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Metallic materials — Vickers hardness test —

Part 1: Test method

Matériaux métalliques — Essai de dureté Vickers —

Partie 1: Méthode d'essai

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

This fourth edition cancels and replaces the third edition (ISO 6507-1:2005), which has been technically revised.

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

— requirements for testing hardmetals and other cemented carbides have been added;

— all references of indentation diagonals, <0,020 mm, have been removed;

— resolution requirements for the measuring system have been defined;

— the lower test force limit of the Vickers microhardness test has been expanded to 0,009 807 N;

— requirements for the periodic (weekly or daily) verifications of the testing machine are normative, and the maximum permissible bias value has been revised. Requirements for the maximum permissible error in measuring a reference indentation have been revised;

— recommendations for inspection and monitoring of the indenter have been added;

— requirements have been added for the approach velocity of the indenter prior to contact with the sample surface;

— the timing requirements for the test force application and the duration at maximum test force have been revised to indicate target time values;

— Figure 2, which illustrates the requirements for the minimum distance between indentations, has been added, but the requirements have not changed;

— requirements have been added to the test report for reporting the test date and any hardness conversion method used;

— Annex D has been revised;

— Annexes E, F and G have been added concerning Vickers hardness measurement traceability, the CCM — Working group on hardness and adjustment of Köhler illumination systems.

A list of all parts in the ISO 6507 series can be found on the ISO website.

Metallic materials — Vickers hardness test —

Part 1:
Test method

1 Scope

This document specifies the Vickers hardness test method for the three different ranges of test force for metallic materials including hardmetals and other cemented carbides (see Table 1).

Table 1 — Ranges of test force

Ranges of test force, *F* N	Hardness symbol	Designation
$F \geq 49,03$	≥HV 5	Vickers hardness test
$1,961 \leq F < 49,03$	HV 0,2 to <HV 5	Low-force Vickers hardness test
$0,009\,807 \leq F < 1,961$	HV 0,001 to <HV 0,2	Vickers microhardness test

The Vickers hardness test is specified in this document for lengths of indentation diagonals between 0,020 mm and 1,400 mm. Using this method to determine Vickers hardness from smaller indentations is outside the scope of this document as results would suffer from large uncertainties due to the limitations of optical measurement and imperfections in tip geometry.

A periodic verification method is specified for routine checking of the testing machine in service by the user.

For specific materials and/or products, particular International Standards exist.

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 6507-2:2017, *Metallic materials — Vickers hardness test — Part 2: Verification and calibration of testing machines*

ISO 6507-3, *Metallic materials — Vickers hardness test — Part 3: Calibration of reference blocks*

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:

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

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

4 Principle

A diamond indenter, in the form of a right pyramid with a square base and with a specified angle between opposite faces at the vertex, is forced into the surface of a test piece followed by measurement of the diagonal length of the indentation left in the surface after removal of the test force, F (see Figure 1).

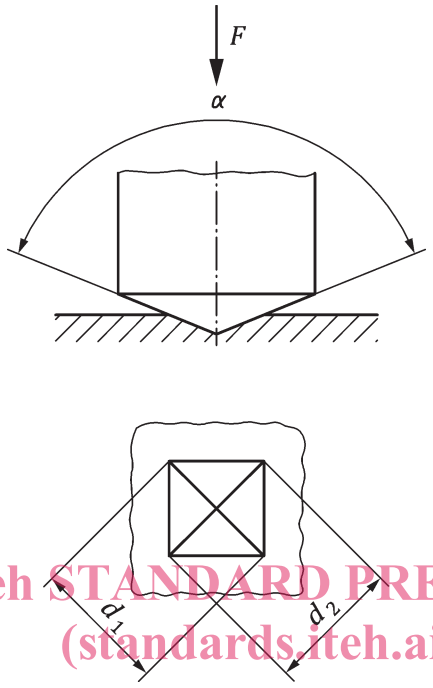


Figure 1 — Principle of the test, geometry of indenter and Vickers indentation

The Vickers hardness is proportional to the quotient obtained by dividing the test force by the area of the sloped surface of indentation, which is assumed to be a right pyramid with a square base and having at the vertex the same angle as the indenter.

NOTE 1 A right pyramid has its apex aligned with the centre of the base.

NOTE 2 As applicable, this document has adopted hardness test parameters as defined by the Working Group on Hardness (CCM-WGH) under the framework of the International Committee of Weights and Measures (CIPM) Consultative Committee for Mass and Related Quantities (CCM) (see Annex F).

5 Symbols and designations

5.1 Symbols and designations used in this document

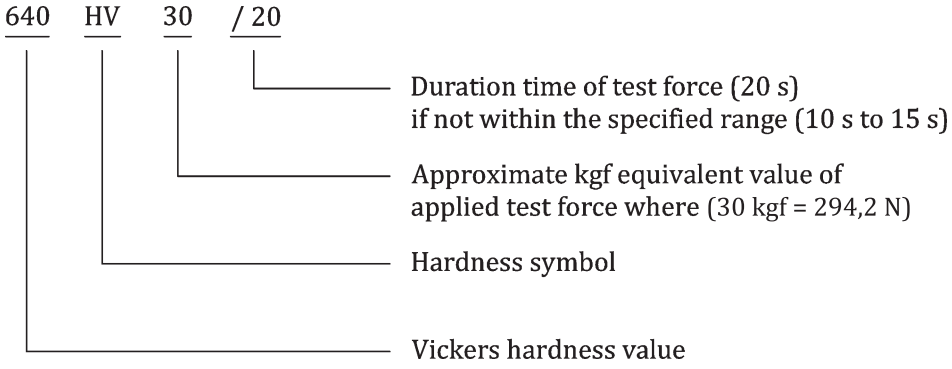
See Table 2 and Figure 1.

Table 2 — Symbols and designations

Symbol	Designation
α	Mean angle between the opposite faces at the vertex of the pyramidal indenter (nominally 136°) (see Figure 1)
F	Test force, in newtons (N)
d	Arithmetic mean, in millimetres, of the two diagonal lengths d_1 and d_2 (see Figure 1)
HV	Vickers hardness $= \dfrac{\text{Test force (kgf)}}{\text{Surface area of indentation (mm}^2\text{)}}$ $= \dfrac{1}{g_n} \times \dfrac{\text{Test Force (N)}}{\text{Surface area of indentation (mm}^2\text{)}}$ $= \dfrac{1}{g_n} \times \dfrac{F}{d^2 / \left(2\sin\dfrac{\alpha}{2}\right)} = \dfrac{1}{g_n} \times \dfrac{2F\sin\dfrac{\alpha}{2}}{d^2}$ For the nominal angle α = 136°, Vickers hardness $\approx 0{,}1891 \times \dfrac{F}{d^2}$
NOTE 1 Standard acceleration due to gravity, g_n = 9,806 65 m/s^2 which is the conversion factor from kgf to N To reduce uncertainty, the Vickers hardness may be calculated using the actual mean indenter angle, α.	

5.2 Designation of hardness number

Vickers hardness, HV, is designated as shown in the following example.



6 Testing machine

6.1 Testing machine

The testing machine shall be capable of applying a predetermined force or forces within the desired range of test forces, in accordance with ISO 6507-2.

6.2 Indenter

The indenter shall be a diamond in the shape of a right pyramid with a square base, as specified in ISO 6507-2.

6.3 Diagonal measuring system

The diagonal measuring system shall satisfy the requirements in ISO 6507-2.

Magnifications should be provided so that the diagonal can be enlarged to greater than 25 % but less than 75 % of the maximum possible optical field of view. Many objective lenses are nonlinear towards the edge of the field of view.

A diagonal measuring system using a camera for measurement can use 100 % of the camera's field of view provided it is designed to consider field of view limitations of the optical system.

The resolution required of the diagonal measuring system depends on the size of the smallest indentation to be measured and shall be in accordance with Table 3. In determining the resolution of the measuring system, the resolution of the microscope optics, the digital resolution of the measuring scale and the step-size of any stage movement, where applicable, should be taken into account.

Table 3 — Resolution of the measuring system

Diagonal length, d mm	Resolution of the measuring system
$0{,}020 \leq d < 0{,}080$	0,000 4 mm
$0{,}080 \leq d \leq 1{,}400$	0,5 % of d

7 Test piece

7.1 Test surface

The test shall be carried out on a surface which is smooth and even, free from oxide scale, 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.

For hardmetal samples, the thickness of the layer removed from the surface shall be not less than 0,2 mm.

7.2 Preparation

Surface preparation shall be carried out in such a way as to prevent surface damage or alteration of the surface hardness due to excessive heating or cold-working.

Due to the small depth of Vickers microhardness indentations, it is essential that special precautions be taken during preparation. It is recommended to use a polishing/electropolishing process which is suitable for the material to be measured.

7.3 Thickness

The thickness of the test piece or of the layer under test shall be at least 1,5 times the diagonal length of the indentation as defined in Annex A. No deformation shall be visible at the back of the test piece after the test.

The thickness of a hardmetal test piece shall be at least 1 mm.

NOTE The depth of the indentation is approximately 1/7 of the diagonal length (0,143 d).

7.4 Tests on curved surfaces

For tests on curved surfaces, the corrections given in Tables B.1 to B.6 shall be applied.

7.5 Support of unstable test pieces

For a test piece of small cross-section or of irregular shape, either a dedicated support should be used or it should be mounted in a similar manner to a metallographic micro-section in appropriate material so that it is adequately supported and does not move during the force application.

8 Procedure

8.1 Test temperature

The test is normally carried out at ambient temperature within the limits of 10 °C to 35 °C. If the test is carried out at a temperature outside this range, it shall be noted in the test report. Tests carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

8.2 Test force

The test forces given in Table 4 are typical. Other test forces may be used including greater than 980,7 N, but not less than 0,009 807 N. Test forces shall be chosen that result in indentations with diagonals greater than 0,020 mm.

NOTE For hardmetals, the preferred test force is 294,2 N (HV 30).

Table 4 — Typical test forces

Hardness test[a]		Low-force hardness test		Microhardness test	
Hardness symbol	Nominal value of the test force, F N	Hardness symbol	Nominal value of the test force, F N	Hardness symbol	Nominal value of the test force, F N
—	—	—	—	HV 0,001	0,009 807
—	—	—	—	HV 0,002	0,019 61
—	—	—	—	HV 0,003	0,029 42
—	—	—	—	HV 0,005	0.049 03
HV 5	49,03	HV 0,2	1,961	HV 0,01	0,098 07
HV 10	98,07	HV 0,3	2,942	HV 0,015	0,147 1
HV 20	196,1	HV 0,5	4,903	HV 0,02	0,196 1
HV 30	294,2	HV 1	9,807	HV 0,025	0,245 2
HV 50	490,3	HV 2	19,61	HV 0,05	0,490 3
HV 100[a]	980,7	HV 3	29,42	HV 0,1	0,980 7

[a] Nominal test forces greater than 980,7 N may be applied.

8.3 Periodic verification

The periodic verification defined in Annex C shall be performed within a week prior to use for each test force used but is recommended on the day of use. The periodic verification is recommended whenever the test force is changed. The periodic verification shall be done whenever the indenter is changed.

8.4 Test piece support and orientation

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

For anisotropic materials, for example, those which have been heavily cold-worked, there could be a difference between the lengths of the two diagonals of the indentation. Therefore, where possible, the

indentation should be made so that the diagonals are oriented in plane at approximately 45° to the direction of cold-working. The specification for the product could indicate limits for the differences between the lengths of the two diagonals.

8.5 Focus on test surface

The diagonal measuring system microscope shall be focused so that the specimen surface and the desired test location can be observed.

NOTE Some testing machines do not require that the microscope be focused on the specimen surface.

8.6 Test force application

The indenter shall be brought into contact with the test surface and the test force shall be applied in a direction perpendicular to the surface, without shock, vibration or overload, until the applied force attains the specified value. The time from the initial application of the force until the full test force is reached shall be 7^{+1}_{-5} s .

NOTE 1 The requirements for the time durations are given with asymmetric limits. For example, 7^{+1}_{-5} s indicates that 7 s is the nominal time duration, with an acceptable range of not less than 2 s (calculated as 7 s – 5 s) to not more than 8 s (calculated as 7 s + 1 s).

For the Vickers hardness range and low-force Vickers hardness range tests, the indenter shall contact the test piece at a velocity of ≤0,2 mm/s. For micro-hardness tests, the indenter shall contact the test piece at a velocity of ≤0,070 mm/s.

The duration of the test force shall be 14^{+1}_{-4} s , except for tests on materials whose time-dependent properties would make this an unsuitable range. For these tests, this duration shall be specified as part of the hardness designation (see 5.2).

NOTE 2 There is evidence that some materials are sensitive to the rate of straining which causes changes in the value of the yield strength. The corresponding effect on the termination of the formation of an indentation can make alterations in the hardness value.

8.7 Prevention of the effect of shock or vibration

Throughout the test, the testing machine shall be protected from shock or vibration[5].

8.8 Minimum distance between adjacent indentations

The minimum distance between adjacent indentations and the minimum distance between an indentation and the edge of the test piece are shown in Figure 2.

The distance between the centre of any indentation and the edge of the test piece shall be at least 2,5 times the mean diagonal length of the indentation in the case of steel, copper and copper alloys and at least three times the mean diagonal length of the indentation in the case of light metals, lead and tin and their alloys.

The distance between the centres of two adjacent indentations shall be at least three times the mean diagonal length of the indentation in the case of steel, copper and copper alloys and at least six times the mean diagonal length in the case of light metals, lead and tin and their alloys. If two adjacent indentations differ in size, the spacing shall be based on the mean diagonal length of the larger indentation.

