International Standard

ISO 14705

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for hardness of monolithic ceramics at room temperature

Céramiques techniques — Méthodes d'essai de dureté des céramiques monolithiques à température ambiante

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Foreword

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This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 184, *Advanced technical ceramics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 14705:2016), which has been technically revised.

The main changes are as follows:

— clarification of the required resolution of the diagonal measuring system (4.4.3 and 5.4.3);

— modification of the required measurement accuracy (4.6.12 and 5.6.12).

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.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for hardness of monolithic ceramics at room temperature

1 Scope

This document specifies a test method for determining the Vickers and Knoop hardness of monolithic fine ceramics at room 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 4545-1, *Metallic materials — Knoop hardness test — Part 1: Test method*

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

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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/

3.1
Vickers hardness
value obtained by dividing the applied force by the projected area of the indentation, calculated from the arithmetic mean of the measured diagonals of the indentations, assuming that the indentation is a permanent imprint of the undeformed indenter

Note 1 to entry: Vickers hardness may be expressed either

a) with units of GPa, obtained by dividing the applied force in N by the projected area of the indentation in mm^2,

or

b) as a dimensionless Vickers hardness number, obtained by dividing the applied force in N by a scaling factor corresponding to the standard gravity (9,806 65 m/s^2) and by the projected area of the indentation in mm^2.

Note 2 to entry: The scaling factor ensures that the resulting dimensionless value is numerically identical to legacy calculations historically expressed in kgf/mm^2.

3.2
Vickers indenter
indenter in the shape of a right-angle pyramid with a square base and an angle between opposite faces of 136°

Note 1 to entry: See Table 1 and Figure 1.

3.3
Knoop hardness
value obtained by dividing the applied force by the projected area of the indentation, calculated from the measured long diagonal of the indentation, assuming that the indentation is a permanent imprint of the undeformed indenter

Note 1 to entry: The Knoop hardness may be expressed either

a) with units of GPa, obtained by dividing the applied force in N by the projected area of the indentation in mm^2,

or

b) as a dimensionless Knoop hardness number, obtained by dividing the applied force in N by a scaling factor corresponding to the standard gravity (9,806 65 m/s^2) and by the projected area of the indentation in mm^2.

Note 2 to entry: The scaling factor ensures that the resulting dimensionless value is numerically identical to legacy calculations historically expressed in kgf/mm^2.

3.4
Knoop indenter
indenter in the shape of a rhombic-based pyramid with the two angles between the opposite edges at 172,5° and 130°

Note 1 to entry: See Table 3 and Figure 6.

4 Vickers hardness

4.1 Principle

Forcing a diamond indenter in the form of a right-angle pyramid with a square base, and with a specified angle between opposite faces at the vertex into the surface of a test piece and measuring the length of the diagonals of the indentation left in the surface after removal of the test force, *F*. See Figure 1 and Figure 2.

4.2 Symbols, abbreviated terms and designations

4.2.1 See Table 1, Figure 1 and Figure 2.

4.2.2 The Vickers hardness is expressed either as a physical unit of pressure (GPa) or as a conventional, dimensionless hardness number.

When using SI unit (GPa), the hardness value is denoted by the unit symbol GPa, followed by the designation HV and a value representing the exact test force in Newtons (N)

EXAMPLE 1 15,0 GPa HV 9,807 N represents a Vickers hardness of 15,0 GPa, determined with a test force of 9,807 N.

When using the dimensionless Vickers hardness number, the value is denoted by the symbol HV, preceded by the hardness value and followed by a force indicator number representing the nominal test force (see Table 2).

EXAMPLE 2 1 500 HV 1 represents a Vickers hardness number of 1 500, determined with a test force indicator of 1 (corresponding to a nominal test force of 9,807 N).

Table 1 — Symbols, abbreviated terms and designations for Vickers hardness testing

Symbol or abbreviated term	Designation
α	Angle between the opposite faces at the vertex of the pyramidal indenter (136° ± 0,5°)
F	Test force, in newtons
d	Arithmetic mean, in millimetres, of the two diagonals, d_1 and d_2
HV	Vickers hardness $= \text{Constant} \times \frac{\text{Test force}}{\text{Surface area of indentation}}$ a) Units of GPa $= 0,001\ \frac{2F \sin \frac{136°}{2}}{d^2} = 0,001\ 854 \frac{F}{d^2}$ b) Hardness number (no units specified) $= \frac{1}{g} \frac{2F \sin \frac{136°}{2}}{d^2} = 0,101\,97 \frac{2F \sin \frac{136°}{2}}{d^2} = 0,189\,1 \frac{F}{d^2}$
c	Arithmetic mean of the half of the two median crack lengths, $2c_1$ and $2c_2$
SD	Standard deviation $= \sqrt{\frac{\sum \left(\overline{\text{HV}} - \text{HV}_n\right)^2}{n-1}}$ where $\overline{\text{HV}}$ is the arithmetic mean of the Vickers hardness $= \frac{\sum \text{HV}_n}{n}$; HV_n is the HV obtained from nth indentation; n is the number of indentations.

NOTE The scaling constant $\frac{1}{g} = \frac{1}{9,806\,65} = 0,101\,97$, where g is the acceleration of gravity is a historical mathematical wrapper ensuring that the resulting hardness number remains numerically identical to legacy engineering records previously calculated in kgf/mm^2.

Table 2 — Hardness symbols and the nominal values of test forces, *F*, for Vickers hardness testing

Hardness symbol	**Test force**, F (nominal value)
HV 0,5	4,903 N
HV 1	9,807 N
HV 2	19,61 N
HV 3	29,42 N
HV 5	49,03 N
HV 10	98,07 N
HV 20	196,1 N