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Standard Test Method for Rubber Property—Pusey and Jones Indentation[1]

This standard is issued under the fixed designation D 531; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

[1] This test method is under the jurisdiction of ASTM Commitee D-11 on Rubber and is the direct responsibility of Subcommittee D11.10 on Physical Testing.
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1. Scope

1.1 This test method covers the determination of the indentation of rubber or rubber-like materials by means of the Pusey and Jones type of plastometer. This apparatus is used to measure the depth of indentation of an indentor, under fixed force into the surface of a ~~rubber~~ specimen.

1.2 The values stated in SI units are to be regarded as the standards.

1.3 *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:*

D 1415 Test Method for Rubber Property—International Hardness[2]

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries[2]

NOTE 1—The specific dated edition of the practice that prevails in this document is referenced in the Precision section.

3. Significance and Use

3.1 The Pusey and Jones indentation value is the depth of indentation, expressed in hundredths of a millimet~~r~~er, of a ball 3.175 mm (0.1250 in.) in diameter under an expressed force of 9.8 N (2.2 lbf). This value may be used to compare the indentation resistance of rubber and rubber-like materials.

3.2 The indentation value obtained should not be confused with hardness as measured by Test Method D 1415, since in the latter test the rubber immediately adjacent to the indentor is precompressed.

4. Apparatus

4.1 *Plastometer*, an instrument consisting of an indentor, a mass for applying ~~a fixed gravitational~~ the stated force on the indentor, ~~and~~ a ~~suitable device~~ micrometer for indicating the depth of the indentation, a specimen holder and support.

4.1.1 ~~*Support*—The supporting frame shall be configured so that the indentor and mass may be independently raised or lowered vertically, permitting the indentor to rest on the surface of the test specimen and the mass to be applied subsequently to the indentor.~~

4.1.2 ~~*Indentor*,~~ for indenting the specimen, consisting of a vertical steel shaft attached, at the upper end to ~~the spindle of the~~ a depth indicator gage, and ~~having at the lower end~~ terminating in a steel ~~ball. The steel ball shall be~~ sphere having a diameter of 3.175 ± 0.015 mm (0.1250 ± 0.0005 in.) ~~in diameter and shall be made~~ of ~~highly~~ polished, noncorrosive hard metal ~~properly~~ treated to resist wear.

4.1.3~~2~~ *Mass*—~~The~~, the mass shall be 1000 ± 0.01 g.

4.1.3 *Depth Indicator Gage*, a micrometer attached to the plastometer, either an electronic digital gage or analog dial gage, capable of displaying indentor movement (indentation) in increments of at least 0.01 mm (0.0004 in.) and having travel of 0 (zero) to no less than 3 mm (0.12 in).

4.1.4 ~~*Depth Indicator*—A dial gage or other suitable device graduated in increments of 0.01 mm (0.0004 in.) and having~~Support, a ~~range of at least 3 mm~~ support frame, or fixture, for the plastometer, shall ~~indicate~~ be configured so that the specimen holder and hence, the specimen, are perpendicular to the indentor support shaft and that the mass may be independently raised or lowered vertically, permitting the indentor to rest on the surface of the specimen and the~~n~~ mass to~~r~~ be subsequently applied.

[2] *Annual Book of ASTM Standards*, Vol 09.01.

4.1.5 *Specimen Holder*, for the ~~block~~ standard, or reference specimen described in 5.1, shall ~~be provided consisting~~ consist of a ~~clamp made~~ clamping fixture of two metal plates ~~held together~~ secured by two threaded bolts. The uppermost plate shall have a hole and a slot, as ~~shown~~ depicted in Fig. 1, to allow for the unencumbered introduction of the indentor to the specimen.

4.1.5.1 The purpose of the ~~clamp~~ specimen holder is to ~~hold~~ support the ~~specimens flat and free from slight movements~~ specimen in a manner that ~~might introduce variations into the test. The top plate shall be provided with~~ reduces, or eliminates, relative positioning or movement that may adversely affect test determinations.

4.1.5.2 In routine testing, a ~~hole and slot for the operation~~ specimen holder, a support, or both, of other, but similar, configurations may be employed to accommodate specimens other than those described in 5.1, refer to 5.1.1.

5. Test Specimens

5.1 The standard, or reference, test specimen shall be a uniform molded rectangular block ~~approximately~~ a minimum of 13 mm (0.51 in.) in thickness, 30 mm (1.~~2~~18 in.) in width, and 75 mm ~~(3~~ (2.95 in.) in length. The ~~top~~ upper and ~~bottom faces~~ lower surfaces, those opposite surfaces with the largest area, shall be ~~as~~ parallel ~~as possible. This~~ to within ± 0.5 mm (± 0.20 in).

5.1.1 The standard, or reference, test specimen shall be used ~~in all cases~~ when the ~~apparatus~~ plastometer is employed for ~~reference standard purposes as distinguished from routine control testing~~ the purpose of ~~commercial articles.~~ determining a standard, or reference, either within or between laboratories, that is, in other than routine testing.

5.2 In routine testing, specimens may be used ~~that have dimensions~~ with a configuration other than those of the ~~standard specimen, including manufactured products of such size and shape to support the apparatus~~ standard, or ~~where it can be suitably mounted above them.~~ reference, test specimen described in 5.1.

6. Procedure

6.1 *Measurement of Indentation*—~~Place~~ of Standard, or Reference Specimens.

6.1.1 When measuring the ~~specimen~~ indentation on a ~~firm base with the surface under test horizontal. Flat specimens may rest on a table having a truly level surface~~ standard, or ~~on the secondary base mentioned in 4.1.1. Place curved specimens such as rubber-covered rolls so that the center line of the indentor shaft is perpendicular to the tangent at the point of contact of the indentor. When using the standard~~ reference specimen as described in 5.1, ~~clamp~~ secure it in the specimen holder (refer to Fig. 1 and Section 4.1.5) with the bolts tightened sufficiently to hold it firmly without ~~compression. Mount~~ measurable compression.

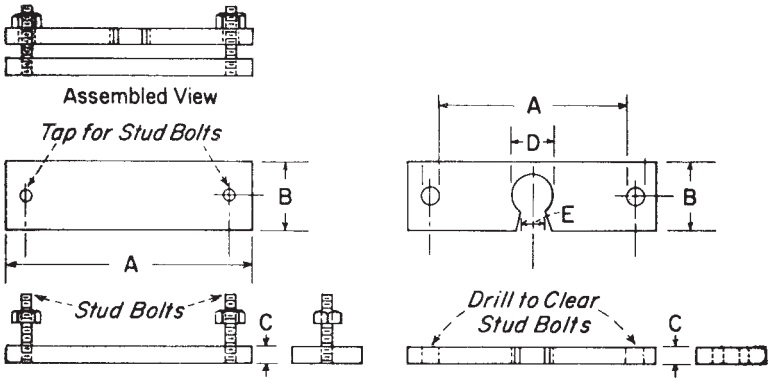
6.1.2 Place the ~~apparatus over the~~ specimen ~~and adjust, by means of a spirit level placed~~ holder on the ~~base,~~ support.

6.1.3 Mount the plastometer over the specimen so that the indentor shaft is ~~v~~ pertpendicular to the support and hence the specimen holder, to within ± 0.05 mm (± 0.002 in).

6.1.4 The plastometer and support shall ~~not rock or~~ be ~~unsteady, whether its feet rest on the table around~~ placed upon a ~~small specimen or directly on~~ flat surface in a ~~large specimen,~~ manner that prevents unsteadiness or ~~whether it is mounted on a rod and secondary base as is required with~~ movement other than described in 6.3.

6.1.5 Lower the ~~standard specimen and holder. Lower the~~ indentor shaft until the indentor is ~~in~~ at the moment of contact with the specimen ~~an~~.

6.1.5.1 Adjust the depth indicator ~~is adjusted~~ gage to reacord indentations up to 3 mm (0.12 in.).



mm		in.
A, min	80	3.15
B, min	30	1.2
D	17 to 18	0.67 to 0.70
E	11 to 12	0.43 to 0.47
F	60	2.36

FIG. 1 Holder for Test Specimens

6.1.5.2 Adjust the depth indicator gage so that the needle display indicates zero.

6.1.6 Lower the mass onto the indentor carefully without indentor, in a fashion that eliminates shock, and lower until the supporting plate still farther so that the mass rests fully on the indentor. Read the indentor.

6.1.7 The amount of indentation displayed on the depth indicator gage exactly 60 s (± 1 min. s) after the application of a total force of 9.8 N, shall be recorded.

6.1.8 Make no less than 3 such determinations on the specimen at least 13 mm (0.51 in) apart and from any edge.

6.1.9 The median of the determinations, expressed as a whole number indicating hundredths of millimeters, shall be reported as the Pusey and Jones Indentation Value, refer to 8.1.1.

6.2 *Number Measurement of Indentation of Specimens for Routine Tests (nonstandard specimengs)*—T.

6.2.1 When making determinations on specimens other than those described ing 5.1, specimen holders, supports or other suitable fixturing, similar to those previously described, may be employed and the procedure in 6.1 may be followed, otherwise:

6.2.2 Mount the plastometer over, or directly upon, the specimen, so that the indentor shaft is vertical and perpendicular to the specimen surface and both are level, as determined by means of a spirit level or similar device.

6.2.3 Position curved (convex or concave) or irregularly shaped specimens, so that the center line of the indentor shaft is perpendicular to the tangent of the specimen at the point of contact of the indentor and that determinations shall be made in accordance with 6.2.8.

6.2.4 The plastometer and specimen, or any fixtures employed, shall be secure and situated in a manner that prevents unsteadiness or movement other than described in 6.3.

6.2.5 Lower the indentor shaft until the indentor is at the moment of contact with the specimen.

6.2.5.1 Adjust the depth indicator gage to record indentations up to 3 mm (0.12 in).

6.2.5.2 Adjust the depth indicator gage so the display indicates zero.

6.2.6 Lower the mass onto the indentor, in a fashion that eliminates shock, until the mass rests fully on the indentor.

6.2.7 The amount of indentation displayed on the depth indicator gage 60 s (± 1 s) after the application of a total force of 9.8 N, shall be recorded.

6.2.8 Make no less than 3 such determinations on the specimen at least 13 mm (0.51 in) apart and from any edge.

6.2.9 The median of the determinations, expressed as a whole number indicating hundredths of millimeters, shall be reported as the Pusey and Jones Indentation Value, refer to 8.1.1.

6.2.10 When tests are performed on specimens other than those described in 5.1 and without the specimen holder and support the results shall be compared only to those obtained on similarly configured specimens under similar conditions.

6.3 *Temperature*—For comparative purposes, all tests shall be carried out at 23 ± 2°C (73 ± 3.6°F). Test specimens shall be conditioned at least 3 h immediately prior to testing. Specimens that are affected by atmosphere moisture shall be conditioned in an atmosphere controlled to 50 ± 5 % relative humidity for at least 24 h.

6.4 *Routine Tests*—When tests are made for control purposes on commercial articles of dimensions differing from those of the standard specimen and without using the specimen holder, the results are comparative only with those obtained under essentially the same conditions of specimen size and shape, temperature, and method of assembly of the apparatus and specimen.

6.5 *Pusey and Jones Indentation Number*— The median of three indentation values expressed as a whole number indicating the hundredths of millimetres of indentation shall be known as the Pusey and Jones indentation number.

NOTE 2—For certain federal specifications, a vibrator may be specified.

6.6 *Vibrator*—A small vibrator which is activated prior to the mass being applied to the indentor and operates continuously during a test to overcome any friction in the apparatus. An instrument that vibrates approximately 120 times per s, with an amplitude of vibration of the fixed platform of the tester varying from approximately 0.002 to 0.005 mm (0.0001 to 0.0002 in.), has been found satisfactory.

TABLE 1 Special Precision Results—Pusey and Jones Indentation

Material	Mean Level	Within Instrument[A]			Between Instrument[A]		
		S(*w*)	*r*(*w*)	(*r*)(*w*)	*S*(*B*)	*r*(*B*)	(*r*)(*B*)
1	11.7(a)	0.265	0.750	6.4	0.374	1.06	9.1
2	20.9	0.296	0.838	4.0	0.309	0.875	4.2
3	38.1	0.379	1.073	2.8	0.668	1.89	5.0
4	63.0	0.192	0.543	0.86	1.67	4.73	7.5

[A]

S(w) = within instrument, standard deviation.
r(w) = repeatability (within instrument) measurement units.
(r)(w) = repeatability (within instrument), %.
S(B) = between instrument, standard deviation.
r(B) = repeatability (between instrument) measurement units.
(r)(B) = repeatability (between instrument), %.
(a) = Pusey and Jones indentation number.

6.~~7~~4 Such a vibrator may consist of a simple-cored solenoid fastened to the top of a C-shaped piece of strap steel. The lower part of the solenoid core is a loose cylindrical piece of steel with a shoulder at its lower end. When the current is off, the loose-cored section rests on a screw projecting from the bottom of the C-shaped support. When the current is on, the loose-cored section is attached to the solenoid but is restrained by a flat split ring of spring brass through which the cored section passes, and which bears on the shoulder of the cored section. The cored section is caused to vibrate by the alternating forces of attraction by the solenoid and repulsion by the flat ring acting as a spring. A small plate bearing a toggle switch for closing the circuit to the solenoid is fastened to the top of the C-shaped piece of strap steel by means of the same bolt that holds the solenoid. The bottom of the C-shaped piece is fastened by screws to a portion of a brass nut that serves to clamp the vibrator to one upright post of the tester.

7. ~~R~~Laboratory Atmosphere and Test Specimen C~~o~~nditioning

7.1 ~~S~~The t~~ate~~sts shall be conducted in the ~~test was made~~ standard laboratory atmosphere as defined in D 618, Terminology: "standard laboratory atmosphere".

7.2 Test specimen conditioning shall be in accordance with ~~this designation and include the following information:~~

~~7.1.1 The Pusey and Jones indentation number,~~

~~7.1.2 Description of test specimen including dimensions,~~

~~7.1.3 Date of vulcanization,~~ D 618, Standard Procedures for Conditioning Prior to Test: Procedure A.

7.3 These conditions may be modified if ~~known,~~

~~7.1.4 Duration~~ agreed upon between laboratories or between supplier and ~~temperature of vulcanization, if known,~~

~~7.1.5 Temperature of test room, and~~

~~7.1.6 Date~~ user and are in accord with the alternative procedures described in D 618.

7.4 When tests are conducted, within a laboratory, for purposes of research, development or empirical study and reported beyond that laboratory, the conditions shall be reported in accordance with D 618.

8. Report

8.1 State that the test was made in accordance with this designation and include the following information:

8.1.1 The Pusey and Jones indentation number,

8.1.2 Description of test specimen including dimensions,

8.1.3 Date of vulcanization, if known,

8.1.4 Duration and temperature of vulcanization, if known,

8.1.5 Temperature of test room, and

8.1.6 Date of test.

9. Precision and Bias [3]

~~8~~9.1 These precision statements have been prepared in accordance with Practice D 4483. Refer to Practice D 4483 for terminology and other testing and statistical concepts.

~~8~~9.2 The Pusey and Jones Indentation Plastometer is used mainly in the rubber roll industry. In this program no interlaboratory precision data were obtained due to the limited use of this test method. The precision program consisted of tests by one operator on three different (in-house) instruments on three different days. Four materials were tested. A test result is the median value of three separate (determinations) indentation measurements.

~~8~~9.3 Table 1 gives the within and among "instrument" precision. Repeatability refers to within instrument variation; reproducibility refers to among (between) instrument variation, with the same operator for both.

~~8~~9.4 *Bias*—In test method statistical terminology, bias is the difference between an average test value and the reference or true test property value. Reference values do not exist for this test method since the value or level of the test property is exclusively defined by the test method. Bias, therefore, cannot be determined.

10. Keywords

10.1 hardness; indentation hardness; relative hardness; plastometer

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[3] Supporting data are available from ASTM Headquarters. Request RR: D11–1028.