Designation: D1630 – 16

Standard Test Method for Rubber Property—Abrasion Resistance (Footwear Abrader)[1]

This standard is issued under the fixed designation D1630; 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 U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of the resistance to abrasion of vulcanized rubber, or other rubber materials that are similar to the standard reference compound, used for the soles and heels of footwear. It is not recommended for materials less than 2.5 mm (0.1 in.) in thickness.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

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:*[2]

D1349 Practice for Rubber—Standard Conditions for Testing

D2240 Test Method for Rubber Property—Durometer Hardness

D4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries

3. Significance and Use

3.1 It is recognized that when comparing different types of rubber materials, the service performance may not correlate to the results of this predictive test.

3.2 This test method should not be used as a measure of abrasion resistance for compositions that differ markedly from the standard reference compound. Misleading results, for example, are obtained from polyurethane compositions when compared with the standard reference compound.

3.3 Some specimens may bounce (chatter) against the abrasive paper, producing inaccurate results. These should be interpreted with care and the condition reported.

3.4 If test results are inconsistent, the specimens should be cut, after the test is run, and inspected for voids. If any voids are present, the results should be disregarded and the test repeated using test specimens that are free from voids.

4. Test Conditions

4.1 Unless otherwise specified, the standard temperature for testing shall be 23 ± 2°C (73.4 ± 3.6°F), or the standard test temperature according to Practice D1349.

4.2 Humidity affects the abrasive paper; therefore, the relative humidity shall be controlled at 50 ± 5 % for at least 24 h prior to and during testing.

4.3 The specimens shall be conditioned at this temperature and humidity for no less than 24 h prior to testing.

5. Apparatus

5.1 *Abrasion Machine*—The footwear abrader, often referred to as the National Bureau of Standards (NBS) model, is shown in Fig. 1 and consists of the following components:

5.1.1 *Metal Drum,* rubber-coated or metal-surfaced, 150 mm (6 in.) in diameter. The drum is rotated at a rate of 5.7 ± 0.6 rad/s (45 ± 5 rpm) by means of an electric motor. The number of revolutions of the drum is indicated by either a digital or analog counter.

5.1.2 *Arms,* three, each pivoted at one end and having a mass suspended from the other end. The mass is attached so that a force of 22 N (5 lbf) is exerted directly on the specimen in contact with the abrasive paper.

5.1.3 *Thickness Gauges,* three, either digital or analog and graduated to indicate in increments of no more than 0.02 mm (0.001 in.), attached to a bridge so that each gauge contacts each arm at a point directly over the specimen. The bridge is hinged at one end to allow the arms to swing back for mounting the specimen.

5.1.4 *Compressed Air,* filtered to be free of moisture and contaminants, for cleaning the surface of the abrasive paper.

[1] This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.

Current edition approved June 1, 2016. Published June 2016. Originally approved in 1961. Last previous edition approved in 2012 as D1630 – 06 (2012). DOI: 10.1520/D1630-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

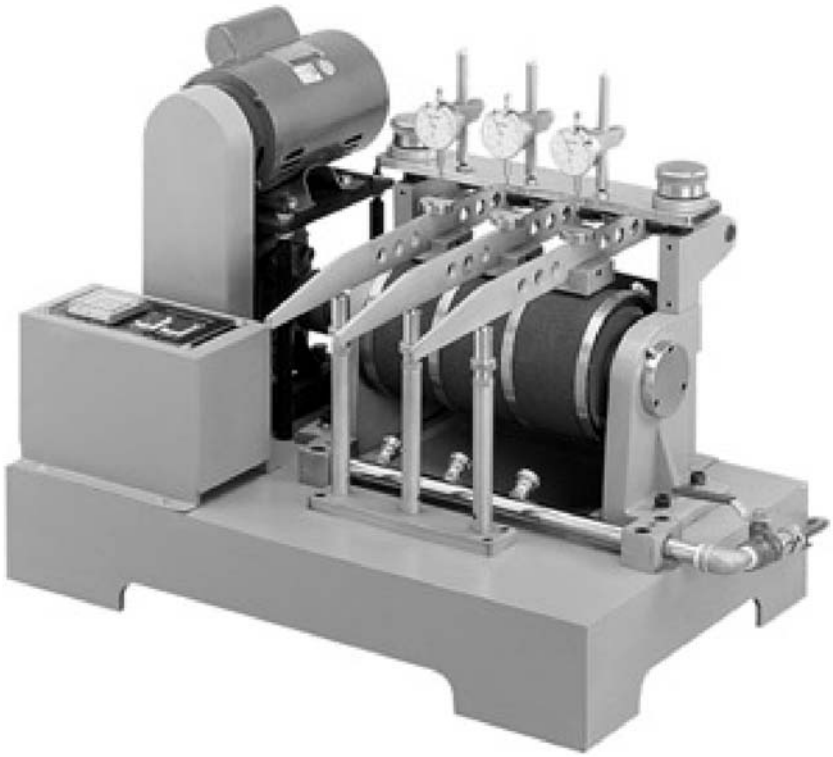

FIG. 1 NBS Abrasion Test Machine

The air is delivered to a manifold or nozzle where the pressure shall be maintained at 210 ± 35 kPa (30 ± 5 psi).

5.1.5 It is recommended to use a suitable suction or vacuum device to remove abraded particles during the test.

5.1.6 *Arm Stop,* one for each arm.

5.1.7 *Rubber Bands or Metal Clamps,* for holding the strip of abrasive paper in position around the rotating drum. The ends of the abrasive paper are cut at an angle of about 80° to the length of the paper and, when in place, permit a clearance (gap) of about 1.5 mm (0.063 in.) with no overlap.

5.2 *Abrasive Paper*—A controlled abrasive consisting of 425 µm 40 grit, No. 1½ garnet paper 150 mm (6 in.) in width.[3,4] (**Warning—**Use of abrasive paper different than that recommended will lead to incorrect results.)

5.3 *Alternative Abrasive Paper*—Corundum (aluminum oxide) of 40 grit, bonded to a carrier sheet of either paper or cloth, 150 mm (6 in.) in width, and sufficient in length to fully encircle the drum may be substituted for the paper described in 5.2 provided that the alternative abrasive paper meets the Abrasion Index requirements specified in 7.1 (AI of 30 to 35).

5.3.1 Since the abrasiveness of virgin abrasive sheets is usually higher than desired, it is necessary to blunt the sheets with one or two test runs using a steel test piece in place of the break-in compound to bring it into the desired range. The direction of rotation used for blunting shall be marked on the sheets.

5.3.2 After blunting, the abrasive sheets shall be thoroughly cleaned by brushing, blowing, or suction and test runs with the break-in compound in shall be made until the Abrasion Index of 30 to 35 is achieved.

5.3.3 Test results obtained with abrasive sheets, thus calibrated, are more consistent.

6. Reference Compound

6.1 The standard reference compound[4,5] shall conform to the following formula and cure specifications.

[3] The sole source of supply of the abrasive paper known to the committee at this time is CCSI, Inc., 221 Beaver Street, Akron, OH 44304. When ordering paper, the order should state the following: D1630 NBS Belt Paper, Roll 6 in.

[4] If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[5] The sole source of supply of the compound known to the committee at this time is Smithers Rapra, North America, 425 W. Market St., Akron OH 44303. The minimum amount which may be ordered is one standard package containing 20 strips.

TABLE 1 Requirements for Comparing Reference Compounds[A]

Run	Arm		
	1	2	3
1	A	B	C
2	B	A	D
3	C	D	A
4	D	C	B

[A] A, B, and C represent the previous three standards in chronological order; D represents the new standard.

Materials	Parts by Mass
Natsyn 2200[4,6]	100.0
Pliolite S6B[4,7]	2.5
Stearic Acid	2.0
N762 Black (SRF)	40.0
N330 Black (HAF)	5.0
Octylated diphenylamine	1.0
2-(Morpholinothio)benzothiazole	0.8
Zinc Oxide	20.0
Sulfur	2.0

NOTE 1—RMA Standard Reference Compound[4,5] shall be provided in the form of a strip 200 mm (8 in.) long and 25 mm (1 in.) wide with one face concaved to the contour of the abrasive wheel.

NOTE 2—Levels of carbon black can be adjusted to provide a reference compound that meets the specifications listed in 7.1.

6.2 *Cure*—The standard reference compound shall be cured at 160 ± 1°C (320 ± 2°F). The time of cure may be varied with each individual lot of compounds to give the proper state of cure and uniform abrasion.

6.3 *Hardness*—The durometer hardness of properly cured standard reference compounds shall be A/62 ± 3/1, as determined by Test Method D2240.

6.4 *Uniformity:*

6.4.1 Comparison of a newly prepared (D) reference compound with previous reference compounds (A, B, and C) shall be made as follows:

6.4.1.1 The number of revolutions per 2.5 mm (0.1 in.) of wear of the new reference compound shall be obtained concurrently with the last three reference compounds in accordance with the requirements in Table 1. Repeat the experiment a total of four times.

6.4.2 The composite average value for compounds A, B, and C and the average value for D shall be calculated.

6.4.3 A newly prepared reference compound shall be considered acceptable when the difference between the number of revolutions per 2.5 mm (0.1 in.) for the new compound D and the same arithmetic average of the three previous reference compounds, A, B, and C does not exceed ± 5.0 % (in number of revolutions of wear).

6.4.4 Standard reference compounds more than 6 months old shall not be used. The standard reference compounds shall be stored in an airtight container out of direct light and at 23 ± 2°C (73.4 ± 3.6°F) or may be refrigerated during storage.

[6] The sole source of supply of Natsyn 2200 known to the committee at this time is Americas International, Inc., 1680 Akron-Peninsula Road, Suite 101, Akron, OH 44313.

[7] The sole source of supply of Pliolite S6B known to the committee at this time is Eliokem, Inc., 1452 East Archwood Avenue, Suite 240, Akron, OH 44306.

7. Break-in Compound

7.1 The standard break-in compound shall be a nonblack toplift compound prepared under carefully controlled conditions and conform to the following requirements:

D2240 Type D Hardness	D/55 to 60/1
Tensile Strength, min	7.0 MPa (1000 psi)
Elongation, min	200 %
Abrasion Index	30 to 35

7.1.1 A break-in compound designated as RMA break-in compound shall be used.[4,8] The order should specifically state that the compound is to be used for break in of the abrasive paper in connection with tests on the National Bureau of Standards (NBS) abrasion machine.

7.2 The standard break-in compound shall be stored out of direct light at 23 ± 2°C (73.4 ± 3.6°F) or may be refrigerated during storage.

8. Test Specimen

8.1 Unless otherwise specified, the test specimen shall consist of a portion of the test sample or piece, 25 by 25 mm (1 by 1 in.) and approximately 6 mm (0.25 in.) in thickness.

8.2 Unless otherwise specified, materials thinner than 6.4 mm (0.25 in.) shall be plied to obtain the desired thickness (use no adhesive or bonding material). The contact surfaces of the plied pieces shall be free of voids and accurately aligned.

9. Procedure

9.1 *Preparation of the Test Specimen*—If the material is too thick, has a fabric backing, surface coating, or an uneven surface that may interfere with the abrasion test, buff it to the dimensions specified in 8.1. If the specimen is too thin, prepare it as specified in 8.2.

9.2 Before the start of any test when new abrasive paper has been applied to the apparatus, mount a specimen of the standard break-in compound on each arm of the testing machine and run the machine for 500 revolutions. Discard the standard break-in compounds used for this break-in.

9.3 Following this, mount a specimen of the standard reference compound on each arm of the testing machine and run the machine for 500 revolutions as a second break-in of the abrasive paper. Discard the standard reference compounds used for this second break-in.

9.4 No more than 18 runs of three specimens each (excluding standard reference compounds run before each of the six tests) shall be made on one abrasive paper after the break-in runs.

9.5 One specimen from the standard reference compound shall be mounted on each arm of the machine. Rotate the drums at a speed of 4.7 ± 0.5 rad/s (45 ± 5 rpm) with the air pressure turned on, and allow the machine to run until the surface of the specimen is worn to the shape of the drum. At this point, stop the machine and lock the gauge bridge in place.

[8] The sole source of supply of the compound known to the committee at this time is Smithers Scientific Services, 425 W. Market St., Akron OH 44303.

TABLE 2 ASTM Test Method D1630 Type 1 Precision[A] —Abrasion Index

Material	Mean Level	Within Laboratories[B]			Between Laboratories		
		s_r	r	(r)	S_R	R	(R)
Natural Rubber (NR)	48.3[C]	4.3	12.1	25.0	12.2	34.6	71.6
NR/Polybutadiene	130.8	5.5	15.6	11.9	25.2	71.5	54.6
Nitrile Rubber	210.5	20.3	57.3	27.2	70.6	199.9	94.9
Pooled or Averaged Values	129.9	12.4	35.0	26.9	43.9	124.2	95.6

[A] This is short-term precision (days).
[B] Symbols are defined as follows:
s_r = Within laboratory standard deviation.
r = Repeatability (in measurement units).
(r) = Repeatability (in percent).
S_R = Between laboratory standard deviation.
R = Reproducibility (in measurement units).
(R) = Reproducibility (in percent).
[C] Mean level values as abrasive index (unitless ratio).

9.6 Set the thickness gauges and the revolution counter to zero. Start the machine again and run until approximately 2.5 mm (0.1 in.) thickness has been abraded from the specimens as recorded on the thickness gauges.

9.7 Stop the machine, and record the number of revolutions and the gauge readings for each specimen. Using the data obtained, calculate the number of revolutions required to abrade 2.5 mm thickness from each specimen and record the value as $R2$. Record the thickness readings with the drum as near as possible to the position as when the thickness gauges were set at zero.

9.8 Remove the standard reference samples from the machine. Mount one test specimen each on each arm of the machine. Test these specimens and record the number of revolutions required to abrade 2.5 mm (0.1 in.) thickness from each test specimen as R_1. Make a minimum of one and a maximum of six runs of test specimens, after which make a second run of standard reference specimens.

10. Calculation

10.1 Express the abrasive resistance of the specimen by an abrasive index which shall be calculated as follows:

$$\text{Abrasive Index} = \frac{R_1}{R_2} \times 100 \quad (1)$$

where:

R_1 = number of revolutions required to abrade 2.5 mm (0.1 in.) of the test specimen, and
R_2 = average number of revolutions required to abrade 2.5 mm (0.1 in.) thickness of the reference compound run before and after the test specimens.

11. Report

11.1 The report shall include the following:

11.1.1 The abrasive index of the test specimens, as the average of the values obtained (record to the nearest one unit),

11.1.2 Type of specimen used, and whether it was plied, and

11.1.3 Type of abrasive paper used.

12. Precision and Bias

12.1 The interlaboratory program to determine a Type 1 precision (Class I Specimens) was run on three compounds with eight laboratories participating. The control compounds and break-in compounds were supplied along with specimens of the three compounds. The three compounds were chosen to give a wide range of values. They were a natural rubber shoe soling material, a natural rubber/polybutadiene material, and a nitrile compound. There were two determinations for each compound made for each of three days. A determination consists of running three specimens, one on each arm. The program was conducted in June of 1989. This precision and bias section has been prepared in accordance with Practice D4483.

12.2 The precision results in this precision and bias section give an estimate of the precision of this test method with the materials (rubbers used in the particular interlaboratory program) as described in the following. The precision parameters should not be used for acceptance/rejection testing of any group of materials without documentation that they are applicable to those particular materials and the specific testing protocols that include this test method.

12.3 The results of the precision calculations for repeatability and reproducibility are given in Table 2 in ascending order of material average (Abrasion Index), for each of the materials evaluated.

12.4 The precision of this test method may be expressed in the form of the following statements that use what is called an *appropriate value* of r, R, (r), or (R), that is, that value to be used in decisions about test results (obtained with the test method). The appropriate value is that value of r or R associated with mean level in Table 2 closest to the mean level under consideration at any given time, for any given material in routine testing operation.

12.5 *Repeatability*—The repeatability, r, of this test method has been established as the appropriate value tabulated in Table 2. Two single test results, obtained under normal test method procedures, that differ by more than this tabulated r (for any given level) must be considered as derived from different or nonidentical sample populations.

12.6 *Reproducibility*—The reproducibility, R, of this test method has been established as the appropriate value tabulated in Table 2. Two single test results obtained in two different laboratories, under normal test method procedures, that differ

by more than the tabulated *R* (for any given level) must be considered to have come from different or nonidentical sample populations.

12.7 Repeatability and reproducibility expressed as a percentage of the mean level, (*r*) and (*R*), have equivalent application statements as above for *r* and *R*. For the (*r*) and (*R*) statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two results.

12.8 *Bias*—In test method 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 (of the test property) is exclusively defined by the test method. Bias, therefore, cannot be determined.

13. Keywords

13.1 abrader; abraser; abrasion; abrasion index; abrasion resistance; abrasive; break-in compound; footwear; footwear abrader; National Bureau of Standards; NBS abrader; reference compound; RMA