INTERNATIONAL STANDARD

ISO 4545-1

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Metallic materials — Knoop hardness test —

Part 1: Test method

Matériaux métalliques — Essai de dureté Knoop —
Partie 1: Méthode d'essai

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 4545-1 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

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ISO 4545-1 cancels and replaces ISO 4545:1993, which has been technically revised.

ISO 4545 consists of the following parts, under the general title *Metallic materials — Knoop hardness test*:

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— *Part 1: Test method*

— *Part 2: Verification and calibration of testing machines*

— *Part 3: Calibration of reference blocks*

— *Part 4: Table of hardness values*

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Introduction

The periodic checking of the testing machine described in informative Annex A is good metrological practice. It is intended to make this annex normative in the next revision of this part of ISO 4545.

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Metallic materials — Knoop hardness test —

Part 1: Test method

1 Scope

This part of ISO 4545 specifies the Knoop hardness test method for metallic materials, for test forces from 0,098 07 N to 19,614 N. The method is recommended only for indentations with diagonals $\geqslant$ 0,020 mm.

2 Normative references

The following referenced documents are indispensable for the application 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.

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ISO 4545-2:2005, *Metallic materials — Knoop hardness test — Part 2: Verification and calibration of testing machines*

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ISO 4545-3:2005, *Metallic materials — Knoop hardness test — Part 3: Calibration of reference blocks*

ISO 4545-4, *Metallic materials — Knoop hardness test — Part 4: Table of hardness values*

3 Principle

A diamond indenter, in the form of a rhombic-based pyramid with angles α and β between opposite faces respectively equal to 172,5° and 130° at the vertex, is forced into the surface of a test piece followed by measurement of the long diagonal, d, of the indentation remaining in the surface after removal of the test force, F (see Figures 1 and 2).

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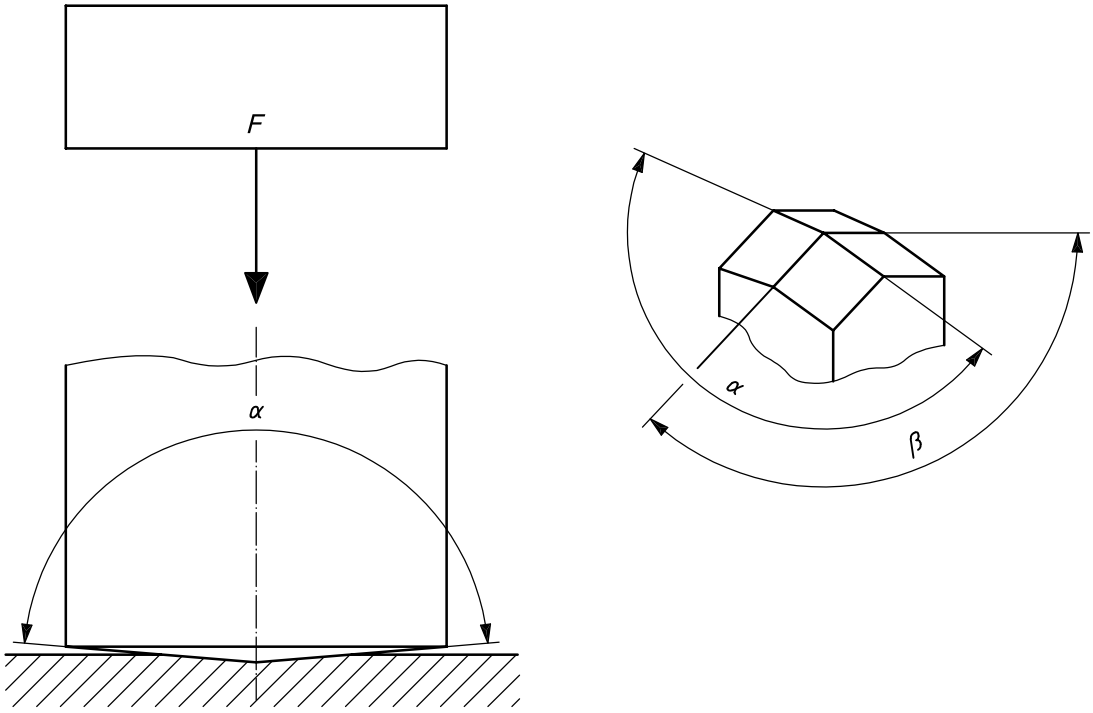

Figure 1 — Principle of the test and indenter geometry

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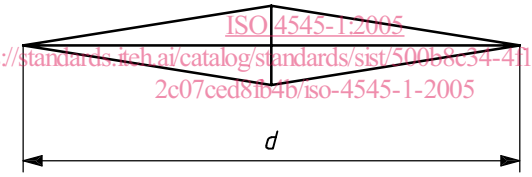

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Figure 2 — Knoop indentation

The Knoop hardness is proportional to the quotient obtained by dividing the test force by the projected area of the indentation, which is assumed to be a rhombic-based pyramid, and having at the vertex the same angles as the indenter.

4 Symbols and abbreviated terms

4.1 See Table 1 and Figures 1 and 2.

4.2 The following is an example of the designation of Knoop hardness.

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EXAMPLE

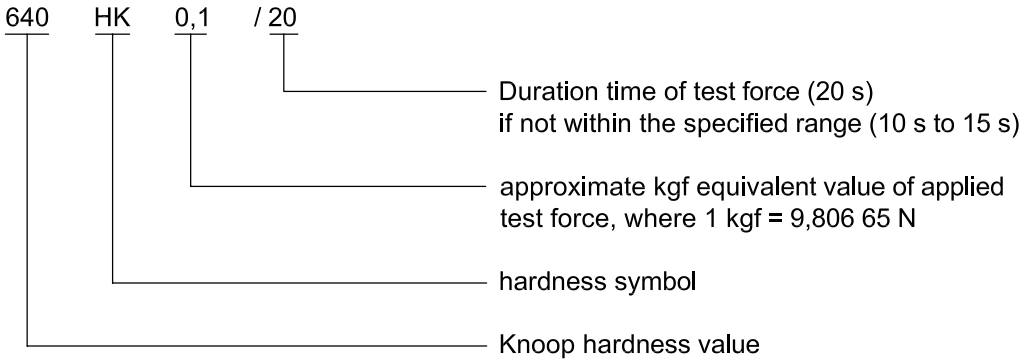

Table 1 — Symbols and abbreviated terms

Symbol/ abbreviated term	Designation
F	Test force, in newtons
d	Length of the long diagonal, in millimetres
c	Indenter constant, relating projected area of the indentation to the square of the length of the long diagonal Indenter constant, $c = \frac{\tan\frac{\beta}{2}}{2\tan\frac{\alpha}{2}}$; ideally $c = 0{,}070\ 28$ where α and β are the angles between the opposite edges at the vertex of the diamond pyramid (see Figure 1)
HK	Knoop hardness $= \text{Constant} \times \frac{\text{Test force}}{\text{Projected area of indentation}}$ $= 0{,}102 \times \frac{F}{cd^2} = 1{,}451\frac{F}{d^2}$
NOTE Constant $= 0{,}102 = \frac{1}{9{,}806\ 65}$, where 9,806 65 is the conversion factor from kgf to N.	

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5 Apparatus

5.1 Testing machine, capable of applying a predetermined force or forces from 0,098 07 N to 19,614 N, in accordance with ISO 4545-2.

5.2 Indenter, a diamond in the shape of a rhombic-based pyramid, as specified in ISO 4545-2.

5.3 Measuring system, as specified in ISO 4545-2.

The optical portion of the measuring system should have Kohler illumination. See Annex A of ISO 4545-3:2005.

Magnifications should be provided so that the diagonal can be enlarged to greater than 25 % but less than 75 % of the field of view.

The measuring system should report the diagonal lengths in 0,1 µm increments.

NOTE A suggested procedure for checking the testing machine by the user is given in Annex A.

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6 Test piece

6.1 The test shall be carried out on a polished surface, which is smooth and even, free from oxide scale and foreign matter and, in particular, completely free from lubricants, unless otherwise specified in product standards The finish of the surface shall permit accurate determination of the diagonal length of the indentation.

6.2 Preparation shall be carried out in such a way that any alteration of the surface hardness, due to excessive heating or cold work, for example, is minimized.

6.3 Due to the small depth of Knoop hardness indentations, it is essential that special precautions be taken during preparation. It is recommended to use a polishing/electropolishing technique that is adapted to the material to be measured.

6.4 No deformation shall be visible at the back of the test piece after the test.

6.5 For test pieces of small cross-section or of irregular shape, it may be necessary to provide some form of additional support, for example, mounting in plastic material. The test piece shall be adequately supported by the mounting medium so that the test piece does not move during the force application.

7 Procedure

7.1 The test is normally carried out at a temperature of (23 ± 5) °C. If the test is carried out at a temperature outside this range, it shall be noted in the test report.

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7.2 The test forces given in Table 2 are recommended.

7.3 The test piece shall be placed on a rigid support. The support surfaces shall be clean and free from foreign matter (scales, oil, dirt, etc.). It is important that the test piece lies firmly on the support so that displacement cannot occur during the test.

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7.4 Focus the measuring microscope so that the specimen surface can be observed.

7.5 Bring the indenter into contact with the test surface and apply the test force in a direction perpendicular to the surface, without shock or vibration, until the applied force attains the specified value. The approach velocity of the indenter shall be within the range of 15 µm/s to 70 µm/s. The time from the initial application of the force until the full test force is reached shall not exceed 10 s.

7.6 The duration of the test force shall be from 10 s to 15 s unless otherwise specified. For certain materials, a longer time for maintaining the force may be necessary to obtain consistent results; this time shall be applied with a tolerance of ± 2 s.

7.7 Throughout the test, the apparatus shall be protected from shock or vibration.

7.8 The minimum distance between the limit of any indentation and the edge of the test piece shall be at least 3 times the short diagonal of the indentation.

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Table 2 — Test forces

Hardness symbol	Test force value, F	
	N	approximate kgf [a] equivalent
HK 0,01	0,098 07	0,010
HK 0,02	0,196 1	0,020
HK 0,025	0,245 2	0,025
HK 0,05	0,490 3	0,050
HK 0,1	0,980 7	0,100
HK 0,2	1,961	0,200
HK 0,3	2,942	0,300
HK 0,5	4,903	0,500
HK 1	9,807	1,000
HK 2	19,614	2,000

[a] Not an SI unit.

7.9 The minimum distance between the limits of two adjacent indentations, oriented side-by-side, shall be at least 2,5 times the length of the short diagonal. For indentations oriented end-to-end, the minimum distance between the limits of two adjacent indents shall be at least one time the length of the long diagonal. If two indentations differ in size, the minimum spacing shall be based on the short diagonal of the larger indentation.

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7.10 The length of the long diagonal shall be measured and used for the calculation of the Knoop hardness. For all tests, the perimeter of the indentation shall be clearly defined in the field of view of the microscope.

NOTE In general, decreasing the test force increases the scatter of the results of the measurements. This is particularly true for low force Knoop hardness tests where the principal limitation will arise in the measurement of the long diagonal of the indentation. For Knoop hardness, the accuracy of the determination of the long diagonal length is unlikely to be better than ± 0,001 mm.

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Magnifications should be provided so that the diagonal can be enlarged to greater than 25 %, but less than 75 % of the field of view.

7.11 The Knoop hardness value shall be calculated by the formula given in Table 1, or by using the tables given in ISO 4545-4.

7.12 If one half of the long diagonal differs by more than 10 % from the other half, check the parallelism between the supporting plane and the measuring plane of the specimen and eventually the alignment of the indenter to the specimen. Test results with deviations greater than 10 % should be discarded.

8 Uncertainty of the results

A complete evaluation of the uncertainty should be done according to the *Guide to the expression of uncertainty in measurement* (GUM) [1].

Independent of the type of sources, for hardness there are two possibilities for the determination of the uncertainty.

— One possibility is based on the evaluation of all relevant sources appearing during a direct calibration. As a reference, an EA guideline [2] is available.

— The other possibility is based on indirect calibration using a hardness reference block [abbreviated as CRM (certified reference material)] (see [3-5] in the Bibliography). A guideline for the determination is given in Annex B.

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