Designation: D 1630 – 94 (Reapproved 2000)

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

This standard is issued under the fixed designation D 1630; 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. Scope

1.1 This test method covers the determination of the resistance to abrasion of vulcanized rubber or other compounds, or both, 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 Values stated in SI units are to be regarded as the standard. Values 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:*

D 2240 Test Method for Rubber Property—Durometer Hardness[2]

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

3. Significance and Use

3.1 It is recognized that when comparing different types of rubber, the ranking in service may not follow the ranking from the test results.

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. For example, misleading results are obtained in polyurethane compositions compared with the standard reference compound.

3.3 Some samples will bounce (chatter) over the paper instead of running smoothly. The results obtained on these samples are very inaccurate and should be interpreted with care. If samples give data that is inconsistent, they should be cut after the test is run to check for voids. If any voids are present the results should be discarded and the test repeated using samples 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). Since humidity affects the sandpaper, the relative humidity should be controlled at 50 + 5 %. The samples should be conditioned at this temperature and humidity for at least 24 h prior to running.

5. Apparatus

5.1 *Abrasion Machine*— The footwear abrader referred to as the National Bureau of Standards 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 rotation rate of 5.7 ± 0.6 rad/s (45 ± 5 r/min) by means of an electric motor with a reducing mechanism. The number of revolutions of the drum is indicated by a counter attached to one end of the shaft.

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 downward force of 22 N (5 lbf) is exerted directly on the specimen in contact with the abrasive.

5.1.3 *Dial Thickness Gages*, three, graduated to read 0.02 mm (nonmetric gages to measure 0.001 in.) and attached to a bridge so that one gage contacts one 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*, free from moisture and grease, for cleaning the surface of the abrasive. The air is delivered to a manifold or nozzle where the pressure shall be maintained at 210 ± 35 kPa (30 ± 5 psi). A suitable suction may be used to remove abraded particles.

5.1.5 *Arm Stop*, one for each arm.

5.1.6 *Rubber Bands or Metal Clamps*, for holding a 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 of about 1.5 mm (0.063 in.) but no overlap.

[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 Feb. 15, 1994. Published April 1994. Originally published as D 1630 – 61. Last previous edition D 1630 – 83.

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

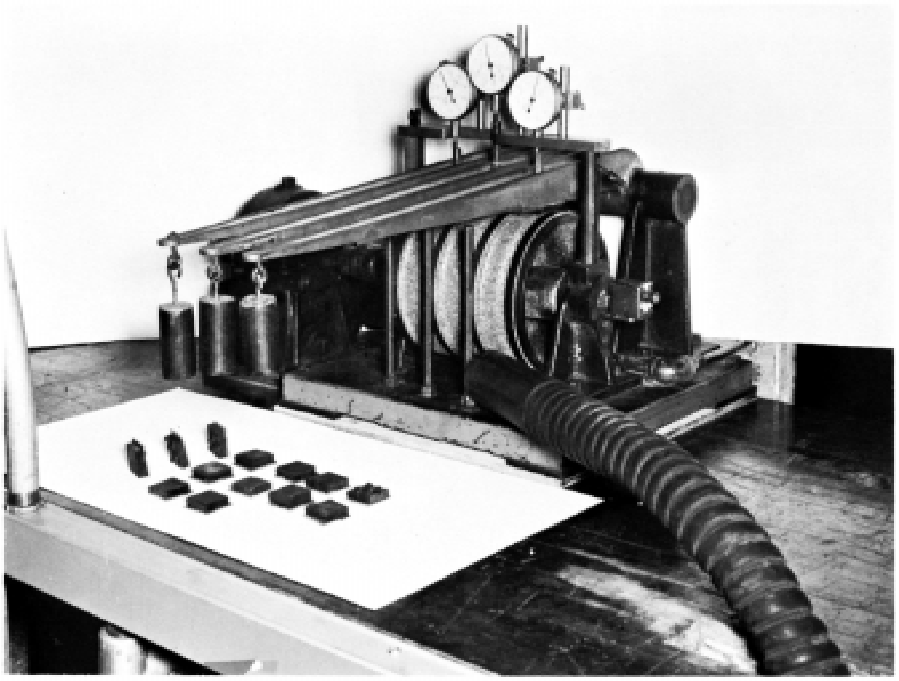

FIG. 1 Abrasion Test Machine

5.2 *Abrasive*—A controlled abrasive consisting of 425 µm 40 grit, No. 1½ garnet paper 150 mm (6 in.) in width.[3]

NOTE 1—**Caution:** Use of abrasive paper different than that recommended will lead to incorrect results.

6. Reference Compound

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

Materials	Parts by Mass
Natsyn 2200[5]	100
Pliolite S6B[5]	2.5
Stearic Acid	2.0
N762 Black (SRF)	40
N330 Black (HAF)	5.0
Octylated diphenylamine	1.0
2-(Morpholinothio)benzothiazole	0.8
Zinc Oxide	20
Sulfur	2.0

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 Shore A Hardness of properly cured standard reference compounds shall be 62 ± 3, as determined by Test Method D 2240.

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 room temperature or lower.

7. Break in Compound

7.1 The standard break in compound shall be a nonblack toplift compound prepared under carefully controlled conditions and conforming to the requirements as follows:

[3] Abrasive paper, 40 Grit Garnet, may be obtained from Liberty Abrasives, Inc., 708 Indian Hills Mound, Goodlettsville, TN 37072, (615) 851-0770. When ordering paper, the order should state the following:

FASTCUT Belt Paper
G 040 E155 F16574
Roll 6 in.

[4] RMA Standard Reference Compound 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. The RMA Reference Compound will be obtained from the Smithers Scientific Services, 425 W. Market St., Akron, OH 44303, in package form. The minimum amount which may be ordered is one standard package containing 20 strips.

[5] Available from Goodyear Tire and Rubber Co., Akron, OH 44316.

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.

Shore D Hardness	55 to 60
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.[6] 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 abrasion machine.

7.2 The standard break in compound shall be stored out of direct light and at room temperature or lower.

8. Test Specimen

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

8.2 Unless otherwise specified in the detail specification, materials thinner than 6.4 mm (0.25 in.) shall be plied up, using thin pieces, accurately aligned, to obtain the desired thickness; the surfaces of the pieces shall be in contact throughout.

9. Procedure

9.1 *Preparation of the Test Specimen*—If the material is too thick or 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 toplift compound on each arm of the testing machine and run the machine for 500 revolutions.

9.3 Discard the standard break in toplift compounds used for this break in. 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 paper. Discard the standard reference compounds used for this second break in. No more than 18 runs of three specimens each (excluding standard reference compounds run before each six tests) shall be made on one abrasive paper after the break in runs.

9.4 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 r/min) 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 gage bridge in place. Set the gages 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 gages. Stop the machine, and record the number of revolutions and the gage readings for each specimen. From the data obtained, calculate the number of revolutions required to abrade 2.5 mm thickness from each specimen and record the value as $R2$. Take the thickness readings with the drum as near as practical in the same position as it was when the gages were set at zero.

9.5 Remove the standard reference samples from the machine. Mount one test specimen each on each arm of the machine. Test these specimens as described in 9.3. 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 up, and

11.1.3 Type of 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 D 4483.

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

[6] Available from the Goodyear Tire and Rubber Co., Windsor, VT 05089.

TABLE 2 ASTM Test Method D 1630 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).

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; abrasion; abrasive; footwear; garnet paper; NBS abrader; sandpaper