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Metallic materials — Brinell hardness test —

Part 2: Verification and calibration of testing machines

Matériaux métalliques — Essai de dureté Brinell —

Partie 2: Vérification et étalonnage des machines d'essai

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Foreword

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The committee responsible for this document is ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This third edition cancels and replaces the second edition (ISO 6506-2:2005), which has been technically revised.

ISO 6506 consists of the following parts, under the general title *Metallic materials — Brinell hardness test*:

— *Part 1: Test method*

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

— *Part 3: Calibration of reference blocks*

— *Part 4: Table of hardness values*

Metallic materials — Brinell hardness test —

Part 2:
Verification and calibration of testing machines

1 Scope

This part of ISO 6506 specifies methods of direct and indirect verification of testing machines used for determining Brinell hardness in accordance with ISO 6506-1, and also specifies when these two types of verification has to be performed.

The direct verification involves checking that individual machine performance parameters fall within specified limits whereas the indirect verification utilizes hardness measurements of reference blocks, calibrated in accordance with ISO 6506-3, to check the machine's overall performance.

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

This part of ISO 6506 is applicable to both fixed location and portable hardness testing machines. For machines that are incapable of satisfying the specified force-time profile, the direct verification of force and testing cycle can be modified by the use of Annex B.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 6506-1:2014, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6506-3, *Metallic materials — Brinell hardness test — Part 3: Calibration of reference blocks*

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

3 General conditions

Before a Brinell hardness testing machine is verified, the machine 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 ball-holder slides correctly in its guide,

b) every ball-holder with a ball used during the calibration is firmly held in the mount,

c) the test force is applied and removed without shock, vibration, or overrun and in such a manner that the readings are not influenced, and

d) if the indentation diameter measuring system is integrated into the machine,

— the change from removing the test force to measuring mode does not influence the diameter measurements,

— the illumination does not affect the diameter measurements, and

— the centre of the indentation is in the centre of the field of view, if necessary.

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 made outside this temperature range, this shall be reported in the verification report.

4.1.2 The instruments used for verification shall be traceable to the SI.

4.1.3 Direct verification involves

a) measurement of the test forces,

b) measurement of the diameter, hardness, and density of the indenter ball,

c) calibration of the indentation diameter measuring system, and

d) measurement of the testing cycle.

For each of the above items, direct verification also includes assessment of the results against the specified tolerances.

4.2 Measurement of the test forces

4.2.1 Each test force shall be measured within the working range of the testing machine. When the force is applied in open-loop mode by a lever or other system employing a mechanical advantage, this shall be done at no fewer than three positions of the indenter uniformly spaced throughout its range of movement during testing.

4.2.2 Three measurements shall be made for each force at each position of the indenter. Immediately before each measurement is taken, the indenter shall be moved in the same direction as during testing.

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

— by means of a force-proving instrument in accordance with ISO 376 Class 1 or better;

— by balancing against a force, accurate to ±0,2 %, applied by means of calibrated masses or another method with the same accuracy.

4.2.4 Each measurement of a force shall be within ±1,0 % of the nominal test force (see Formula A.2), as defined in ISO 6506-1.

4.3 Measurement of the properties of the indenter ball

4.3.1 The indenter consists of a ball and an indenter holder. The verification applies only to the ball.

4.3.2 For the purpose of verifying the size and the hardness of the balls, a minimum of two balls, selected at random from a batch, shall be tested. Each sampled ball shall be verified for size and hardness and then discarded.

4.3.3 The balls shall be polished and free from surface defects.

4.3.4 The user shall either measure the balls to ensure that they meet the following requirements or shall obtain balls from a supplier certifying that the following conditions are met.

4.3.4.1 The diameter shall be determined by taking the mean value of not less than three single values of diameter measured at different positions on the ball. No single value shall differ from the nominal diameter by more than the tolerance given in Table 1.

Table 1 — Tolerances for the different ball diameters

Ball diameter mm	Tolerance mm
10	±0,005
5	±0,004
2,5	±0,003
1	±0,003

4.3.4.2 The characteristics of the tungsten carbide composite balls shall be as follows:

a) Hardness: The hardness shall be not less than 1 500 HV, when determined in accordance with ISO 6507-1. The tungsten carbide composite ball can be tested directly on its spherical surface or by sectioning the ball and testing on the ball interior.

b) Density: ρ = (14,8 ± 0,2) g/cm^3.

The density can be determined from the sampled balls, prior to hardness testing, or from the whole batch. The following chemical composition is recommended:

— tungsten carbide (WC): balance;

— total other carbides: 2,0 %;

— cobalt (Co): 5,0 % to 7,0 %.

4.4 Calibration of the indentation diameter measuring system

4.4.1 For systems where the indentation diameter is measured directly, the scale of the system shall be graduated to permit estimation of the diameter to within ±0,5 %. The indentation diameter measuring system shall be calibrated for every objective lens, and for each incorporated line scale, in two perpendicular measurement axes (if applicable), by measurements made on a standard scale at a minimum of four intervals, arranged centrally in the field of view, for each working range. For each measurement, the magnitude of the difference between the measured and reference values shall not be greater than 0,5 % (see Formula A.7).

4.4.2 For systems where the indentation diameter is calculated from a measurement of projected area, the system shall be calibrated for every objective lens by measurements of a range of at least four standard circular reference images covering the range of areas measured. The maximum error shall not exceed 1 % of the area.

4.4.3 All systems shall also be verified by making measurements of certified reference indentations, such as those on hardness reference blocks calibrated in accordance with ISO 6506-3. For each ball size, at least four indentations, covering the working range of diameters, shall be measured by each objective lens. During these measurements, the type of illumination shall remain unchanged. No mean measured diameter shall differ from the certified mean diameter of the reference indentation by more than 0,5 %.

4.5 Verification of the testing cycle

4.5.1 The testing cycle is to be verified by the testing machine manufacturer at the time of manufacture and when the testing machine undergoes repair which might have affected the testing cycle. Verification of the testing cycle at other times is as specified in Table 4.

4.5.2 The testing cycle shall be verified to conform with the testing cycle defined in ISO 6506-1, taking into account any uncertainty associated with the timing measurements.

5 Indirect verification

5.1 Indirect verification should be carried out at a temperature of (23 ± 5) °C by means of reference blocks calibrated in accordance with ISO 6506-3. If the verification is made outside of this temperature range, this shall be reported in the verification report.

The test and bottom surfaces of the reference blocks and the surfaces of indenters shall not contain any additives or corrosion products.

5.2 The testing machine shall be verified for each test force and for each size of ball used. For each test force, at least two reference blocks shall be selected from the hardness ranges specified in Table 2 (for $0{,}102 \times F/D^2 = 30$) and Table 3 (for other force-diameter indices).

The two reference blocks shall be taken from different hardness ranges, if possible.

5.3 If this indirect verification is not the one immediately following a direct verification, the reference indentation on each reference block shall be measured, with the same type of illumination that was used during the machine's previous direct verification. For each indentation, the difference between the mean measured value and the certified mean diameter shall not exceed 0,5 %. If preferred, this check can instead be made on a similarly sized indentation in a separate reference block.

5.4 On each reference block, five indentations shall be uniformly distributed over the test surface and measured. The test shall be made in accordance with ISO 6506-1.

5.5 For each reference block, let d_1, d_2, d_3, d_4, and d_5 be the mean values of the measured diameters of the indentations, arranged in increasing order of magnitude, and

$$\bar{d} = \frac{d_1 + d_2 + d_3 + d_4 + d_5}{5} \quad (1)$$

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

$$r = d_5 - d_1 \quad (2)$$

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

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

5.7 The repeatability of the testing machine is satisfactory when r_{rel} does not exceed the values specified in Table 2 or Table 3.

5.8 For each reference block, let H_1, H_2, H_3, H_4, and H_5 be the hardness values corresponding to the five indentations, with the mean hardness, $\bar{H}$, being given by

$$\bar{H} = \frac{H_1 + H_2 + H_3 + H_4 + H_5}{5} \quad (4)$$

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

$$E = \bar{H} - H_C \quad (5)$$

where

H_C is the certified hardness of the reference block.

The relative error, E_{rel}, is calculated, as a percentage of H_C from the following formula:

$$E_{rel} = 100 \times \frac{\bar{H} - H_C}{H_C} \quad (6)$$

The error of the testing machine, expressed as a percentage of the certified hardness of the reference block, shall not exceed the values given in Table 2 and Table 3.

Table 2 — Repeatability and error of the testing machine for force-diameter index = 30

Hardness range	Hardness	Permissible repeatability, r_{rel}, of the testing machine %	Permissible error, E_{rel}, of the testing machine %
1	H_C < 250 HBW	3,0	±3,0
2	H_C from 250 HBW to 450 HBW	2,5	±2,5
3	H_C > 450 HBW	2,0	±2,0

Table 3 — Repeatability and error of the testing machine for other force-diameter indices

Hardness range	0,102 × F/D^2 = 10	0,102 × F/D^2 = 5	0,102 × F/D^2 ≤ 2,5	Permissible repeatability r_{rel} of the testing machine %	Permissible error E_{rel} of the testing machine %
	Hardness	Hardness	Hardness		
1	H_C < 100 HBW	H_C < 70 HBW	H_C < 70 HBW	3,0	±3,0
2	H_C from 100 HBW to 200 HBW	H_C from 70 HBW to 100 HBW	N/A	3,0	±3,0
3	H_C > 200 HBW	H_C > 100 HBW	N/A	3,0	±3,0

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

6 Intervals between verifications

The specifications for the direct verifications are given in Table 4.

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

Table 4 — Direct verifications of hardness testing machines

Requirements of verification	Force	Indentation diameter measuring system	Test cycle	Indenter[a]
before setting to work first time	x	x	x	x
after dismantling and reassembling, if force, indentation diameter measuring system or test cycle are affected	x	x	x	
failure of indirect verification[b]	x	x	x	
indirect verification > 13 months ago	x	x	x	

[a] In addition, it is recommended that the indenter be directly verified or replaced after two years of use.

[b] Direct verification of these parameters can 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 replacement indenter) that the indenter was the cause of the failure.

7 Verification report/calibration certificate

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

a) reference to this part of ISO 6506 (i.e. ISO 6506-2);

b) method of verification (direct and/or indirect);

c) identification data for the hardness testing machine;

d) means of verification (reference blocks, elastic proving devices, etc.);

e) diameter of the ball indenter and test force;

f) verification temperature;

g) result obtained;

h) date of verification and reference to the verification institution;

i) uncertainty of the verification results.

Annex A
(informative)

Uncertainty of measurement of the verification results of the hardness testing machine

A.1 General

The metrological chain necessary to define and disseminate hardness scales is shown in ISO 6506-1:2014, Figure C.1.

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 part of ISO 6506 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 part of ISO 6506. However, there might be special circumstances where reducing the tolerance by the measurement uncertainty is appropriate. This should only be done with the agreement of all parties involved.

A.2 Direct verification of the hardness testing machine

A.2.1 Measurement of the test forces

The combined relative standard uncertainty of the test force calibration is calculated according to the following formula:

$$u_F = \sqrt{u_{F\mathrm{RS}}^2 + u_{F\mathrm{HTM}}^2} \tag{A.1}$$

where

$u_{F\mathrm{RS}}$ is the relative standard uncertainty of measurement of the force transducer (from calibration certificate) for $k = 1$;

$u_{F\mathrm{HTM}}$ is the relative standard uncertainty of the test force generated by the hardness testing machine.

The uncertainty of measurement of the reference instrument, force transducer, is indicated in the corresponding calibration certificate. The following influence quantities should be considered for critical applications:

— temperature dependence;

— long-term stability;

— interpolation deviation.

Depending on the design of the force transducer, the rotational position of the transducer related to the indenter axis of the hardness testing machine should be considered.

EXAMPLE

Uncertainty of measurement of the force transducer (from calibration certificate): U_{FRS} = 0,12 % (k = 2)

Nominal test force: F_{RS} = 1 839 N

Table A.1 — Results of the test force calibration

Number of height position for test force calibration	Series 1 F_1 N	Series 2 F_2 N	Series 3 F_3 N	Mean value $\bar{F}$ N	Relative deviation ΔF_{rel} %	Relative standard measurement uncertainty u_{FHTM} %
1	1 835,0	1 836,6	1 837,9	1 836,5	−0,14	0,10
2	1 834,3	1 835,7	1 837,5	1 835,8	−0,17	0,12
3	1 831,0	1 839,5	1 835,3	1 835,3	−0,20	0,31

where

$$\Delta F_{rel} = 100 \times \frac{\bar{F} - F_{RS}}{F_{RS}} \tag{A.2}$$

$$u_{FHTM} = 100 \times \frac{s_{F,i}}{\bar{F}} \times t \quad \text{(for three readings, } t = 1{,}32\text{)} \tag{A.3}$$

where

$s_{F,i}$ is the standard deviation of the test force indication values in the i-th height position.

In Table A.2, the maximum value of u_{FHTM} from Table A.1 is used.

Table A.2 — Calculation of the uncertainty of measurement of the test force

Quantity X_i	Estimated value x_i	Relative limit values a_i	Distribution type	Relative standard measurement uncertainty $u(x_i)$	Sensitivity coefficient c_i	Relative uncertainty contribution u_{rel}
Force transducer measurement	1 839 N		Normal	$0,6 \times 10^{-3}$	1	$0,6 \times 10^{-3}$
Generated test force	1 839 N		Normal	$3,1 \times 10^{-3}$	1	$3,1 \times 10^{-3}$
Relative combined standard uncertainty, u_F						$3,1 \times 10^{-3}$
Relative expanded uncertainty of measurement, U_F (k = 2)						$6,2 \times 10^{-3}$

Table A.3 — Calculation of the maximum relative deviation of the test force including the uncertainty of measurement of the reference instrument

Relative deviation of test force ΔF_{rel} %	Expanded relative measurement uncertainty of test force U_F %	Max. relative deviation of test force including measurement uncertainty of reference instrument ΔF_{max} %
−0,20	0,62	0,83

where

$$\Delta F_{max} = |\Delta F_{rel}| + U_F \qquad (A.4)$$

The result of the example means that the deviation of the test force including the uncertainty of measurement of the reference instrument specified in 4.2, amounting to ±1,0 % is complied with.

A.2.2 Calibration of the indentation diameter measuring system

The combined relative standard uncertainty of the indentation diameter measuring system is calculated as follows:

$$u_L = \sqrt{u_{LRS}^2 + u_{ms}^2 + u_{LHTM}^2} \qquad (A.5)$$

where

u_{LRS} is the relative uncertainty of measurement of object micrometer (reference standard) from the calibration certificate for $k = 1$;

u_{ms} is the relative uncertainty of measurement due to the resolution of the measuring system;

u_{LHTM} is the relative standard uncertainty of length measurement of the hardness testing machine.

The uncertainty of measurement of the object micrometer (the reference standard for the indentation diameter measuring system) is indicated in its calibration certificate. The following influence quantities do not exert an essential influence on the uncertainty of measurement of the object micrometer:

— temperature dependence;

— long-term stability;

— interpolation deviation.

EXAMPLE

Uncertainty of measurement of the object micrometer:	U_{LRS} = 0,000 5 mm (k = 2)
Resolution of the measuring system:	δ_{ms} = 1,0 µm

Table A.4 — Results of the calibration of the indentation diameter measuring system

Indication value of the object micrometer L_{RS} mm	Series 1 L_1 mm	Series 2 L_2 mm	Series 3 L_3 mm	Mean value $\bar{L}$ mm	Relative deviation ΔL_{rel} %	Relative standard measurement uncertainty u_{LHTM} %
1,000	1,002	1,003	1,001	1,002	0,20	0,13
2,000	2,001	2,003	2,001	2,002	0,08	0,08
3,000	3,002	3,002	3,001	3,002	0,06	0,03
4,000	4,001	4,003	4,002	4,002	0,05	0,03

where

$$u_{LHTM} = \frac{s_{L,i}}{\bar{L}} \times t \text{ , (for three readings, } t = 1{,}32) \quad \text{(A.6)}$$

where

$s_{L,i}$ is the standard deviation of the length indication values for the i-th indication value of the object micrometer.

$$\Delta L_{rel} = \frac{\bar{L} - L_{RS}}{L_{RS}} \quad \text{(A.7)}$$

In Table A.5, the maximum value of u_{LHTM} from Table A.4 is used, although these calculations should also be performed at every other reference length.

Table A.5 — Calculation of the uncertainty of measurement of the indentation diameter measuring system

Quantity X_i	Estimated value x_i	Limit value a_i	Distribution type	Relative standard measurement uncertainty $u(x_i)$	Sensitivity coefficient c_i	Relative uncertainty contribution u_i
Reference standard length	1,0 mm		Normal	$2{,}5 \times 10^{-4}$	1	$2{,}5 \times 10^{-4}$
Measurement system resolution		$\pm 1{,}0 \times 10^{-3}$	Rectangular	$2{,}9 \times 10^{-4}$	1	$2{,}9 \times 10^{-4}$
Measurement system calibration	1,0 mm		Normal	$1{,}3 \times 10^{-3}$	1	$1{,}3 \times 10^{-3}$
Relative combined uncertainty of measurement, u_L, %						0,14
Relative expanded uncertainty of measurement, U_L (k = 2), %						0,27

Table A.6 — Calculation of the maximum relative deviation of the indentation diameter measuring system including the uncertainty of measurement of the length reference instrument

Test length L_{RS}	Relative deviation of the indentation diameter measuring system ΔL_{rel} %	Expanded relative uncertainty of measurement U_L %	Maximum relative deviation of indentation diameter measuring system including measurement uncertainty of length reference instrument ΔL_{max} %
1,0 mm	0,20	0,27	0,47

where

$$\Delta L_{max} = |\Delta L_{rel}| + U_L \quad (A.8)$$

The result of the example means that the deviation of the indentation diameter measuring system including the uncertainty of measurement of the length reference instrument specified in 4.4 amounting to ±0,5 %, is complied with.

A.2.3 Measurement of the indenter ball

The indenter, consisting of indenter tip (ball) and holder, cannot be verified *in situ*. The geometrical characteristics, physical properties, and chemical composition of the indenter ball (see 4.3) should be confirmed by a valid calibration certificate or test report of an accredited calibration or testing laboratory.

A.2.4 Measurement of the testing cycle

Verification of the testing cycle and associated uncertainty considerations are detailed in 4.5. An estimation of the uncertainty of measurement is therefore not necessary.

A.3 Indirect verification of the hardness testing machine

NOTE In this annex, the index “CRM (Certified Reference Material)” means, according to the definitions of the hardness testing standards, “Hardness Reference Block”.

By indirect verification with hardness reference blocks, the overall function of the hardness testing machine is checked, and the repeatability and also deviation of the hardness testing machine from the certified hardness value are determined.

The uncertainty of measurement of the indirect verification of the hardness testing machine follows from the formula:

$$u_{HTM} = \sqrt{u_{CRM}^2 + u_{CRM-D}^2 + u_H^2 + u_{ms}^2} \quad \text{(A.9)}$$

where

u_{CRM} is the calibration uncertainty of the hardness reference block according to the calibration certificate for $k = 1$;

$u_{CRM\text{-}D}$ is the hardness change of the hardness reference block since its last calibration due to drift (negligible for use of the hardness reference block complying with the standard);

u_H is the standard uncertainty of hardness testing machine when measuring CRM;

u_{ms} is the standard uncertainty due to the resolution of the hardness testing machine.

EXAMPLE

Hardness reference block: H_{CRM} = 100,0 HBW 2,5/187,5

Uncertainty of measurement of the hardness reference block: U_{CRM} = 1,0 HBW 2,5/187,5 (k = 2)

Resolution of the hardness testing machine: δ_{ms} = 0,5 µm

Table A.7 — Results of the indirect verification

Number	Measured indentation diameter *d* mm	Calculated hardness value *H* HBW
1	$1{,}462_{min}$	$101{,}1_{max}$
2	1,469	100,1
3	$1{,}472_{max}$	$99{,}6_{min}$
4	1,471	99,8
5	1,468	100,3
Mean value $\bar{H}$	1,468 4	100,2
Standard deviation s_H		0,60

$$\bar{b} = \bar{H} - H_{CRM}$$
$$\bar{b} = 100{,}2 - 100{,}0 = 0{,}2 \text{ HBW} \quad \text{(A.10)}$$

$$u_H = \frac{t \times s_H}{\sqrt{n}} \quad \text{(A.11)}$$

For t = 1,14, n = 5, and s_H = 0,60 HBW follows:

u_H = 0,31 HBW

A.4 Budget of uncertainty of measurement

Table A.8 — 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 $u_i(H)$
u_{CRM}	100,0 HBW	0,50 HBW	Normal	1,0	0,50 HBW
u_H	0 HBW	0,31 HBW	Normal	1,0	0,31 HBW
u_{ms}	0 HBW	0,000 14 mm	Rectangular	−152,2 HBW/mm (see Note)	0,02 HBW
u_{CRM-D}	0 HBW	0 HBW	Triangular	1,0	0 HBW
Combined uncertainty of measurement, u_{HTM}					0,59 HBW
Expanded uncertainty of measurement, U_{HTM} ($k = 2$)					1,17 HBW
HBW: Brinell hardness					

NOTE The sensitivity coefficient follows from:

$$\frac{\partial H}{\partial d} = -\frac{H}{d} \cdot \frac{D+\sqrt{D^2-d^2}}{\sqrt{D^2-d^2}} \tag{A.12}$$

for H = 100,0 HBW, D = 2,5 mm, d = 1,469 mm.

Table A.9 — Maximum deviation of the hardness testing machine including the uncertainty of measurement

Measured hardness on the hardness testing machine H	Expanded uncertainty of measurement U_{HTM} HBW	Deviation of the testing machine when calibrating with the reference block $\lvert \bar{b} \rvert$ HBW	Maximum deviation of the testing machine including uncertainty of measurement ΔH_{HTMmax} HBW
100,2 HBW 2,5/187,5	1,2	0,2	1,4

where

$$\Delta H_{HTMmax} = U_{HTM} + \lvert \bar{b} \rvert = 1,2 + 0,2 = 1,4 \text{ HBW} \tag{A.13}$$

Annex B
(normative)

Verification of hardness testing machines that are incapable of meeting the specified force/time profile

B.1 Procedure

For machines that, due to their design, are incapable of meeting the specified force/time profile, it is permissible to limit the direct verification to only the indentation measurement system and the indenter ball characteristics. The machine shall be verified indirectly on an annual basis and any hardness test results from machines thus verified shall use the designation HBW/P rather than HBW.

The indirect verification shall be carried out in accordance with Clause 5, the only exception being that the time loading profile specified in ISO 6506-1 and referred to in 5.4, does not have to be followed. If the design of the machine is such that, in order to achieve optimal results, more than one force application is required at a given indentation site, the specified number of force applications shall be performed and this number recorded in the verification report. ISO 6506-1 test results obtained using such a machine shall only be valid if this specified number of force applications has been performed.

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