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**Knoop hardness test—
Part 1: Test method**

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Foreword

This Japanese Industrial Standard has been established by the Minister of Economy, Trade and Industry based on the provision of Article 14, paragraph (1) of the Industrial Standardization Act in response to a proposal for establishment of Japanese Industrial Standard with a draft being attached, submitted by The Japan Iron and Steel Federation (JISF), an accredited standards development organization. This Standard partially replaces **JIS Z 2251**:2009, which has been withdrawn.

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JIS Z 2251 series consists of the following 2 parts under the general title *Knoop hardness test*:

Part 1: Test method

Part 2: Table of hardness values

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Knoop hardness test—Part 1: Test method

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 4545-1:2017**, Edition 2, 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 JA.

1 Scope

This Standard specifies the Knoop hardness test method for metallic materials for test forces from 0.009 807 N to 19.613 N.

The Knoop hardness test specified in this Standard is for lengths of indentation diagonals ≥ 0.020 mm; it may be used for lengths of indentation diagonals < 0.020 mm upon agreement between the parties involved. **ISO 14577-1** allows the determination of hardness from smaller indentations.

A periodic verification method is specified for routine checking of the testing machine in service by the user.

Special considerations for Knoop testing of metallic coatings can be found in **ISO 4516**.

NOTE 1 Using the method specified in this Standard for determination from indentations < 0.020 mm in diagonal length may cause large uncertainties in the results.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 4545-1:2017 *Metallic materials—Knoop hardness test—Part 1: Test method* (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**.

2 Normative references

Part or all of the provisions of the following standards, 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 7734 *Knoop hardness test—Verification and calibration of testing machines*

JIS G 0202 *Glossary of terms used in iron and steel (Testing)*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in JIS G 0202 apply.

4 Principle

A diamond indenter, in the form of a rhombic-based pyramid with angles, α and β , between opposite edges respectively equal to 172.5° and 130° at the vertex, is forced into the surface of a test piece followed by measurement of the long diagonal, d , of the indentation remaining in the surface after removal of the test force, F (see Figures 1 and 2).

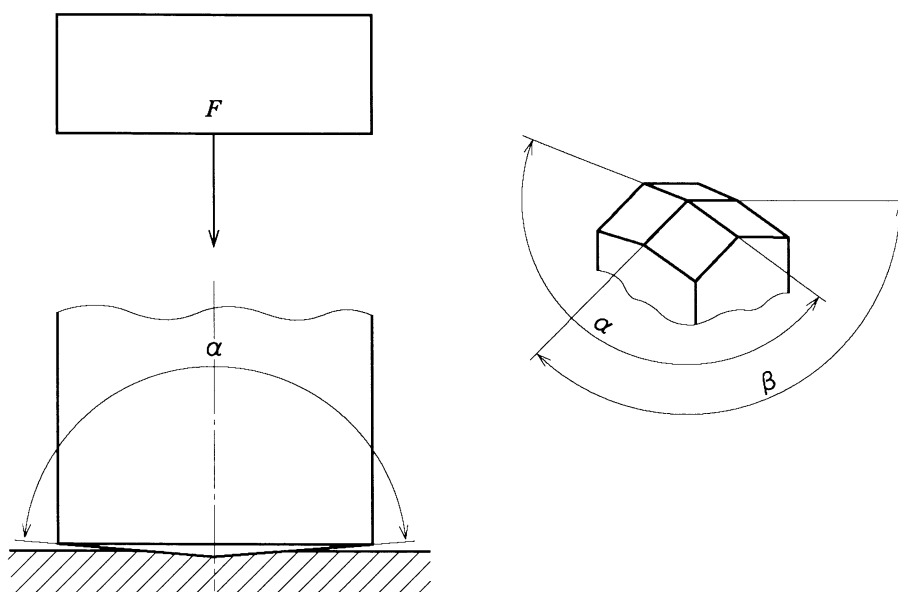


Figure 1 Principle of the test and indenter geometry

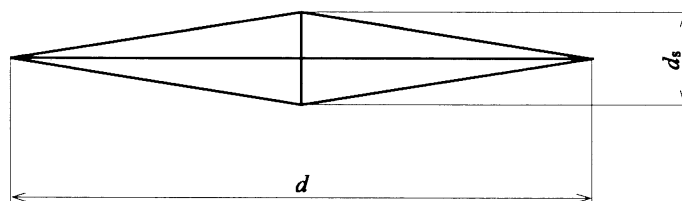


Figure 2 Knoop indentation

The Knoop hardness is proportional to the quotient obtained by dividing the test force by the projected area of the indentation, which is assumed to be a rhombic-based pyramid, and having at the vertex the same angles as the indenter.

NOTE As applicable, this Standard has adopted hardness test parameters as defined by the Working Group on Hardness (CCM-WGH) under the framework of the International Committee of Weights and Measures (CIPM) Consultative Committee for Mass and Related Quantities (CCM) (see Annex D).

5 Symbols and designation of hardness number

5.1 Symbols and designations

See Table 1 and Figures 1 and 2.

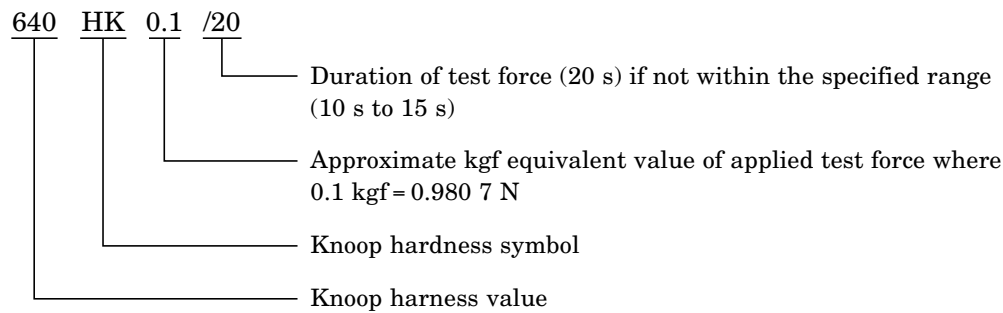
Table 1 Symbols and designations

Symbol	Designation
F	Test force (N)
d	Length of the long diagonal (mm)
d_s	Length of the short diagonal (mm)
α	Angle between the opposite edges of the long diagonal at the vertex of the diamond pyramid indenter (nominally 172.5°) (see Figure 1)
β	Angle between the opposite edges of the short diagonal at the vertex of the diamond pyramid indenter (nominally 130°) (see Figure 1)
V	Magnification of the measuring system
c	Indenter constant, relating projected area of the indentation to the square of the length of the long diagonal $c = \frac{\tan \frac{\beta}{2}}{2 \tan \frac{\alpha}{2}} \approx 0.070\,28$
HK	Knoop hardness symbol $\text{Knoop hardness} = \frac{\text{Test force (kgf)}}{\text{Projected area of indentation (mm}^2\text{)}}$ $= \frac{1}{g_n} \times \frac{\text{Test force (N)}}{\text{Projected area of indentation (mm}^2\text{)}}$ $= \frac{1}{g_n} \times \frac{F}{cd^2}$ Nominal indenter constant $c \approx 0.070\,28$ Standard acceleration due to gravity $g_n = 9.806\,65 \text{ m/s}^2$ Knoop hardness $\approx 1.451 \times \frac{F}{d^2}$ To reduce uncertainty, the Knoop hardness can be calculated using the actual indenter angles α and β. NOTE Standard acceleration due to gravity is the conversion factor from kgf to N.

5.2 Designation of hardness number

Knoop hardness is designated as shown in the following example.

Example



6 Testing machine

6.1 Testing machine

The testing machine shall be capable of applying a predetermined force or forces within the desired range of test forces, in accordance with **JIS B 7734**.

6.2 Indenter

The indenter shall be a diamond in the shape of a rhombic-based pyramid, as specified in **JIS B 7734**.

6.3 Diagonal measuring system

The diagonal measuring system shall satisfy the requirements in **JIS B 7734**.

Magnifications should be provided so that the diagonal can be enlarged to greater than 25 % but less than 75 % of the maximum possible optical field of view. Many objective lenses are non-linear towards the edge of the field of view.

A diagonal measuring system using a camera for measurement can use 100 % of the camera's field of view, provided it is designed to consider field of view limitations of the optical system.

The resolution required of the diagonal measuring system depends on the size of the smallest indentation to be measured, and shall be in accordance with Table 2. In determining the resolution of the measuring system, the resolution of the microscope optics, the digital resolution of the measuring scale and the step-size of any stage movement, where applicable, should be taken into account.

Table 2 Resolution of the measuring system^{a)}

Diagonal length, d mm	Resolution of the measuring system
$0.020 \leq d \leq 0.080$	0.000 4 mm
$0.080 < d$	0.5 % of d
Note ^{a)} The resolution for determination from indentations <0.020 mm in diagonal length shall be as agreed between the parties involved.	

7 Test piece

7.1 Test surface

The test shall be carried out on a polished surface, which is smooth and even, free from oxide scale and foreign matter and, in particular, free from lubricants, unless otherwise specified in product standards. The finish of the surface shall permit accurate determination of the diagonal length of the indentation.

7.2 Preparation

Surface preparation shall be carried out in such a way as to prevent surface damage, or alteration of the surface hardness due to excessive heating or cold-working.

Due to the small depth of Knoop hardness indentations, it is essential that special precautions be taken during preparation. It is recommended to use a polishing/electropolishing technique that is adapted to the material to be measured.

7.3 Thickness

The thickness of the test piece, or of the layer under test, shall be at least 1/3 times the length of the diagonal length of the indentation. No deformation shall be visible at the back of the test piece after the test.

NOTE The depth of the indentation is approximately 1/30 of the diagonal length (0.033 d).

7.4 Support of unstable test pieces

For a test piece of small cross-section or of irregular shape, either a dedicated support should be used or it should be mounted in a similar manner to a metallographic micro-section in appropriate material so that it is adequately supported and does not move during the force application.

NOTE If resin is used for mounting a test piece, attention should be paid to the hardness of the test piece as it may be affected by the heat generated in curing of resin, pressure and temperature of pressure moulding, etc.

8 Test procedure

8.1 Test temperature

The test is normally carried out at ambient temperature within the limits of 10 °C to 35 °C. If the test is carried out at a temperature outside this range, it shall be noted in the test report. Tests carried out under tightly controlled conditions shall be made at a temperature of (23 ± 5) °C.

8.2 Test force

The test forces given in Table 3 are typical. Other test forces may be used. Unless otherwise agreed between the parties involved, test forces shall be chosen that result in indentations with a long diagonal greater than 0.020 mm.