
**Metallic materials — Knoop hardness
test —**

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

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*Matériaux métalliques — Essai de dureté Knoop —
Partie 2: Vérification et étalonnage des machines 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 4545-2 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

ISO 4545-2 cancels and replaces ISO 4546:1993, which has been technically revised.

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

- *Part 1: Test method* [ISO 4545-2:2005](https://standards.iteh.ai/catalog/standards/sist/4b55d4a-d9b0-417a-a7e6-2bb07e5266d9/iso-4545-2-2005)
- *Part 2: Verification and calibration of testing machines*
- *Part 3: Calibration of reference blocks*
- *Part 4: Table of hardness values*

Metallic materials — Knoop hardness test —

Part 2: Verification and calibration of testing machines

1 Scope

This part of ISO 4545 specifies the method of verification of testing machines for determining Knoop hardness for metallic materials in accordance with ISO 4545-1-1. It covers test forces from 0,098 07 N to 19,614 N. The method is recommended only for indentations with diagonals $\geq 0,020$ mm.

It specifies a direct verification method for checking the main functions of the machine, and an indirect verification method suitable for the overall checking of the machine. The indirect verification method may be used on its own for periodic routine checking of the machine in service.

If a testing machine is also to be used for other methods of hardness testing, it should be verified independently for each method.

2 Normative references

ISO 4545-2:2005

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.

ISO 376:2004, *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines*

ISO 4545-1:2005, *Metallic materials — Knoop hardness test — Part 1: Test method*

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

3 General conditions

Before a Knoop hardness testing machine is verified, it shall be checked to ensure that it is properly set up in accordance with the manufacturer's instructions.

Especially, it should be checked that:

- a) the mount holding the indenter is capable of moving freely without any friction or excess side play;
- b) the indenter is firmly mounted in the mount;
- c) the test force can be applied and removed without shock or vibration and in such a manner that the readings are not influenced;

- d) the measuring system is integral with the machine:
 - the change in mode from the application and removal of the test force to the measuring mode does not influence the readings,
 - illumination does not affect the readings,
 - the centre of the indentation is near the centre of the field of view.

4 Direct verification

4.1 General

4.1.1 Direct verification should be carried out at a temperature of (23 ± 5) °C. If the verification is carried out at a temperature outside this range, it shall be noted in the verification report.

4.1.2 The instruments used for verification and calibration shall be traceable to national standards.

4.1.3 Direct verification involves:

- a) calibration of the test force;
- b) verification of the indenter;
- c) calibration of the measuring system;
- d) verification of the testing cycle.

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4.2 Calibration of the test force

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4.2.1 Each test force used (see Table 2 in ISO 4545-1:2005) within the working range of the testing machine, shall be measured.

4.2.2 The test force shall be measured by one of the following two methods:

- by means of an elastic proving device in accordance with ISO 376:2004, class 1, or
- by balancing against a force, accurate to $\pm 0,2$ %, applied by means of calibrated masses or another method with the same accuracy.

4.2.3 Three readings shall be taken for each test force. Immediately before each reading is taken, the indenter shall be moved in the same direction as during the test. All readings shall be within the tolerances defined in Table 1.

Table 1 — Test-force tolerances

Test force, F N	Tolerance %
$0,098\ 07 \leq F < 1,961$	$\pm 1,5$
$1,961 \leq F \leq 19,614$	$\pm 1,0$

4.3 Verification of the indenter

4.3.1 The four faces of the diamond pyramid shall be polished and free from surface defects.

4.3.2 Verification of the shape of the indenter can be made by direct measurement or optical measurement. The device used for the verification shall be accurate to within $\pm 0,07^\circ$.

4.3.3 The angle α between the opposite edges at the vertex of the diamond pyramid shall be $(172,5 \pm 0,1)^\circ$ (see Figure 1).

4.3.4 The angle β between the opposite edges at the vertex of the diamond pyramid shall be $(130 \pm 1,0)^\circ$ (see Figure 1).

4.3.5 The indenter constant c (see ISO 4545-1:2005, Table 1) shall be within 1,0 % of the ideal value 0,070 28, $(0,069\ 58 \leq c \leq 0,070\ 98)$.

NOTE To achieve the tolerances for the indenter constant c , the values of angle α and/or angle β may be kept to closer tolerances than given above.

4.3.6 The angle between the axis of the diamond pyramid and the axis of the indenter holder (normal to the seating surface) shall be within $\pm 0,5^\circ$.

4.3.7 The four faces shall meet at a common point. The maximum permissible length of the line of conjunction between opposite faces shall be less than $1,0\ \mu\text{m}$ (see Figure 2).

NOTE For indents less than $0,020\ \text{mm}$, the maximum permissible length of the line of conjunction should be proportionally less. The line of conjunction may be determined by measuring an indentation.

4.4 Calibration of the measuring system

4.4.1 The system for measuring the long diagonal of the indentation shall be calibrated at each magnification to be used against an accurately ruled line scale (object micrometer) or system of equivalent accuracy. The errors of the line scale shall be known within an uncertainty of $0,1\ \mu\text{m}$ or $0,05\ \%$, whichever is greater.

4.4.2 The measuring system shall be verified by measurements made on a stage micrometer at a minimum of five intervals over each working range.

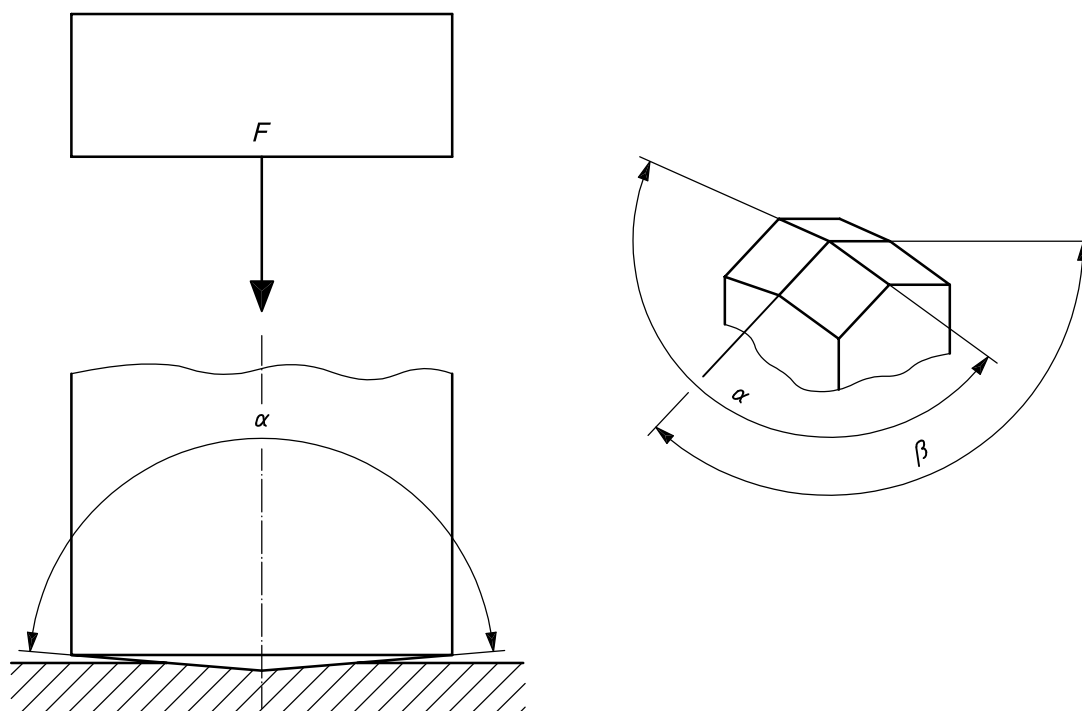


Figure 1 — Principle of the test and indenter geometry

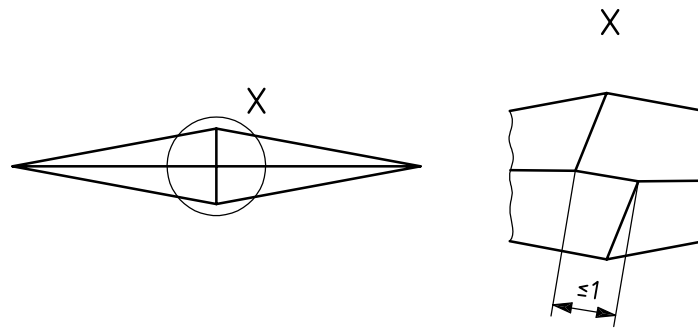


Figure 2 — Line of conjunction on the top of the indenter (schematic)

4.4.3 The maximum permissible error of the measuring system shall be $\pm 0,5 \%$ or $0,4 \mu\text{m}$, whichever is greater. If necessary, a calibration factor can be applied to comply with this tolerance.

4.5 Verification of the testing cycle

The testing cycle shall be timed with an uncertainty of 1 s and shall conform to the testing cycle of ISO 4545-1.

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5 Indirect verification

5.1 Indirect verification should be carried out at a temperature of $(23 \pm 5) \text{ }^\circ\text{C}$ by means of reference blocks calibrated in accordance with ISO 4545-3. If the verification is carried out at a temperature outside this range, it shall be noted in the verification report.

5.2 On each reference block, measure the reference indentation. For each block, the difference between the mean measured value and the certified long diagonal shall not exceed the greater of $0,5 \%$ and $0,4 \mu\text{m}$.

5.3 When verifying testing machines used for several test forces, all used forces shall be chosen. One of the forces shall be the lowest force used and the other force shall be chosen within the upper half of those used. For each test force chosen, two different reference blocks shall be chosen within the range for which the machine is used. The ratio of the hardness values for the two blocks shall be equal to or greater than 2.

5.4 When verifying testing machines used for only one test force, three reference blocks shall be used, uniformly distributed over the range of the machine.

5.5 On each reference block, five indentations shall be made and measured. The tests shall be carried out in accordance with ISO 4545-1.

5.6 For each reference block, let d_1, d_2, \dots, d_5 be the values of the measured diagonals of the indentations, arranged in increasing order of magnitude, and

$$\bar{d} = \frac{d_1 + d_2 + \dots + d_5}{5} \tag{1}$$

5.7 The repeatability r of the testing machine, under the particular verification conditions, is calculated as:

$$r = d_5 - d_1 \tag{2}$$

The repeatability, expressed as a percentage of \bar{d} , is calculated as:

$$r_{\text{rel}} = 100 \frac{d_5 - d_1}{\bar{d}} \quad (3)$$

The repeatability of the testing machine is satisfactory if $r \leq 0,001$ mm. If $r > 0,001$ mm, the repeatability of the testing machine is satisfactory when r_{rel} is less than or equal to the percentages indicated in Table 2.

Table 2 — Relative repeatability

Hardness range of standardized test blocks	Test force N	Maximum permissible r_{rel} %
100 ≤ HK ≤ 250	0,098 07 ≤ F ≤ 4,903	9
250 < HK ≤ 650		5
HK > 650		4
100 ≤ HK ≤ 250	4,903 < F ≤ 19,614	8
250 < HK ≤ 650		5
HK > 650		4

HK: Knoop hardness

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5.8 The error, E , of the testing machine under the particular verification conditions is calculated by the following formula:

$$E = \bar{d} - d_c \quad (4)$$

The percent error, E_{rel} , is calculated by the following equation:

$$E_{\text{rel}} = 100 \frac{\bar{d} - d_c}{d_c} \quad (5)$$

where d_c is the reported certified mean diagonal length for the reference block, in millimetres.

The error of the testing machine is satisfactory if $E \leq \pm 0,000 5$ mm. If $E > 0,000 5$ mm, the error of the testing machine is satisfactory when $E_{\text{rel}} \leq \pm 2$ %.

5.9 The determination of the uncertainty of measurement of the calibration results of the hardness testing machine is given in Annex B.

6 Intervals between verifications

The specifications for the direct verifications of hardness testing machines are given in Table 3.

Indirect verification shall be performed at least once every 12 months and after a direct verification has been performed.

Table 3 — Direct verifications of hardness testing machines

Requirements of verification	Force	Measuring system	Test cycle	Indenter ^a
before setting to work first time	x	x	x	x
after dismantling and reassembling, if force, measuring system or test cycle are affected	x	x	x	
failure of indirect verification ^b	x	x	x	
indirect verification > 14 months ago	x	x	x	

^a In addition, it is recommended that the indenter be directly verified after 2 years of use.

^b Direct verification of these parameters may be carried out sequentially (until the machine passes indirect verification) and is not required if it can be demonstrated (e.g. by tests with a reference indenter) that the indenter was the cause of the failure.

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7 Verification report/calibration certificate

The verification report/calibration certificate shall contain the following information:

- a) a reference to this part of ISO 4545: [ISO 4545-2:2005](https://standards.iteh.ai/catalog/standards/sist/4b55d4a-d9b0-417a-a7e6-2bb07e5266d9/iso-4545-2-2005)
- b) method of verification (direct and/or indirect);
- c) identification data of the hardness testing machine;
- d) means of verification (reference blocks, elastic proving devices, etc.);
- e) test force(s) used;
- f) hardness values of standardized blocks used;
- g) verification temperature, if it is outside the range specified in Clause 4;
- h) the result obtained;
- i) date of verification and reference to the verification institution;
- j) uncertainty of the verification result.

Annex A **(informative)**

Notes on diamond indenters

Experience has shown that a number of initially satisfactory indenters can become defective after use for a comparatively short time. This is due to small cracks, pits or other flaws in the surface. If such faults are detected in time, regrinding may reclaim many indenters. If not, any small defects on the surface rapidly worsen and make the indenter useless.

Therefore,

- the condition of indenters should be monitored by visually checking the appearance of the indentation on a reference block, each day the testing machine is used;
- the verification of the indenter is no longer valid when the indenter shows defects;
- reground or otherwise repaired indenters shall meet all of the requirements of 4.3.

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