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Metallic materials — Vickers hardness test —

Part 1:
Test method

Matériaux métalliques — Essai de dureté Vickers —

Partie 1: Méthode d'essai

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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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This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459, ECISS - European Committee for Iron and Steel Standardization, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fifth edition of ISO 6507-1, together with ISO 4545-1:2023, cancels and replaces ISO 4516:2002, ISO 4545-1:2017 and ISO 6507-1.

The main changes are as follows:

— Scope revised to include testing on metallic coatings and other inorganic coatings;

— added 7.6 - Metallic and other inorganic coatings;

— requirements have been added to the test report for reporting the surface curvature, if the curvature correction is applicable;

— added Annex H to cover coatings specific requirements;

— updated references.

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

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.

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 hard metals and other cemented carbides (see Table 1), metallic coatings and other inorganic coatings.

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.

The Vickers hardness specified in this document is also applicable for metallic and other inorganic coatings including electrodeposited coatings, autocatalytic coatings, sprayed coatings and anodic coatings on aluminium.

This document is applicable to measurements normal to the coated surface and to measurements on cross-sections, provided that the characteristics of the coating (smoothness, thickness, etc.) permit accurate readings of the diagonal of the indentation.

This document is not applicable for coatings with thickness less than 0,030 mm when testing normal to the coating surface. This standard is not applicable for coatings with thickness less than 0,100 mm when testing a cross-section of the coating. ISO 14577-1 can be used for the determination of hardness from smaller indentations."

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

For specific materials and/or products, relevant 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 6507-2:2018, *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 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/

4 Symbols and designations

4.1 Symbols and designations used in this document

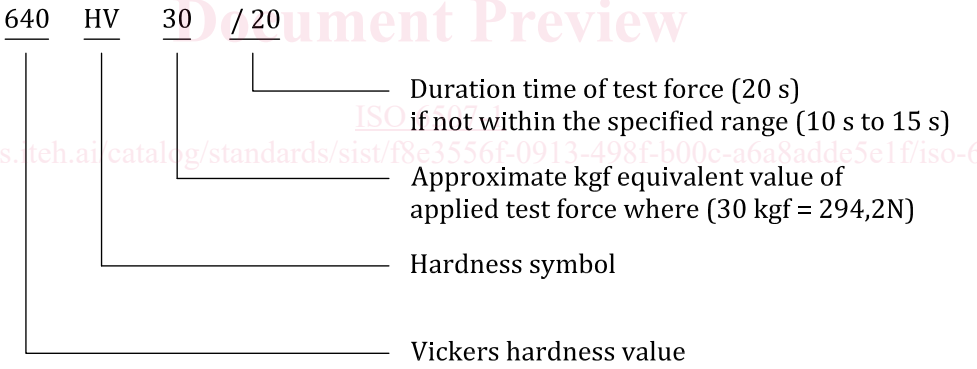
See Table 2 and Figure 1.

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 $\approx 0{,}189\ 1 \times \dfrac{F}{d^2}$
To reduce uncertainty, the Vickers hardness may be calculated using the actual mean indenter angle, α. NOTE Standard acceleration due to gravity, g_n = 9,806 65 m/s^2 which is the conversion factor from kgf to N	

4.2 Designation of hardness number

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



5 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).

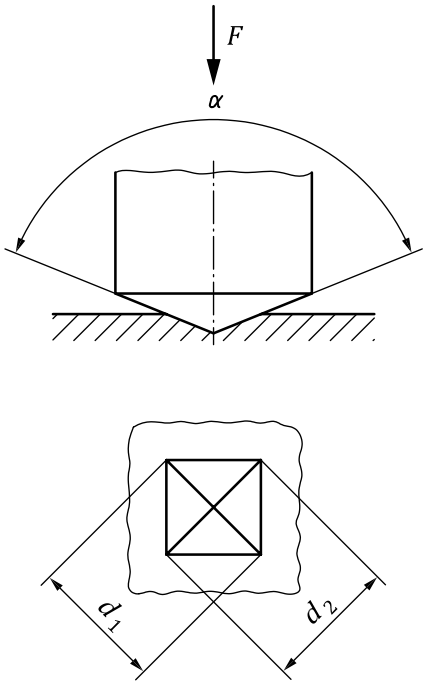


Figure 1 — Principle of the test, geometry of indenter and Vickers indentation

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).

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 hard-metal 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 hard-metal 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.

7.6 Metallic and other inorganic coatings

Annex H specifies additional procedures and requirements, which shall be applied when determining the Vickers hardness of metallic and other inorganic coatings.

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 not less than 0,020 mm.

NOTE For hard metals, 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 4.2).

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

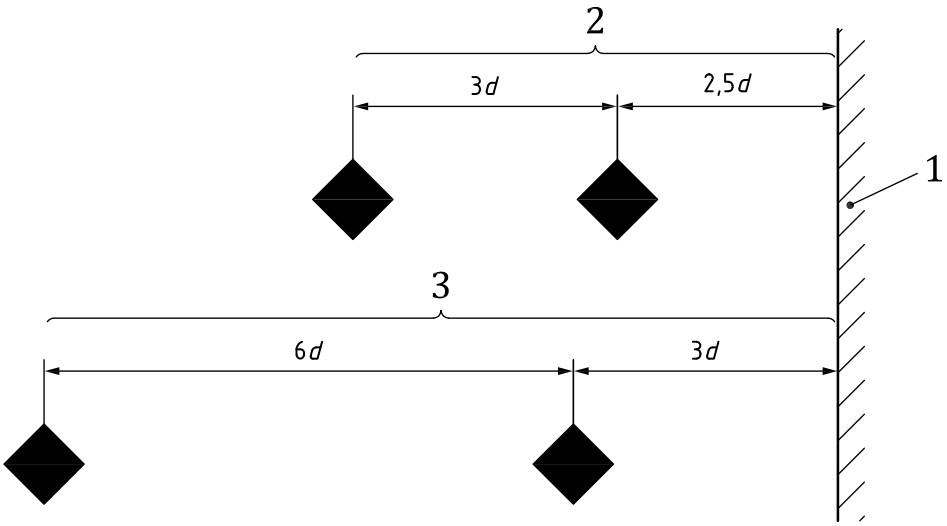
Throughout the test, the testing machine shall be protected from shock or vibration[1].

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.



Key

1 edge of test piece

2 steel, copper and copper alloys

3 light metals, lead and tin and their alloys

Figure 2 — Minimum distance for Vickers indentations

8.9 Measurement of the diagonal length

The lengths of the two diagonals shall be measured. The arithmetical mean of the two readings shall be taken for the calculation of the Vickers hardness. For all tests, the perimeter of the indentation shall be clearly defined in the field of view of the microscope.

Magnifications should be selected so that the diagonal can be enlarged to greater than 25 %, but less than 75 % of the maximum possible optical field of view; see 6.3.

NOTE 1 In general, decreasing the test force increases the scatter of results of the measurements. This is particularly true for low-force Vickers hardness tests and Vickers microhardness tests, where the principal limitation will arise in the measurement of the diagonals of the indentation. For Vickers microhardness, the accuracy of determination of the mean diagonal length is unlikely to be better than ±0,001 mm when using an optical microscope (see References [2] to [5]).

NOTE 2 A helpful technique for adjusting optical systems that have Köhler illumination is given in Annex G.

For flat surfaces, the difference between the lengths of the diagonals should not be greater than 5 %. If the difference is greater, this shall be stated in the test report.

This standard is not applicable to indentations having diagonal lengths less than 0,020 mm. Hardness measurements requiring smaller indentation sizes can be made in accordance with ISO 14577-1, ISO 14577-2 and ISO 14577-3 (see References [6] to [8]).

8.10 Calculation of hardness value

Calculate the Vickers hardness value using the formula given in Table 2. The Vickers hardness value can also be determined using the calculation tables given in ISO 6507-4.[9] For curved surfaces, the correction factors given in Annex B shall be applied.

9 Uncertainty of the results

A complete evaluation of the uncertainty should be done according to JCGM 100:2008[10].