



Standard Test Method for Knoop Indentation Hardness of Glass¹

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1. Scope

1.1 This test method covers the determination of the Knoop indentation hardness of glass and the verification of Knoop indentation hardness testing machines using standard glasses.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 4 Practices for Force Verification of Testing Machines²

E 384 Test Method for Microhardness of Materials²

3. Terminology

3.1 Descriptions of Terms Specific to This Standard:

3.1.1 *Knoop hardness number (KHN)*—a number obtained by dividing the applied load in kilograms-force by the projected area of the indentation in square millimetres, computed from the measured long diagonal of the indentation and the included edge angles of the diamond. It is assumed that the indentation is an imprint of the undeformed indenter.

3.1.1.1 *The Knoop hardness number (KHN) is computed as follows:*

$$KHN = (P/A_p) = (P/d^2C_p) \quad (1)$$

P = load, kgf,

A_p = projected area of the indentation, mm²,

d = length of the long diagonal of the indentation, mm,

C_p = $\frac{1}{2} (\cot A/2 \times \tan B/2)$,

A = included longitudinal edge angle (see Fig. 1), and

B = included transverse edge angle (see Fig. 1).

3.1.1.2 *Knoop indentation hardness tests in glass are made at a test load of 100 gf (0.1 kgf).*

3.1.1.3 *The rate of indenter motion prior to contact with the specimen shall be 0.20 ± 0.05 mm/min. This low rate of load application tends to alleviate the effect of the magnitude of the load on Knoop hardness number.*

3.1.1.4 *The indenter should remain in contact with the specimen between 20 and 30 s. Most of the calibrated machines that are used for making Knoop hardness tests are dash-pot controlled and this dwell time is consistent with the adjustment of the dash-pot to meet the loading rate standard.*

3.1.1.5 *Table 1 gives the Knoop hardness of several glasses as a function of load when the loading rate and dwell time are held at the values recommended above.*

3.1.2 *Knoop indentation hardness test*—an indentation hardness test using a calibrated machine to force a pointed, rhombic-base, pyramidal diamond indenter having specified face angles, under a predetermined load, into the surface of the material under test and to measure the long diagonal of the resulting impression after removal of the load.

NOTE 1—A general description of the Knoop indentation hardness test is given in Test Method E 384. The present method differs from this description only in areas required by the special nature of glasses.

4. Significance and Use

4.1 The Knoop indentation hardness is one of many properties that is used to characterize glasses. Attempts have been made to relate Knoop indentation hardness to tensile strength, grinding speeds, and other hardness scales, but no generally accepted methods are available. Such conversions are limited in scope and should be used with caution, except for special cases where a reliable basis for the conversion has been obtained by comparison tests.

5. Apparatus

5.1 Testing Machines:

5.1.1 There are two general types of machines available for making this test. One type is a self-contained unit built for this purpose, and the other type is an accessory available to existing microscopes. Usually, this second type is fitted on an inverted-stage microscope. Good descriptions of the various machines are available.^{3,4}

5.1.2 Design of the machine should be such that the loading rate, dwell time, and applied load can be standardized within the limits set forth in 3.1.1.2-3.1.1.4. It is an advantage to eliminate the human element whenever possible by appropriate

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² *Annual Book of ASTM Standards*, Vol 03.01.

³ Specifications for Knoop indenters can be found in the book Small, L., *Hardness Theory and Practice* (Part I: Practice), Service Diamond Tool Co., Ann Arbor, MI, 1960, pp. 241–243.

⁴ Mott, B. W., *Micro-Indentation Hardness Testing*, Butterworth's Scientific Publications, London, 1956.

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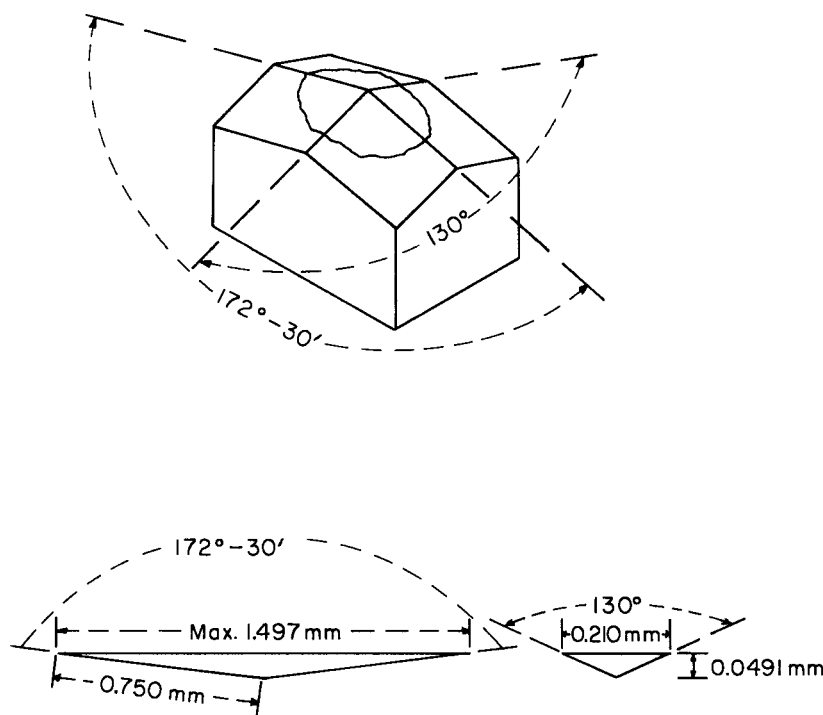


FIG. 1 Knoop Indenter Showing Maximum Usable Dimension

TABLE 1 Knoop Hardness of NIST Standard and Other Glasses^{A,B}

Laboratory	NIST 710	NIST 711	NIST 715	GE Fused Quartz	NIST 710	NIST 711	NIST 715	GE Fused Quartz
	25-gf Load				50-gf Load			
A	486	411	589	614	497	394	575	559
C	594	450			537	415		
D	479	426	505	541	478	380	538	501
E	521	415	608	620	497	392	574	586
F	498	414	568	643	484	403	567	577
G								
Avg	516	423	567.5	609.5	499	397	563.5	556
Departure, max, %	15	6	11	11	8	5	5	10
Range, max, %	22	9	18	17	12	9	7	15
	100-gf Load				200-gf Load			
A	475	387	558	554	468	380	550	523
C	478	387	554	593	468	371	544	530
D	452	368	521	473	433	360	529	474
E	490	396	544	530	488	372	546	510
F	467	381	538	524	457	367	524	502
G	481	388	550	558				
Avg	474	384.5	544	539	463	370	539	508
Departure, max, %	5	4	4	12	6	3	3	7
Range, max, %	8	7	7	22	12	5	5	11

^A NIST 710—NIST standard soda-lime-silica glass (no longer available; NIST 710a may be substituted), NIST 711—NIST standard lead-silica glass. NIST 715—NIST standard alkali-free aluminosilicate glass.

^B These data were obtained from ASTM round-robin testing.

machine design. The machine should be designed so that vibrations induced at the beginning of a test will be damped out by the time the indenter touches the sample.

5.1.3 The calibration of the balance beam should be checked monthly or as needed. Indentations in standard glasses are also used to check calibration when needed.

5.2 Indenter:

5.2.1 The indenter shall meet the specifications for Knoop

indenters.⁴ See Test Method E 384.

5.2.2 Fig. 1 shows the indenter and its maximum usable dimensions. The diagonals have an approximate ratio of 7:1, and the depth of the indentation is about 1/30 the length of the long diagonal. A perfect Knoop indenter has the following angles:

5.2.2.1 Included longitudinal angle 172° 30' 00".

5.2.2.2 Included transverse angle 130° 00' 00".