

UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON

NATIONAL BUREAU OF STANDARDS
SPECIFICATION FOR KNOOP INDENTERS

(April 1, 1946)

I. INTRODUCTION

The Knoop indenter was developed at the National Bureau of Standards and described in Research Paper 1220, "A Sensitive Pyramidal-Diamond Tool for Indentation Measurements" by Frederick Knoop, Chauncey G. Peters, and Walter B. Emerson. Research Paper 1220 is part of the Journal of Research of the National Bureau of Standards, Volume 23, No. 1, July 1939.

The Knoop indenter can be used to determine hardness numbers of a wide range of materials although it appears to be most useful in the investigation of brittle materials such as glasses, hard carbides and oxides, thin layers of metals, and small samples.

The indenting surfaces of the indenter are four planes produced on a diamond which is secured in a suitable mount. The lines of intersection between adjacent planes form the edges of the indenter. The four edges of the indenter intersect very nearly at a point on the axis of the indenter. An indentation viewed normally to the specimen surface appears rhombic in outline with one diagonal perpendicular to and about seven times the length of the other. The depth of the indentation is about one-thirtieth the length of the longer diagonal. The indentation number is defined as the indenting load in kilograms divided by the projected area of the indentation in square millimeters.

It has been determined from a large number of tests that the resistance of the indenter point to fracture is greatest when an octahedral diamond is used having one crystallographic axis parallel to the axis of the indenter mount. For this reason it is necessary to specify the type of diamond and its orientation.

II. DEFINITIONS

1. INCLUDED EDGE ANGLE

An included edge angle is the included angle between opposite edges of the indenter.

2. OFFSET

The offset is the length of the line of intersection of opposite plane faces of the indenter caused by the failure of all

four plane faces to intersect at a point.

3. INDENTER CONSTANT

The indenter constant is the ratio of the projected area of the indentation to the square of the length of the long diagonal. Its value is given by the formula

$$C = 1/2 \cotangent(A/2) \ tangent(B/2)$$

where: A = Included longitudinal edge angle
B = Included transverse edge angle

4. INDENTATION NUMBER

The indentation number is defined by the relation

$$I = \frac{P}{L^2 C}$$

where: I = Indentation number
P = Indenting load in kilograms
L = Length of long diagonal in millimeters
C = Indenter constant

Note: It is convenient to determine indentation numbers from tables which have been computed for an indenter having the standard longitudinal edge angle of 172° 30' and the standard transverse edge angle of 130° 0'. The constant for such an indenter is 0.07028. The constant for an indenter complying with this specification may differ from 0.07028 by not more than one percent.

III. REQUIREMENTS

1. GENERAL

A Knoop indenter shall consist of a pyramidal diamond indenting tool secured in a mount of suitable shape and material. The diamond shall be a well formed octahedron free from carbon spots and flaws. One crystallographic axis shall be parallel to the axis of the indenter mount to within 5 degrees. The longitudinal edges shall be parallel to within 5 degrees to a plane containing that crystallographic axis and one of the other crystallographic axes. The mount shall be symmetrical about an axis which passes through the vertex of the indenter and is perpendicular to the base of the mount. The end of the mount opposite the indenter shall be counterbored and shall have a tapped hole concentric with both the counterbore and axis.

2. MOUNTING

- (a) The distance from the vertex of the indenter to the base of the mount shall be 0.85 ± 0.10 inch.
- (b) The diameter of the counterbore shall be 0.376 ± 0.001 inch.
- (c) The depth of the counterbore shall be $3/32 \pm 1/32$ inch.
- (d) The outside diameter of the mount at the counterbored end shall be $0.500 (+.100, -.020)$ inch.
- (e) The mount shall be tapped with a 10-32 thread, 1/2 inch deep, loose fit (Class 1) and countersunk to leave not less than 10 full threads.

Note: The base of the mount should be smooth and flat to permit repeatable measurements of the half angles.

3. INDENTER

- (a) Each longitudinal edge shall be not less than 0.7 mm in length.
- (b) Each transverse edge shall be not less than 0.5 mm in length.
- (c) The vertex of the indenter shall be not more than 0.01 in. distant from the normal to the center of the base of the indenter.
- (d) The offset shall not exceed 3 microns.
- (e) The included longitudinal edge angle shall be not less than $172^{\circ} 25'$ and not more than $172^{\circ} 35'$.
- (f) The constant for the indenter shall differ from the constant for an indenter having standard angles by not more than 1.0 percent.
- (g) The angles between a perpendicular to the base of the indenter and the two longitudinal edges shall differ by not more than 14 minutes of arc. The angles between a perpendicular to the base of the indenter and the two transverse edges shall differ by not more than 20 minutes of arc.
- (h) The longitudinal edges shall be free from nicks greater in length than 0.5 micron for a distance of 125 microns from the point. From 125 microns to 1000 microns or a distance equal to the length of the shorter longitudinal edge, whichever is the smaller, the ratio of the length of any nick to its distance from the point shall not exceed 0.004.

IV. METHODS OF TEST

1. PROOF LOAD

Each indenter, before inspection, shall be proof loaded to 5 kg on a sample having an indentation number not less than 700.

2. DIMENSIONAL TOLERANCES

Dimensional tolerances shall be checked by standard gaging methods.

3. EDGE ANGLES

The edge angles shall be measured with a sine bar or other suitable device so used that the error of measurement shall not exceed one minute of arc.

4. NICKS AND OFFSET

The longitudinal edges of the indenter shall be inspected for nicks and offset by viewing indentations made with the indenter in a polished steel block.

V. METHOD OF REPORTING RESULTS

1. CERTIFICATES

For an indenter which complies with the requirements of this specification a certificate will be issued giving the values of the included edge angles.

2. REPORTS

For an indenter which fails to comply with the requirements of this specification a report will be issued stating wherein the indenter fails to comply.