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**Knoop hardness test—Verification
and calibration of testing machines**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Testing Machine Association (JTM)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS B 7734:1997**), which has been technically revised.

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Knoop hardness test—Verification and calibration of testing machines

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 4545-2:2017**, Edition 3, with some modifications of the technical contents.

The dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JC. Annex JA and Annex JB are unique to **JIS** and not given in the corresponding International Standard.

1 Scope

This Standard specifies a method of verification and calibration of testing machines for determining Knoop hardness in accordance with **JIS Z 2251-1**.

A direct method of verification and calibration is specified for the testing machine, indenter and the diagonal length measuring system. An indirect verification method using reference blocks is specified for the overall checking of the machine.

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

It should be noted that using the method specified in this Standard for determination from indentations $< 20 \mu\text{m}$ in diagonal length may cause large uncertainties in the results.

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 4545-2:2017 *Metallic materials—Knoop hardness test—Part 2: Verification and calibration of testing machines* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

WARNING Persons carrying out tests based on this Standard should be familiar with normal laboratory practice. This Standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this Standard to establish appropriate safety and health practices.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 0601 *Geometrical Product Specifications (GPS)—Surface texture: Profile method—Terms, definitions and surface texture parameters*

JIS B 0621 *Definitions and designations of geometrical deviations*

JIS B 7728 *Calibration of force-proving instruments used for the verification of uniaxial testing machines*

NOTE Corresponding International Standard: ISO 376 *Metallic materials—Calibration of force-proving instruments used for the verification of uniaxial testing machines*

JIS Z 2251-1 *Knoop hardness test—Part 1: Test method*

NOTE Corresponding International Standard: ISO 4545-1 *Metallic materials—Knoop hardness test—Part 1: Test method*

JIS Z 8103 *Glossary of terms used in measurement*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS Z 2251-1** and **JIS Z 8103**, and the following apply.

3.1

Knoop hardness testing machine

equipment consisting of a test force loading system, a diagonal measuring system, and an indenter

3.2

diagonal measuring system

system for measuring the long diagonal length of indentations

3.3

direct verification

verification where main components of a testing machine (test forces, indenter, diagonal measuring system, etc.) are verified individually

3.4

indirect verification

verification where the overall performance of a testing machine is verified by means of a hardness test using hardness reference blocks

3.5

reference indentation

indentation, among those given for hardness determination on a hardness reference block, whose position and diagonal length are certified

4 Symbols and definitions

The symbols used in this Standard and their definitions are provided in Table 1.

Table 1 Symbols and their definitions

Symbol	Unit	Definition
F	N	Test force
F_{RS}	N	Nominal test force
ΔF_{rel}	%	Percent relative error of each measured test force F
r_{rel}	%	Repeatability of hardness values expressed as a percentage of $\bar{H}$
H_i	(HK)	Measured Knoop hardness
$\bar{H}$	(HK)	Mean measured hardness
d_i	mm, μm	Mean measured diagonal length
H_{CRM}	(HK)	Hardness value of reference block
b	(HK)	Bias (mean measured hardness – hardness value of reference block)
b_{rel}	%	Bias expressed as a percentage of H_{CRM}

5 General conditions

Before a Knoop hardness testing machine is verified and calibrated, 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 plunger holding the indenter is capable of sliding in its guide without any friction or excessive side play;
- b) the indenter-holder is firmly mounted in the plunger;
- c) the test force can be applied and removed without shock, vibration or overshoot and in such a manner that the readings are not influenced;
- d) the diagonal measuring system:
 - 1) if integral with the machine, the change in mode from the application and removal of the test force to the diagonal measuring mode does not influence the readings,
 - 2) the illumination device of the measuring microscope produces uniform lighting of the whole observed field with enough contrast between the indentation and the surrounding surface to determine the boundary clearly, and
 - 3) the centre of the indentation is in the centre of the field of view, if necessary.

NOTE 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.

6 Direct verification

6.1 General

6.1.1 Direct verification shall be conducted in accordance with the schedule given in Clause 8.

6.1.2 Direct verification involves:

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

6.1.3 Direct verification should be carried out at a temperature of $(23 \pm 5) ^\circ\text{C}$. If the verification is made outside this temperature range, this shall be stated in the verification report.

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

6.2 Calibration of the test force

6.2.1 Each test force shall be measured at three positions of the plunger uniformly spaced throughout its range of movement during testing. The positions should be such that they at least cover the depth of the indentations. For testing machines whose test force is shown not to be influenced by the position of the plunger, e.g. closed-loop controlled loading system, or whose plunger position during loading is approximately constant, the test force can be calibrated in one position.

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

- a) by means of a force-proving instrument in accordance with **JIS B 7728**, class 1 or better;
- b) by means of a device accurate to 0.2 %. Evidence should be available to demonstrate that the output of the device does not vary by more than 0.2 % in the period of 1 s to 30 s following a stepped change in force.

6.2.3 Three readings shall be taken for each test force, F , at each position of the plunger. Immediately before each reading is taken, the indenter shall be moved in the same direction as during testing. All readings shall be within the maximum permissible percent relative error, ΔF_{rel} , defined in Table 2.

The percent relative error, ΔF_{rel} , of each measurement of the force, F , is calculated according to Formula (1):

$$\Delta F_{\text{rel}} = 100 \times \frac{F - F_{\text{RS}}}{F_{\text{RS}}} \dots\dots\dots (1)$$

where, F : test force (N)

F_{RS} : nominal test force (N)

Table 2 Test force tolerances

Ranges of the nominal test force, F_{RS} N	Maximum permissible relative error, ΔF_{rel} %
$0.009\,807 \leq F_{RS} < 0.098\,07$	± 2.0
$0.098\,07 \leq F_{RS} < 1.961$	± 1.5
$1.961 \leq F_{RS} \leq 19.613$	± 1.0

6.3 Verification of the indenter

6.3.1 The four faces of the square-based diamond pyramid shall be polished and free from surface defects.

6.3.2 The verification of the shape of the indenter can be made by direct measurement or optical measurement. The device used for the verification should have an accuracy of $\pm 0.07^\circ$.

6.3.3 The measured angle α between the opposite edges at the vertex of the diamond pyramid shall be within the range $172.5^\circ \pm 0.1^\circ$ (see Figure 1).

6.3.4 The measured angle β between the opposite edges at the vertex of the diamond pyramid shall be within the range $130^\circ \pm 1.0^\circ$ (see Figure 1).

6.3.5 The indenter constant c 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 can be kept to closer tolerances than given above.

6.3.6 The angle between the axis of the diamond pyramid and the axis of the indenter-holder shall be not more than 0.5° .

6.3.7 The four faces should ideally meet at a common point, however, there is usually a line of junction between opposite faces as shown in Figure 2. The length of the line of junction shall be determined by directly measuring the indenter tip or by measuring the tip impression in an indentation. The maximum permissible length of the line of junction between opposite faces shall be $1\,\mu\text{m}$.

6.3.8 A valid calibration certificate which confirms the geometrical deviations of the indenter shall be attached to the indenter.

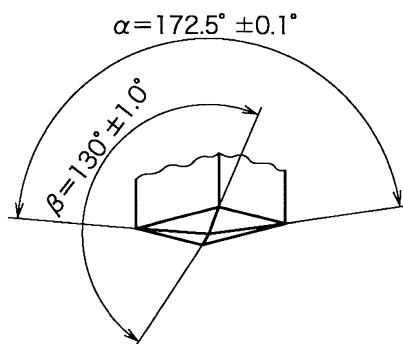


Figure 1 Angle between opposite edges of the diamond indenter

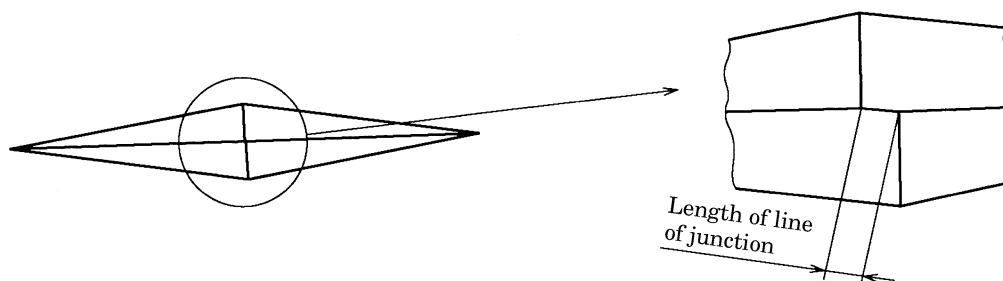


Figure 2 Length of line of junction on the top of the diamond indenter

6.4 Calibration and verification of the diagonal measuring system

6.4.1 The system for measuring the diagonal of the indentation shall be verified at each magnification using a calibrated stage micrometer. When an individual scale is used in two perpendicular axes, it shall be calibrated in both orientations. The maximum expanded uncertainty of the distances between the line intervals on the stage micrometer should be as indicated in Table 3.

6.4.2 Measurements shall be made at a minimum of four evenly spaced intervals, arranged centrally in the field of view, covering each working range. Three measurements shall be made at each of the evenly spaced intervals. Requirements for stage micrometer and permissible error of measurements of the diagonal measuring system shall be as indicated in Table 3.

Table 3 Calibration and verification requirements of the diagonal measuring system

Measurement parameters	Requirements
Maximum expanded uncertainty of the distances between the line intervals on the stage micrometer (see 6.4.1)	Greater of 0.4 μm or 0.2 % of the measurement interval
Maximum permissible error of the measurements of the diagonal measuring system (see 6.4.2)	Greater of 0.8 μm or 1.0 % of the measurement interval

6.5 Verification of the testing cycle

The test force loading and holding durations shall be timed with an accuracy of ± 1 s, and shall fall within the limits set in **JIS Z 2251-1**.

6.6 Uncertainty of calibration/verification

Uncertainty of the calibration/verification results shall be determined. An example is given in Annex A.

7 Indirect verification

7.1 General

7.1.1 Indirect verification shall be conducted in accordance with the schedule given in Clause 8.

7.1.2 Indirect verification involves verification of the overall performance of the testing machine by means of reference blocks calibrated in accordance with Annex JA.

7.1.3 Indirect verification should be carried out at a temperature of $(23 \pm 5) ^\circ\text{C}$. If the verification is made outside this temperature range, this shall be stated in the verification report.

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

7.2 Test force and hardness levels

The testing machine shall be verified by testing reference blocks that have been calibrated in accordance with Annex JA. It is desirable that the blocks have been calibrated using the same test forces that the machine will use for future testing.

The combination of test force and hardness range shall be as follows.

- When verifying testing machines using only one test force, three reference blocks shall be used, one from each of the three hardness ranges specified in Table 4.
- When verifying more than one test force, at least two reference blocks shall be selected from the hardness ranges specified in Table 4 for each test force while ensuring that the combinations of test force and hardness range are such that the machine can be verified for all of the three hardness ranges through testing at different test forces.
- When verifying the machine for all the test forces, at least one reference block from the three hardness ranges specified in Table 4 shall be selected for each test force.

The hardness ranges should be chosen, when possible, to replicate the hardness levels most commonly tested when using the specific test forces.

Indirect verification should be carried out for $\text{HK} \geq 0.01$.

The combination of test force and hardness range should be such that the diagonal length of indentation is $\geq 20 \%$ of the working range of the diagonal measuring system.

Table 4 Hardness ranges for indirect verification

Hardness range	Certified value of reference block, H_{CRM} HK
Low	< 250
Medium	250 to 650
High	> 650

7.3 Measurement of reference indentations

One of the reference indentations on each reference block shall be measured. For each indentation, the difference between the measured value and the certified diagonal length should not exceed $1 \mu\text{m}$ or 1.25% of the reference indentation length, whichever is greater. If preferred, this check may instead be made on a similarly-sized indentation in a different reference block with similar hardness. If the deviation is within the permitted range in the indirect verification, the verification of the reference indentation may be omitted.