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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Specification for Special Purpose, Smooth–Tread Tire, Operated on Fixed Braking Slip Continuous Friction Measuring Equipment[1]

This standard is issued under the fixed designation E 1551; 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.

1. Scope

1.1 This specification covers the general requirements for a special purpose, smooth-tread standard tire for measuring tire-pavement friction forces. The tire is utilized on fixed braking slip continuous friction measuring equipment such as the Runway Friction Tester, Surface Friction Tester, or BV-11 Skiddometer Trailer.

1.2 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 297 Test Methods for Rubber Products—Chemical Analysis[2]

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension[2]

D 1054 Test Method for Rubber Property—Resilience Using a Rebound Pendulum[2]

D 1765 Classification System for Carbon Blacks Used in Rubber Products[2]

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

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[2]

2.2 *Other Documents:*

K.J. Law Slip Friction Tester —Instruction and Servicing Manual

Surface Friction Tester —Instruction and Servicing Manual

BV-11 Skiddometer Trailer—Instruction and Servicing Manual

DOT/FAA/AS-90-1 Reliability and Performance of Friction Measuring Tires and Friction Equipment Correlation[3]

Advisory Circular 150/5320-12 —"Measurement, Construction and Maintenance of Skid Resistant Airport Pavement Surfaces"[4]

Tatra–Intertech Friction Tester —Instruction and Servicing Manual[5]

3. Materials and Manufacture

3.1 The individual standard tires shall conform to the design standards of Section 5. Dimensions, weights, and permissible variations are also given in Section 5 and in Fig. 1 and Fig. 2.

3.2 Tread compounding, fabric processing, and all steps in tire manufacturing shall be certified to ensure that the specifications are met (see Section 7, Test Methods).

3.3 The markings on the tire as shown in Fig. 1 shall be molded on both sides of the tire.[6]

3.4 Fig. 1 shows a view of the tread surface and a side view of the standard, special purpose, smooth tread tire and Fig. 2 is a typical tire cross section with critical dimensions identified.

4. Material Requirements

4.1 The compounding requirements for the tread compound are given in Table 1.

4.2 The fabric shall be Nylon, 1260/2 Denier.

NOTE 1—Certain proprietary products have been specified since exact duplication of properties of the finished tire may not be achieved with other similar products. This inclusion does not in any way comprise a recommendation for these proprietary products nor against similar products of other manufacturers, nor does it imply any superiority over any such similar products.

5. Construction, Dimensions and Permissible Variations

5.1 *Construction*—The tire shall be a size 4.00-8, tube type, four plies, Nylon cord, and bias construction.

5.2 *Dimensions*—Tread width shall be 2.4 ± 0.1 in. (61 ± 2.5 mm), the tread radius shall be 10.0 ± 1.5 in. (254 ± 38 mm), the cross-sectional width shall be 4.1 ± 0.15 in. (104 ± 3.8 mm), and the outside diameter at the tread centerline shall be 16.4 ± 0.2 in. (417± 5 mm) when measured on an 8 by 3.00D rim at 30 ± 0.5 psi (207 ± 2 kPa) inflation pressure. See Fig. 2 which shows inflated dimensions of the new tire.

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[1] This specification is under the jurisdiction of ASTM Committee E-17 on Vehicle-Pavement Systems and is the direct responsibility of Subcommittee E17.24 on Tire and Slider Characteristics.

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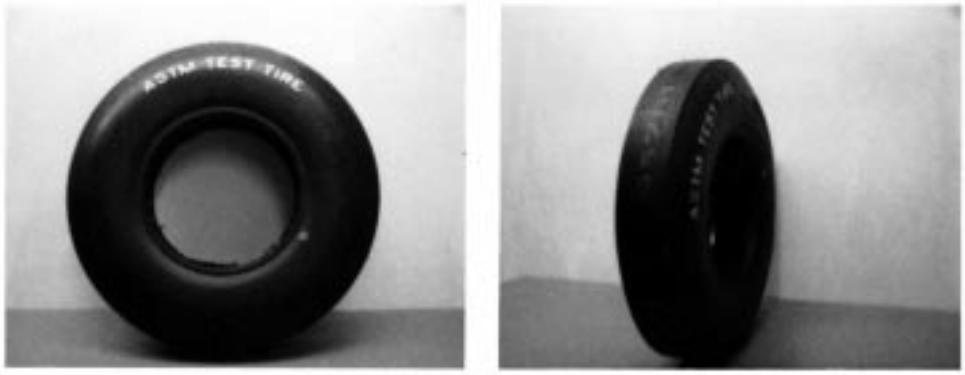
[2] *Annual Book of ASTM Standards*, Vol 09.01.

[3] Available from National Technical Information Service, Springfield, VA 22161.

[4] Available from U.S. Department of Transportation Federal Aviation Administration, 800 Independence Ave., S.W., Washington, DC 20591.

[5] Available from Intertech Engineering Inc., 726 S. Mansfield Ave., Los Angeles, CA 90036.

[6] ASTM E1551 tire is available from Specialty Tires of America, Inc., P.O. Box 749, 1600 Washington St., Indiana, PA 15701.



Suggested Marking on Tire
ASTM Test Tire E 1551
4.00 – 8 NHS
6 Ply Rating
Tube Type
Manufacturer's Name or Trademark

FIG. 1 Test Tire

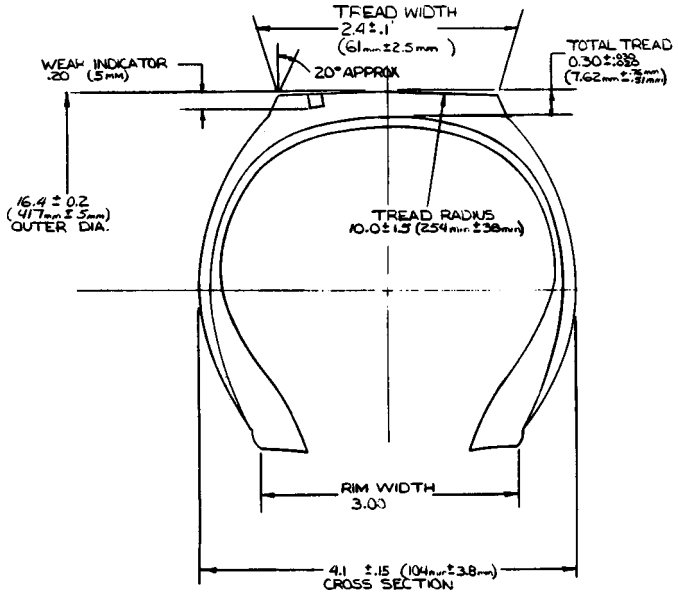


FIG. 2 Tire Section, Including Inflated Dimensions

5.3 *Tread*—The tread surface shall be smooth (blank) without any ribs or grooves. The tread shall have a thickness of 0.16 in. (4.1 mm) and an under skid thickness of 0.14 ± 0.03 in. (3.56 ± 0.76 mm).

5.4 *Wear Indicators*—There will be four holes molded into the tire 0.16 in. (4.1 mm) deep and 0.125 in. (3.18 mm) diameter. These four wear indicators will alternate from one side of the tread centerline to the other and be spaced 90° apart.

6. Workmanship

6.1 Tires shall be free of defects in workmanship and material.

7. Test Methods

7.1 *Tensile Sheet Cure*—Practice D 3182.

TABLE 1 Compounding of Tread Rubber[A]

Material	Parts by Mass
SBR 1714[B]	89.38
CB1252[C]	48.12
N347[D]	75.00
High-Aromatic Oil	9.00
Zinc Oxide	3.00
Stearic Acid	2.00
Santoflex 13[E]	2.00
Paraffin Wax	2.00
Santocure NS[F]	1.10
DPG[G]	0.10
Sulfur	1.80

[A] See Practice D 3182.
[B] Styrene-butadiene rubber (23.5 % styrene) 37.5 parts of high-aromatic oil.
[C] Cis-polybutadiene with 37.5 parts of high-aromatic oil or equivalent.
[D] N347 Carbon Black, see Classification D 1765.
[E] Dimethyl butylphenyl phenylenediamine.
[F] Butyl benzothiazole sulfenamide.
[G] Diphenyl guanidine.

7.2 *Modulus* (300 %)—Test Methods D 412.

7.3 *Tensile Sheet Durometer*—Test Method D 2240, using a Type A Shore Durometer.

7.4 *Restored Energy (Rebound or Resilience)*—Test Method D 1054.

7.5 *Specific Gravity*—Test Methods D 297.

7.6 *Tensile Strength*—Test Methods D 412.

7.7 *Elongation*—Test Methods D 412.

7.8 *Tire Tread Durometer*—Test Method D 2240, in addition to the following specific procedures:

7.8.1 Use a Type A Durometer. A0.5-in. (12.7-mm) diameter presser foot, Shore, code XAHAF is recommended.

7.8.2 The durometer shall be calibrated at a reading of 60 hardness.

7.8.3 Condition the tire and durometer to equilibrium at 73.4 ± 3.6°F (23 ± 2°C) before determining tread hardness.

7.8.4 The tire tread hardness is to be determined by averaging at least one set of six readings. A set should consist of readings taken at equally spaced intervals across the tread. It is

recommended that additional sets of readings be taken around the tread circumference.

7.8.5 Apply presser foot to the tire tread as rapidly as possible without shock, keeping the foot parallel to the tread surface. Apply just sufficient pressure to obtain firm contact between presser foot and tire tread surface. Read the durometer scale within 1 s after presser foot is in contact with the tire tread, but after initial maximum transient which may occur immediately after contact is made.

8. Physical Requirements

8.1 The physical and mechanical test requirements are given in Table 2.

9. Certification

9.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been tested and inspected as directed in this specification, verifying that all requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

9.2 The Annex to this specification contains the test procedures for determining the reliability, performance and consistency of the tires.

TABLE 2 Physical Properties of Tread Compound

Tensile Sheet Cure, min at 300°F (149°C)	30
300 % modulus, psi (MPa) (Test Methods D 412)	800 ± 200 (5.5 ± 1.4)
Tensile sheet durometer (Test Method D 2240)	58 ± 2
Restored energy (rebound or resiliance) (Test Method D 1054)	46 ± 2
Specific gravity (Methods D 297)	1.13 ± 0.02
Tensile strength, min psi (MPa) (Test Methods D 412)	2000 (13.8)
Elongation, min % (Test Methods D 412)	500
Tire tread durometer (Test Method D 2240)	58 ± 2

10. Packaging and Preservation

10.1 The tires should be stored in a dry area, at a temperature not exceeding 90°F (32.2°C) and in subdued light. Tires must not be stored near electric motors, welders, or other ozone generating equipment. The tire is not to be used as a standard test tire after more than one year storage by the consumer nor if it has been stored at more than 85°F (29.4°C) for more than 60 days.

11. Recommendations for Tire Use and Operational Requirements

11.1 The tire is for measuring tire-pavement friction forces only and is not designed for general highway service.

11.2 A new tire break-in sufficient to only remove the glossy tread surface is recommended before using the tire for testing. This break-in time will vary with pavement surface condition, speed, and test tire operating mode.

11.3 The tire shall be operated on fixed slip devices such as the Runway Friction Tester, the Surface Friction Tester, and the BV-11 Skiddometer Trailer. The inflation pressure used in the friction tire shall be 30 ± 0.5 psi (207 ± 3 kPa) measured at ambient temperature (cold).

11.4 The recommended static test load on the friction tire shall be 200 ± 2 lbf (890 ± 9 N) with loading to a maximum of 320 ± 3 lbf (1423 ± 14 N) permissible, at 30 ± 0.5 psi (207 ± 3 kPa) inflation pressure.

11.5 When any irregular wear or damage results from testing or when the wear indicators are no longer visible, the use of the friction tire as a standard test friction tire shall be discontinued.

ANNEX

(Mandatory Information)

A1. TESTING THE E1551 TIRE FOR RELIABILITY, PERFORMANCE AND CONSISTENCY

A1.1 Scope

A1.1.1 This specification describes the test procedures for establishing the reliability, performance, and consistency of the tire from batch to batch.

A1.2 Certification

A1.2.1 The manufacturer of the tire will certify that testing has been completed on each batch of tires.

A1.2.2 A certified testing company may be sub-contracted by the manufacturer to accomplish the testing and certification according to these procedures.

A1.2.3 Testing will be conducted on a properly calibrated, fixed braking slip, continuous friction measuring device (see 11.3).

A1.3 Tire Sampling

A1.3.1 The number of tires randomly selected from each batch is determined from Table A1.1.

TABLE A1.1 Random Sampling of Tires from Tire Batch Size to Determine Acceptance/Failure

Tire Batch Size	Random Tire Sample Size For Testing	Accept If Number of Failed Tires Equals	Reject If Number of Failed Tires Equals
51 to 150	5	1	2
151 to 500	8	2	3
501 to 1200	13	3	4

A1.3.1.1 To ensure random selection of test tires, the tire manufacturer shall divide the batch into as many equal sublots as the number of test tires required by Table A1.1. One tire is then randomly selected from each sublot.

A1.3.1.2 In addition to the current tires selected for comparative testing with the previous batch tires, the manufacturer shall also retain and properly store the required number of randomly selected tires from the current batch for future

comparative testing with the next batch of tires produced. (See Section 10). This will always double the random sample size requirement given in Table A1.1.

A1.3.2 Each tire selected shall be properly labeled according to sequential batch number and marked accordingly to the order of their selection.

A1.4 Test Surfaces

A1.4.1 Four test surfaces will be required as follows:

A1.4.1.1 Test Surface A: Mu[7] values ranging from 0 to 16,

A1.4.1.2 Test Surface B: Mu values ranging from 28 to 44,

A1.4.1.3 Test Surface C: Mu values ranging from 56 to 72, and

A1.4.1.4 Test Surface D: Mu values 84 and above.

A1.4.2 The averaged Mu value for each of the test surfaces identified above is based on a minimum of ten passes conducted at 40 mph (65 km/h).

A1.4.2.1 The average Mu value shall be as close to the middle of the respective ranges as possible and the continuous friction trace produced by the friction device shall be consistently within a band width of ±3 Mu numbers.

A1.4.2.2 In addition, the averaged Mu value for each test surface shall not vary more than ±3 Mu numbers from the averaged Mu value obtained for that surface (A, B, C or D) for the previous batch of tires.

A1.4.3 The physical length of each test surface shall not be less than 250 ft (75 m) or greater than 500 ft (152 m).

A1.4.4 The data acquisition shall be taken within the physical length of each test surface where the friction values are stabilized and are representative of the test surface.

A1.5 Testing

A1.5.1 The manufacturer or testing facility shall select one tire from the current batch of provided samples and one tire from the previous batch of provided samples. The tires will be properly identified.

A1.5.2 Tests shall be conducted on originally dry pavement test surfaces using the friction device's self-watering system. The water depth shall be 0.04 in. (1 mm), applied in front of the friction measuring tire(s).

A1.5.3 To minimize ambient temperature influences on friction values, test trials shall be conducted when the temperature is within 80 ± 10°F (27 ± 6°C).

A1.5.4 A minimum of six passes shall be conducted at each of two speeds, 40 and 60 mph (65 and 95 km/h), on each test surface described in A1.4, using the tires selected under A1.5.1.

A1.5.5 The remaining randomly selected tire samples from each batch (Table A1.1) shall be tested once over each of the test surfaces described in A1.4 at two speeds, 40 and 60 mph (65 and 95 km/h).

A1.6 Analysis of Test Data

A1.6.1 When the test trials have been completed, statistical analyses shall be conducted to develop the Linear Regression Line to establish the reliability, performance and consistency of the current tire batch with the previous tire batch. Paragraph A1.8 details the parameters for conducting the statistical analysis.

A1.6.2 The averaged Mu value for all tests conducted for each speed shall be within One Standard Error of Estimate or ±3 Mu numbers from the Linear Regression Line for each random tire sample of the previous tire batch versus the random tire sample of the current tire batch.

A1.6.3 The averaged Mu value shall be within One Standard Error of Estimate or ±3 Mu numbers from the statistical calculated Linear Regression Line for each of the remaining random tire samples, (see A1.5.5), for each test surface, and two test speed.

A1.7 Retesting

A1.7.1 When any one tire fails to meet the parameters in one of the three sets given in statistical parameters of A1.8, the tire will fail to qualify. If the number of failed tires equals or exceeds the number given in the reject column of Table A1.1, the entire batch fails to qualify. No further testing will be conducted until the tire manufacturer completes a thorough check of the tire specification requirements. When the manufacturer is satisfied that the new batch produced meets the tire specification requirements, qualification trials will be rescheduled.

A1.7.2 When any one tire fails to meet the requirements given either A1.6.2 or A1.6.3, those tires will be retested. These additional tests are conducted to ensure that no unexplained inconsistency occurred either in the conduct of the test trials or testing procedures, equipment calibration, or in the performance of the statistical analyses.

A1.8 Parameters for the Statistical Analysis

A1.8.1 The three sets detailed in the following paragraphs must be met when conducting the statistical analysis. The data for the previous batch of tires shall be plotted on the *X*-axis and the current batch of tires shall be plotted on the *Y*-axis.

A1.8.2 *Intercept Set*—The parameters for this set are divided into three elements: Intercept at X = 0, Slope of Linear Regression Line, and Intercept at X = 100.

A1.8.2.1 *Intercept at X = 0*—The parameter for allowable variance at this intercept is ±3 Mu numbers for One Standard Error of Estimate.

A1.8.2.2 *Slope of Linear Regression Line*—A perfect correlation line is established when the Slope of the Regression Line equals 1.000. The parameter for the allowable variance from this line is ±0.080, or the slope range from 0.920 to 1.080.

A1.8.2.3 *Intercept at X = 100*—The parameter for allowable variance at this intercept is ±5 Mu numbers for One Standard Error of Estimate.

A1.8.3 *The Coefficient Set*—The parameters for this set are divided into two elements: the Coefficient of Correlation and the Coefficient of Determination.

A1.8.3.1 *The Coefficient of Correlation*—The minimum acceptable value for the Coefficient of Correlation is 0.980.

A1.8.3.2 *The Coefficient of Determination*—The minimum acceptable value for the Coefficient of Determination is 0.960. The Coefficient of Determination is calculated by squaring the

[7] Mu = μ; Coefficient of friction. Scale ranges from 0 to 100 and equates actual coefficient ratio multiplied by 100.

Coefficient of Correlation.

A1.8.4 *Standard Error of Estimate Set*—Consists of only one element, the Standard Error of Estimate. The parameter for this set is ± 3 Mu numbers for One Standard Error of Estimate.

A1.9 Precision and Bias

A1.9.1 The analysis of data obtained with a fixed braking slip continuous friction measuring device operated by experienced operators, indicates that duplicated tests show repeatability or agreement within ± 3 Mu numbers of the averaged Mu value. Tire friction data obtained with the same operator and under identical test conditions should not be considered suspect unless they differ by more than 5 %.