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Metallic materials — Vickers hardness test —

Part 3:
Calibration of reference blocks

Matériaux métalliques — Essai de dureté Vickers —

Partie 3: Étalonnage des blocs de référence

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Contents

Page

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 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).

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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 6507-3:2005), which has been technically revised.

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

— requirements have been added for the maximum test surface area of the reference block;

— requirements have been revised for the maximum uncertainty of the line intervals on the stage micrometer;

— requirements for the calibration and verification of the measuring system have been revised per ISO 6507-2;

— requirements for the uniformity of the reference block hardness have been revised to account for different numbers of calibration indentations;

— the timing requirements for the approach velocity and the time duration at maximum test force have been revised to indicate a target time value;

— Annex A has been revised.

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

Metallic materials — Vickers hardness test —

Part 3:
Calibration of reference blocks

1 Scope

This document specifies a method for the calibration of reference blocks to be used for the indirect verification of Vickers hardness testing machines, as specified in ISO 6507-2.

The method is applicable only for indentations with diagonals ≥0,020 mm.

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 376, *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial 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

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 http://www.iso.org/obp

4 Manufacture of reference blocks

4.1 General

The block shall be specially manufactured for use as a hardness-reference block using a manufacturing process that will give the necessary homogeneity, stability of structure, uniformity of surface hardness and time-dependent stability in hardness.

4.2 Thickness

The thickness of the reference block shall not be less than 5 mm.

4.3 Test surface area

The test surface area of the reference block shall not exceed 40 cm^2.

4.4 Magnetism

The reference blocks shall be free of magnetism. It is recommended that the manufacturer shall ensure that the blocks, if made of steel, have been demagnetized at the end of the manufacturing process (before calibration).

4.5 Flatness and parallelism

The maximum deviation in flatness of the test and support surfaces shall not exceed 0,005 mm. The maximum error in parallelism shall not exceed 0,010 mm in 50 mm.

4.6 Surface roughness

The test surface shall be free from scratches that interfere with the measurement of the indentations. The test surface roughness, R_a, shall not exceed 0,05 µm.[1] The bottom support surface shall be a finely ground finish or better.

4.7 Prevention of the regrind of the test surface

To verify that no material has been subsequently removed from the reference block, its thickness at the time of calibration shall be marked on the reference block to the nearest 0,01 mm or an identifying mark shall be made on the test surface [see Clause 9 e)].

5 Calibration machine

5.1 General

In addition to fulfilling the general requirements specified in ISO 6507-2, the calibration machine shall also meet the requirements given in 5.2 to 5.6.

NOTE The criteria specified in this document for the performance of the calibration machine have been developed and refined over a significant period of time. When determining a specific tolerance that the machine needs to meet, the uncertainty associated with the use of measuring equipment and/or reference standards has been incorporated within this tolerance and it would therefore be inappropriate to make any further allowance for this uncertainty by, for example, reducing the tolerance by the measurement uncertainty. This applies to all measurements made when performing a direct verification of the calibration machine.

5.2 Direct verification

The calibration machine shall be verified directly at intervals not exceeding 12 months.

Direct verification involves

a) verification of the test force,

b) verification of the indenter,

c) calibration and verification of the diagonal measuring system, and

d) verification of the testing cycle; if this is not possible, at least the force versus time behaviour.

5.3 Traceability of verification instruments

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

5.4 Test force

Each test force shall be verified at three different positions of the plunger, spaced at approximately equal increments covering the limits of travel used during testing. At each position, the force shall be measured three times using an elastic proving device according to ISO 376, class 0,5 or better or by another method having the same or better accuracy. Each measurement shall agree with the nominal value to within ±0,2 % for normal hardness, to within ±0,3 % for low-force hardness and to within ±0,5 % for microhardness.

5.5 Indenter

The indenter shall comply with ISO 6507-2 and meet the following requirements.

a) The four faces of the square-based diamond pyramid shall be highly polished, free from surface defects and flat within 0,000 3 mm.

b) The angle between the opposite faces of the vertex of the diamond pyramid shall be 136° ± 0,1°.

c) The angle between the axis of the diamond pyramid and the axis of the indenter-holder (normal to the seating surface) shall be less than 0,3°.

d) The point of the diamond indenter shall be examined with a high-power measuring microscope or preferably with an interference microscope. If the four faces do not meet at a point, the line of junction, as described in ISO 6507-2, between opposite faces shall comply with the values in Table 1.

Table 1

Ranges of test force, F **N**	**Maximum permissible length of the line of junction, a** **mm**
$F \geq 49{,}03$	0,001
$1{,}961 \leq F < 49{,}03$	0,000 5
$0{,}009\,807 \leq F < 1{,}961$	0,000 25

e) It shall be verified that the quadrilateral which would be formed by the intersection of the faces with a plane perpendicular to the axis of the diamond pyramid has angles of 90° ± 0,2° (see Figure 1).

A valid calibration certificate shall exist which confirms the geometrical deviations of the indenter.

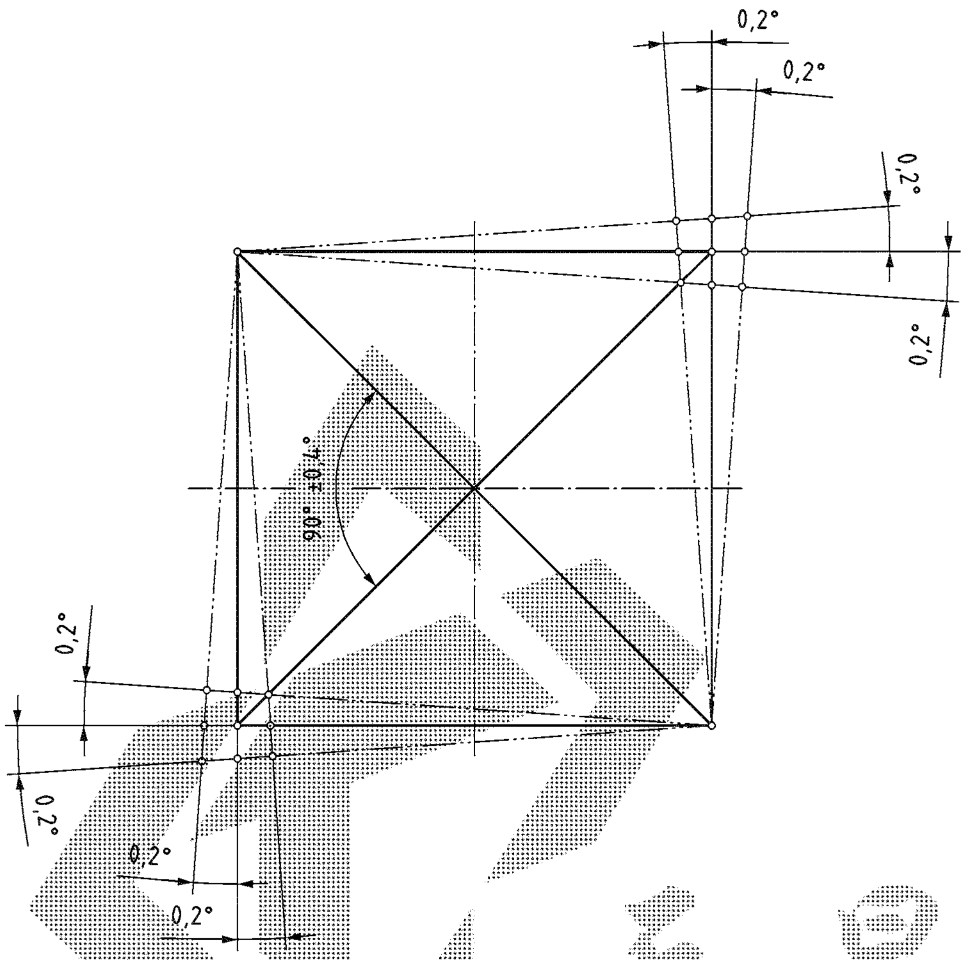

Figure 1 — Permissible difference of the sectional planes of the square form

5.6 Diagonal measuring system

The scale of the diagonal measuring system shall be graduated to permit estimation of the diagonals of the indentation in accordance with Table 2.

Table 2

Diagonal length, ***d*** mm	**Resolution of the diagonal measuring system**	**Maximum permissible error**
$d \leq 0{,}060$	0,000 15 mm	±0,000 3 mm
$0{,}060 < d \leq 0{,}200$	0,25 % of d	±0,5 % of d
$d > 0{,}200$	0,000 5 mm	±0,001 mm

The system for measuring the diagonal of the indentation shall be verified at each magnification and for each incorporated line scale to be used in two perpendicular measurement axis (if applicable), by performing measurements on an accurately ruled stage micrometer. Measurements shall be made at a minimum of five evenly spaced intervals, arranged centrally in the field of view, covering each working range.

The maximum expanded uncertainty of the distance between the line intervals on the stage micrometer shall be 0,000 2 mm or 0,04 %, whichever is greater.

Three measurements shall be made at each of the evenly spaced intervals. The maximum permissible error of each of the three measurements at each interval shall not exceed the values given in Table 2.

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

6 Calibration procedure

The reference blocks shall be calibrated by a calibration machine as described in Clause 5, at a temperature of (23 ± 5) °C, using the general procedure specified in ISO 6507-1.

During calibration, the thermal drift should not exceed 1 °C.

The time from the initial application of force until the full test force is reached and the approach velocity of the indenter shall meet the requirements given in Table 3.

The duration of application of the test force shall be 14^{+1}_{-1} s.

For microhardness testing, (0,009 807 N ≤ F < 1,961 N), the maximum allowable vibrational acceleration reaching the calibration machine shall be 0,005 g_n (g_n equals the standard acceleration of gravity: g_n = 9,806 65 m/s²).

Table 3

Ranges of test force, F N	Time for application of the test force s	Approach velocity of the indenter mm/s
F < 1,961	7^{+1}_{-1}	0,05 to 0,2
1,961 ≤ F < 49,03	7^{+1}_{-1}	0,05 to 0,2
F ≥ 49,03	7^{+1}_{-1}	0,015 to 0,07

7 Number of indentations

On each reference block, a minimum of five indentations shall be made, uniformly distributed over the test surface. At least one of the indentations shall be identified as a reference indentation.

For microhardness tests and to reduce the measurement uncertainty, more than five indentations should be made. It is recommended to make 10, 15 or 25 indentations on five locations on the reference block.

8 Uniformity of hardness

8.1 Relative non-uniformity

For each reference block, let H_1, H_2, ..., H_n be the n measured hardness values arranged in increasing order of magnitude corresponding to the measured diagonals d_1, d_2, ..., d_n in decreasing order of magnitude. The average hardness, $\overline{H}$, is calculated according to Formula (1):

$$\overline{H} = \frac{H_1 + H_2 + ... + H_n}{n} \quad (1)$$

The relative non-uniformity, r_{rel}, expressed as a percentage of $\overline{H}$, is calculated according to Formula (2):

$$r_{rel} = 100 \times \frac{H_n - H_1}{\overline{H}} \quad (2)$$

The maximum permissible value of non-uniformity, r_{rel}, of a reference block is given in Tables 4 to 8.

Table 4 — Maximum permissible non-uniformity for n = 5

Hardness of block	Maximum permissible value of non-uniformity, r_{rel}, %		
	<HV 0,2	HV 0,2 to <HV 5	HV 5 to HV 100
≤250 HV[a]	8,0 or $d_1 - d_n$ = 0,001 mm[b]	6,0	4,0
>250 HV		4,0	2,0

[a] For hardness values <150 HV, the maximum permissible value of non-uniformity shall be 16 % or $d_1 - d_n$ = 0,001 mm, whichever is greater, where d_1 and d_n are the arithmetic mean diagonal lengths corresponding to H_1 and H_n respectively.

[b] Whichever is greater.

Table 5 — Maximum permissible non-uniformity for n = 10

Hardness of block	Maximum permissible value of non-uniformity, r_{rel}, %		
	<HV 0,2	HV 0,2 to <HV 5	HV 5 to HV 100
≤250 HV[a]	10,6 or $d_1 - d_n$ = 0,001 mm[b]	8,0	5,2
>250 HV		5,2	2,6

[a] For hardness values <150 HV, the maximum permissible value of non-uniformity shall be 21,2 % or $d_1 - d_n$ = 0,001 mm, whichever is greater, where d_1 and d_n are the arithmetic mean diagonal lengths corresponding to H_1 and H_n respectively.

[b] Whichever is greater.

Table 6 — Maximum permissible non-uniformity for n = 15

Hardness of block	Maximum permissible value of non-uniformity, r_{rel}, %		
	<HV 0,2	HV 0,2 to <HV 5	HV 5 to HV 100
≤250 HV[a]	12,0 or $d_1 - d_n$ = 0,001 mm[b]	9,0	6,0
>250 HV		6,0	3,0

[a] For hardness values <150 HV, the maximum permissible value of non-uniformity shall be 23,8 % or $d_1 - d_n$ = 0,001 mm, whichever is greater, where d_1 and d_n are the arithmetic mean diagonal lengths corresponding to H_1 and H_n respectively.

[b] Whichever is greater.

Table 7 — Maximum permissible non-uniformity for n = 20

Hardness of block	Maximum permissible value of non-uniformity, r_{rel}, %		
	<HV 0,2	HV 0,2 to <HV 5	HV 5 to HV 100
≤250 HV[a]	12,8 or $d_1 - d_n$ = 0,002 mm[b]	9,6	6,4
>250 HV		6,4	3,2

[a] For hardness values <150 HV, the maximum permissible value of non-uniformity shall be 25,6 % or $d_1 - d_n$ = 0,002 mm, whichever is greater, where d_1 and d_n are the arithmetic mean diagonal lengths corresponding to H_1 and H_n respectively.

[b] Whichever is greater.

Table 8 — Maximum permissible non-uniformity for n = 25

Hardness of block	Maximum permissible value of non-uniformity, r_{rel}, %		
	<HV 0,2	HV 0,2 to <HV 5	HV 5 to HV 100
≤250 HV[a]	13,6 or $d_1 - d_n$ = 0,002 mm[b]	10,2	6,8
>250 HV		6,8	3,4

[a] For hardness values <150 HV, the maximum permissible value of non-uniformity shall be 27,0 % or $d_1 - d_n$ = 0,002 mm, whichever is greater, where d_1 and d_n are the arithmetic mean diagonal lengths corresponding to H_1 and H_n respectively.

[b] Whichever is greater.

8.2 Uncertainty of measurement

The determination of the uncertainty of measurement of hardness reference blocks is given in Annex A.

9 Marking

Each reference block shall be marked with the following information:

a) the arithmetic mean of the hardness values found in the calibration test, for example, 249 HV 30;

b) the name or mark of the supplier or manufacturer;

c) the serial number;

d) the name or mark of the calibrating agency;

e) the thickness of the block, or an identifying mark on the test surface (see 4.7);

f) the year of calibration, if not indicated in the serial number.

All markings shall be placed on the test surface or on the side of the block. Any mark put on the side of the block shall be the right way up when the test surface is facing up.

10 Calibration certificate

Each delivered reference block shall be accompanied with a document giving at least the following information:

a) a reference to this document, i.e. ISO 6507-3;

b) the serial number of the block;

c) the date of calibration;

d) the arithmetic mean of the hardness values in the format defined in ISO 6507-1 and the value characterizing the non-uniformity of the block;

e) information about the location of each calibration indentation, together with its mean measured diagonal length.

11 Validity

The reference block is only valid for the scale for which it was calibrated.

The calibration validity should be limited to a duration of five years. Attention is drawn to the fact that, for Al- and Cu-alloys, the calibration validity should be reduced to two to three years.

Annex A
(informative)

Uncertainty of the mean hardness value of hardness reference blocks

A.1 General

Measurement uncertainty analysis is a useful tool to help determine sources of error and to understand differences between measured values. This annex gives guidance on uncertainty estimation but the values derived are for information only, unless specifically instructed otherwise by the customer. The criteria specified in this document for the performance of the testing machine have been developed and refined over a significant period of time. When determining a specific tolerance that the machine needs to meet, the uncertainty associated with the use of measuring equipment and/or reference standards has been incorporated within this tolerance and it would therefore be inappropriate to make any further allowance for this uncertainty by, for example, reducing the tolerance by the measurement uncertainty. This applies to all measurements made when performing a direct or indirect verification of the machine. In each case, it is simply the measured value resulting from the use of the specified measuring equipment and/or reference standards that is used to assess whether or not the machine complies with this document. However, there may be special circumstances where reducing the tolerance by the measurement uncertainty is appropriate. This should only be done by agreement of the parties involved.

The metrological chain necessary to define and disseminate hardness scales is described in ISO 6507-1.

A.2 Direct verification of the hardness-calibration machine

A.2.1 Calibration of the test force

See ISO 6507-2.

A.2.2 Calibration of the diagonal measuring device

See ISO 6507-2.

A.2.3 Verification of the indenter

See ISO 6507-2.

A.2.4 Verification of the test cycle

See ISO 6507-2.

A.3 Indirect verification of the hardness-calibration machine

NOTE In this annex, the index "certified reference material" (CRM) means, according to the definitions of the hardness testing standards, "hardness reference block".

By the indirect verification with primary hardness-reference blocks calibrated by the national-level calibration agency (see ISO 6507-1), the overall function of the hardness calibration machine is checked and the repeatability, as well as the deviation of the hardness-calibration machine from the actual hardness value, are determined.

The uncertainty of the measurement bias of the hardness calibration machine, u_{CM}, when measuring a primary hardness-reference block is calculated according to Formula (A.1):

$$u_{CM} = \sqrt{u_{CRM\text{-}P}^2 + u_{xCRM\text{-}P}^2 + u_{CRM\text{-}D}^2 + 2 \times u_{ms}^2} \quad (A.1)$$

where

$u_{CRM\text{-}P}$ is the calibration uncertainty of the primary hardness reference block, according to the calibration certificate for $k = 1$;

$u_{xCRM\text{-}P}$ is the standard uncertainty of hardness-calibration machine when measuring the CRM;

$u_{CRM\text{-}D}$ is the standard uncertainty due to the hardness change of the primary hardness reference block since its last calibration due to drift;

u_{ms} is the uncertainty due to the resolution of the hardness-calibration machine.

Regarding u_{ms}, both the resolution of the length measurement indicating instrument and the optical resolution of the measuring microscope shall be considered. In most cases, the overall resolution of the measurement system should be included twice in the calculation of u_{CM} due to resolving the positions of both ends of the long diagonal independently.

EXAMPLE

Using the results shown in Table A.1 and the following information:

— hardness of the primary hardness-reference block: H_{CRM} = 401,1 HV 30;

— uncertainty of measurement of the primary hardness-reference block (k = 1): u_{CRM} = 2,5 HV 30;

— uncertainty of measurement due to time drift of the primary hardness-reference block: u_{CRM-D} = 0;

— resolution of the diagonal measurement system is calculated according to Formula (A.2): δ_{ms} = 0,000 322 mm:

$$\delta_{ms} = \sqrt{\delta_{OR}^2 + \delta_{IR}^2} \quad (A.2)$$

where

δ_{OR} is the optical resolution of the microscope objective (0,000 31 mm);

NOTE $\delta_{OR} = \lambda / (2 \times NA)$

where

λ is the wave length of light in µm (approx. 0,55 µm for green light;,

NA is the numerical aperture of the objective.

EXAMPLE For a 100× objective with an NA of 0,9 using green light, δ_{OR} = 0,55 µm/ (2 × 0,9) = 0,306 µm.

The above optical resolution formula is valid for lighting inclined at large angles.

δ_{IR} is the resolution of the display indicator of the measuring system (0,000 1 mm).

— uncertainty of measurement due to the resolution of the diagonal measurement system is calculated according to Formula (A.3):

$$u_{\mathrm{ms}} = \frac{\delta_{\mathrm{ms}}}{2 \times \sqrt{3}} = 0{,}000\,093\ \mathrm{mm} \tag{A.3}$$

— standard uncertainty of the hardness-calibration machine when measuring the CRM is calculated according to Formula (A.4):

$$u_{x\mathrm{CRM\text{-}P}} = \frac{t \cdot s_{x\mathrm{CRM\text{-}P}}}{\sqrt{n}} = 0{,}36\ \mathrm{HV\ 30} \tag{A.4}$$

where t = 1,14 for n = 5,

the uncertainty of the measurement bias of the hardness calibration machine, u_{CM}, when measuring a primary hardness-reference block is calculated according to Formula (A.1), and as shown in Table A.2.

The bias is calculated according to Formula (A.5):

$$b = \overline{H} - H_{\mathrm{CRM}} \tag{A.5}$$

b = (400 − 401,1) HV 30 = −1,1 HV 30

Table A.1 — Results of the indirect verification

No.	Measured indentation diagonal, d mm	Calculated hardness value, H HV 30[a]
1	0,373 4_{max}	$399{,}0_{min}$
2	0,373 0	399,9
3	0,372 5_{min}	$400{,}9_{max}$
4	0,372 8	400,3
5	0,372 9	400,1
Mean value	0,372 9	400,0
Standard deviation, $s_{x\mathrm{CRM\text{-}P}}$	0,000 33	0,70
Standard uncertainty of measurement, $u_{x\mathrm{CRM\text{-}P}}$	0,000 17	0,36
[a] HV: Vickers hardness.		

Table A.2 — Budget of uncertainty of measurement

Quantity X_i	Estimated value x_i	Standard uncertainty of measurement $u(x_i)$	Distribution type	Sensitivity coefficient c_i	Uncertainty contribution $u_i(H)$ HV 30
u_{CRM}	401,1 HV 30	2,5 HV 30	Normal	1,0	2,5
$u_{x\mathrm{CRM\text{-}P}}$	0 HV 30	0,36 HV 30	Normal	1,0	0,36
u_{ms}	0 mm	0,000 093 mm	Rectangular	−2 145,0[a]	−0,20
$u_{\mathrm{CRM\text{-}D}}$	0 HV 30	0 HV 30	Triangular	1,0	0
Combined uncertainty of measurement of the bias, u_{CM}					2,54
Expanded uncertainty of measurement of the bias, U_{CM} (k = 2)					5,08
[a] The sensitivity coefficient follows from $c = \lvert\partial H/\partial d\rvert = -2(H/d)$ for H = 400,0 HV 30, d = 0,372 9 mm.					

A.4 Uncertainty of measurement of hardness reference blocks

The uncertainty of measurement of hardness reference blocks is calculated according to Formula (A.6):

$$u_{\mathrm{CRM}} = \sqrt{u_{\mathrm{CM}}^2 + u_{x\mathrm{CRM}}^2 + 2 \times u_{\mathrm{ms}}^2} \quad \text{(A.6)}$$

where

u_{CM} is the uncertainty of the measurement bias of the hardness calibration machine when measuring a primary reference block [see Formula (A.1)].

$u_{x\mathrm{CRM}}$ is the standard uncertainty of the hardness measurement of hardness reference blocks with the hardness calibration machine;

u_{ms} is the uncertainty due to the resolution of the hardness-calibration machine.

Regarding u_{ms}, both the resolution of the length measurement indicating instrument and the optical resolution of the measuring microscope shall be considered. In most cases, the overall resolution of the measurement system should be included twice in the calculation of u_{CRM} due to resolving the positions of both ends of the long diagonal independently.

For a hardness-reference block value that is not corrected for measurement bias, the uncertainty of the measurement value is calculated according to Formula (A.7):

$$U_{\mathrm{CRM}} = 2 \times u_{\mathrm{CRM}} + |b| \quad \text{(A.7)}$$

For a hardness-reference block value that is corrected for measurement bias, the hardness-reference block value is corrected according to Formula (A.8):

$$H_{\mathrm{CRM}} = \bar{H} - b \quad \text{(A.8)}$$

and the uncertainty of the measurement value is calculated according to Formula (A.9):

$$U_{\mathrm{CRM}} = 2 \times u_{\mathrm{CRM}} \quad \text{(A.9)}$$

EXAMPLE

Using the test results shown in Table A.3 and the following information:

— standard uncertainty of the hardness measurement of hardness reference blocks is calculated according to Formula (A.10):

$$u_{x\mathrm{CRM}} = \frac{t \cdot s_{x\mathrm{CRM}}}{\sqrt{n}} \quad \text{(A.10)}$$

with t = 1,14 and n = 5:

$u_{x\mathrm{CRM}}$ = 0,39 HV 30

— combined uncertainty of measurement (from Table A.2): u_{CM} = 2,54 HV 30;

— resolution of the diagonal measurement system, using u_{ms} (mm) from Formula (A.3): u_{ms} = −0,20 HV 30,

the uncertainty of measurement of hardness reference blocks, u_{CRM}, is calculated according to Formula (A.6), and as shown in Table A.4.

Table A.3 — Determination of the inhomogeneity of the hardness-reference block

No.	Measured indentation diagonal, d mm	Calculated hardness value, H_{CRM} HV 30[a]
1	0,363 4_{max}	421,3_{min}
2	0,363 0	422,2
3	0,362 5_{min}	423,4_{max}
4	0,362 8	422,7
5	0,362 9	422,4
Mean value	0,362 9	422,4
Standard deviation, s_{xCRM}	0,000 33	0,76

Table A.4 — Uncertainty of measurement of the hardness-reference block

Quantity X_i	Estimated value x_i	Standard uncertainty of measurement $u(x_i)$	Distribution type	Sensitivity coefficient c_i	Uncertainty contribution $u_i(H)$ HV 30
u_{CM}	0 HV 30	2,54 HV 30	Normal	1,0	2,54
u_{xCRM}	—	0,39 HV 30	Normal	1,0	0,39
u_{ms}	0 mm	0,000 093 mm	Rectangular	2 327,7[a]	−0,22
Combined uncertainty of measurement, u_{CRM}					2,59
Hardness-reference block value with measurement uncertainty, $\bar{H} \pm (2 \times u_{CRM} + \|b\|)$					(422,4 ± 6,2)
Corrected hardness-reference block value with measurement uncertainty, $(\bar{H} - b) \pm (2 \times u_{CRM})$					(423,4 ± 5,2)

[a] The sensitivity coefficient follows from $c = |\partial H/\partial d| = -2(H/d)$ for H = 422,4 HV 30, d = 0,3629 mm.

Annex B
(informative)

Adjustment of Köhler illumination systems

B.1 General

While some optical systems are permanently aligned, others have means of minor adjustments. To gain the utmost in resolution, the following adjustments may be helpful.

B.2 Köhler illumination

Focus, to critical sharpness, the surface of a flat polished specimen.

Centre the illuminating source.

Centrally align the field and aperture diaphragms.

Open the field diaphragm so that it just disappears from the field of view.

Remove the eyepiece and examine the rear focal plane of the objective. If all the components are in their proper places, the source of illumination and the aperture diaphragm will appear in sharp focus.

A full-aperture diaphragm is preferred for maximum resolving power. If the glare is excessive, reduce the aperture, but never use less than 3/4 of the opening, since the resolution would be decreased and diffraction phenomena could lead to false measurements.

If the light is too strong for eye comfort, reduce the intensity by using an appropriate neutral density filter or rheostat control.

Bibliography

[1] ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

[2] SAWLA A. *Uncertainty of measurement in the verification and calibration of the force measuring systems of testing machines*, Proceedings of the Asia-Pacific symposium on measurement of force, mass and torque (APMF), Tsukuba, Japan, November 2000

[3] WEHRSTEDT A., & PATKOVSZKY I. *News in the field of standardization about verification and calibration of materials testing machines*, May 2001, EMPA Academy 2001

[4] GABAUER W. *Manual codes of practice for the determination of uncertainties in mechanical tests on metallic materials, The estimation of uncertainties in hardness measurements*, Project No. SMT4-CT97-2165, UNCERT COP 14: 2000

[5] POLZIN T., & SCHWENK D. Method for Uncertainty Determination of Hardness Testing; PC File for Determination, *Materialprüfung* **44** (2002) 3, pp. 64-71

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