})$ h of storage at the test temperature. Intermediate times of reading can be used to enable the hardness to be plotted against time (48 h and 96 h are suggested). Longer times of storage may be used if the hardness is still increasing at 168 h.

If the hardness increase after $(24^{\ 0}_{-0,5})$ h is more than 10 IRHD above the reading of initial hardness, the test shall be repeated using shorter times of storage (1 h, 2 h, 4 h and 8 h are suggested).

9 Procedure

9.1 Hardness measurement

Carry out the hardness measurement in accordance with ISO 48-2. For the initial hardness, select method N, H or L as appropriate: for initial hardness between 10 IRHD and 30 IRHD, the instrument

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specified for method L shall be used, for initial hardness between 30 IRHD and 80 IRHD, the instrument specified for method N shall be used, and for hardness over 80 IRHD, the instrument specified for method H shall be used. The method selected shall also be used for measurements after exposure to low temperature, regardless of whether the hardness still falls within that range. If the hardness increase gives values above 35 IRHD for method L, the hardness readings shall be determined from an extension to ISO 48-2:2018, Table 5, calculated using the formula given in ISO 48-2:2018, Annex A.

Make one measurement at either three or five different points distributed over the test piece and take the median of the results. Make each reading at a point at least 4 mm away from points where any previous readings have been made.

9.2 Original hardness

If required to give further information, first measure the hardness with the test piece and test equipment conditioned at the standard laboratory temperature (see ISO 23529).

9.3 Initial hardness at test temperature

Condition the hardness gauge (5.2) and the tweezers or tongs (5.3) in the cold chamber (5.1) at the desired test temperature for at least 60 min.

Place the test piece in the cold chamber at the desired test temperature. After 15 min ± 1 min, take the first hardness reading, using the tweezers or tongs for handling the test piece and the gloves (5.4) for handling the test equipment. If the initial hardness reading is above 85 IRHD, this test method is not applicable.

9.4 Hardness increase due to crystallization

Repeat the hardness measurements, as specified in 9.1, after the specified times of storage at the test temperature.

After all measurements have been completed, it is advisable to dry all apparatus by warming it with circulating air to approximately 40 °C.

10 Expression of results

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

10.1 Calculate the change in IRHD ΔH before and after storage (see 8.2) using the Formula (1):

$$\Delta H = H_t - H_i \quad (1)$$

where

H_i is the initial hardness;

H_t is the hardness after storage

See Figure 1, a)

Report the result as the median value for the test pieces.

If the hardness increase after 168 h is greater than 10 IRHD, the readings at different times can be plotted against time (time on logarithmic scale) and a smooth curve fitted to the points. From the curve, the time corresponding to a hardness increase of 10 IRHD can be obtained by interpolation. See Figure 1, b).

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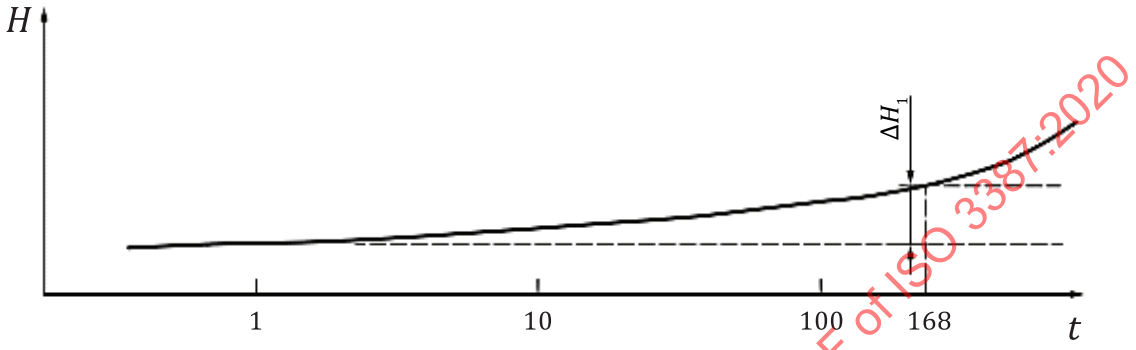
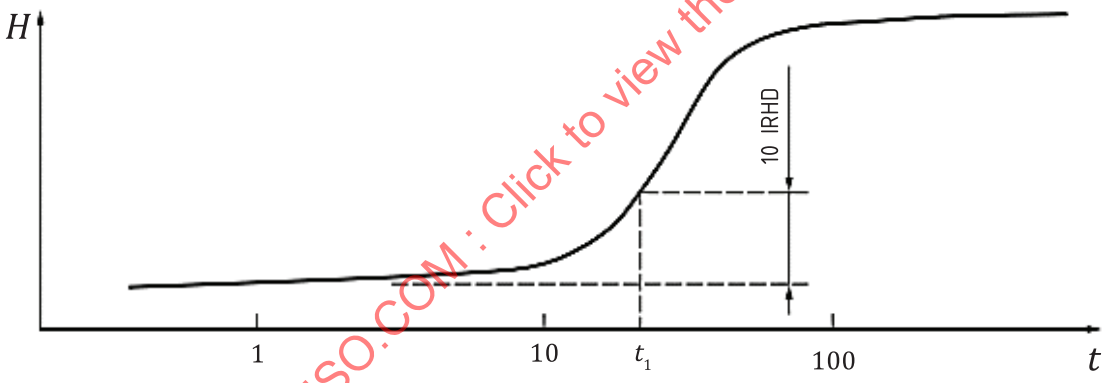
The same procedure can be applied, using the shorter time scale, when the hardness increase after $(24^{0}_{-0,5})$ h exceeds 10 IRHD.

The increase in hardness after a specified time or the time for a specified increase in hardness can also be used for reporting of data to comply with requirements in certain specifications. See Figure 1, c).

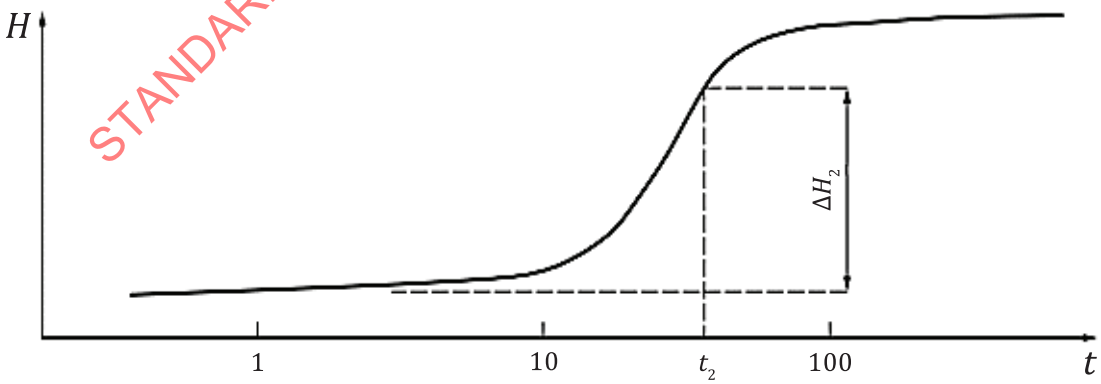
10.2 For other purposes, the time taken for half the hardness increase to occur between the initial and final hardness can be given [see Figure 1, d)], using the smooth curve of hardness versus time. This assumes that hardness measurements are extended in time to secure the level of final hardness.



a) Hardness increase after (168^{0}_{-2}) h **less than 10 IRHD: report the actual hardness increase,** ΔH_1**, after** (168^{0}_{-2}) h



b) Report time t_1 **for 10 IRHD increase to occur**



c) Report time t_2 **for a specified hardness increase,** ΔH_2**, to occur, or report hardness increase** ΔH_2 **after a specified time,** t_2

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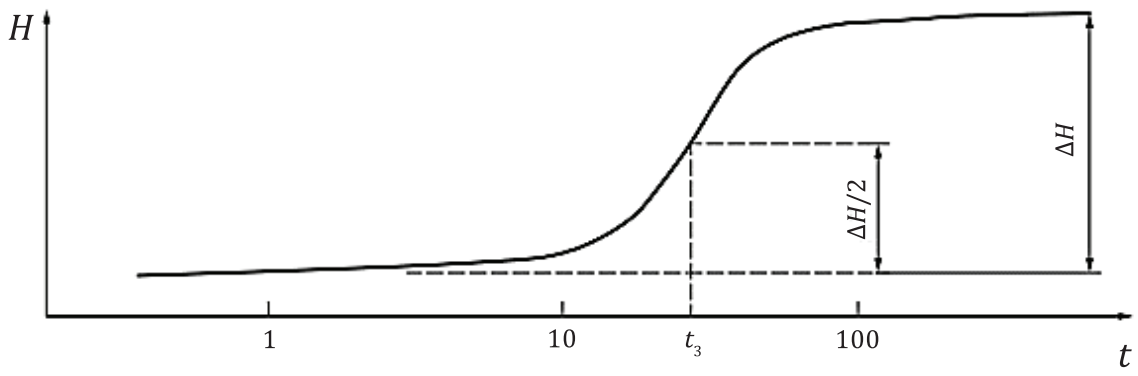

d) Report time t_3 for half the hardness increase between initial and final hardnesses to occur

Key

H hardness (IRHD)

t time of storage at test temperature, h

Figure 1 — Different ways of reporting data from smooth curve obtained by plotting hardness readings against time of storage at test temperature

11 Test report

The test report shall include the following information:

a) sample details:

   1) full description of the sample and its origin;

   2) compound details, and cure details, where appropriate;

   3) method of preparation of test pieces from sample, for example, moulded or cut;

b) test method:

   1) a full reference to the test method used;

   2) the method of measuring hardness;

   3) the type of test piece used;

c) test details:

   1) the standard laboratory temperature;

   2) decrystallization and conditioning prior to test, if carried out;

   3) the test temperature;

   4) time of storage at the test temperature;

   5) details of any procedures not specified in this document;

d) test results:

   1) the number of test pieces used;

   2) the individual test results;

   3) the median results;

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4) date of test.

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