



Designation: D 2229 – 04

Standard Test Method for Adhesion Between Steel Tire Cords and Rubber¹

This standard is issued under the fixed designation D 2229; 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 approval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the force required to pull a steel cord from a block of vulcanized rubber.

1.2 Although designed primarily for steel cord, this test method may be applied with modifications to wire used in rubber products.

1.3 This test method can also be used for evaluating rubber compound performance with respect to adhesion to steel cord.

1.4 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.5 *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

D 76 Specification for Tensile Testing Machines for Textiles

D 123 Terminology Relating to Textiles

D 1566 Terminology Relating to Rubber

D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data

D 6477 Terminology Relating to Tire Cord, Bead Wire, Hose Reinforcing Wire, and Fabrics

E 105 Practice for Probability Sampling of Materials

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process

3. Terminology

3.1 *Definitions*

3.1.1 For definitions of terms relating to tire cord, bead wire, hose wire, and tire cord fabrics, refer to Terminology D 6477.

3.1.1.1 The following terms are relevant to this standard: adhesion, rubber compound, and steel cord.

3.1.2 For definitions of terms relating to rubber, refer to Terminology D 1566.

3.1.3 For definitions of other terms related to textiles, refer to Terminology D 123.

4. Summary of Test Method

4.1 The steel cords are vulcanized into a block of rubber and the force necessary to pull the cords linearly out of the rubber is measured.

5. Significance and Use

5.1 This test method is considered satisfactory for the acceptance testing of commercial shipments of steel tire cord because current estimates of between-laboratory precision for single materials are considered acceptable and the method has been used extensively in the trade for acceptance testing.

5.1.1 If there are differences or practical significances between reported results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, the test samples should be used that are as homogenous as possible, that are drawn from the material from which the disparate test results were obtained, and that are randomly assigned in equal numbers to each laboratory for testing. Other materials with established test values may be used for this purpose. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 The mold described in this test method is primarily designed for quality acceptance testing for steel cord where the sample size for each cord is 4 or a multiple thereof, but any mold/cavity combination which will provide the required test block dimensions (Figs. 1 and 2) is acceptable.

5.3 Appendix X1 contains suggested ranges of environmental conditions for aging tests.

5.4 The property measured by this test method indicates whether the adhesion of the steel cord to the rubber is greater than the cohesion of the rubber, that is, complete rubber

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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.

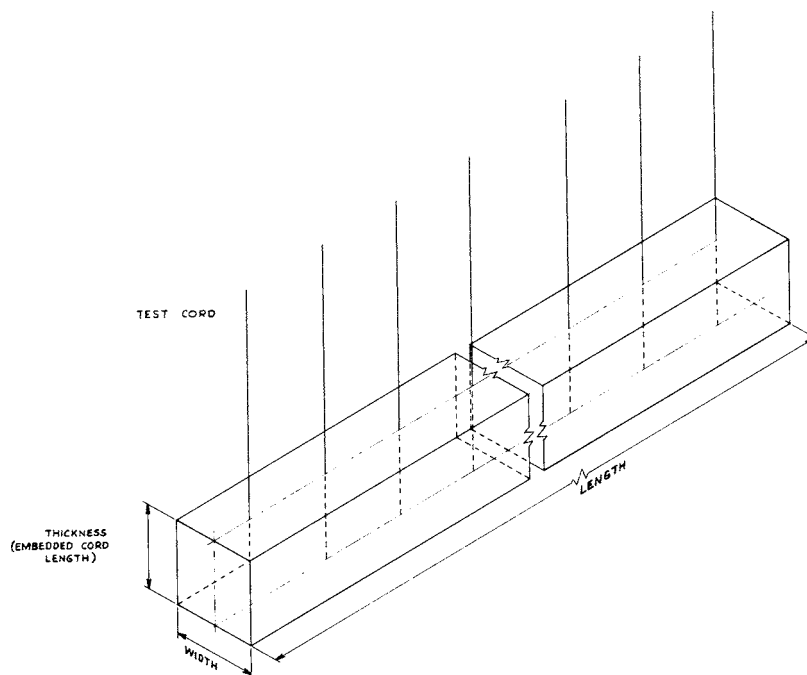


FIG. 1 Definition of Test Block Dimensions

coverage of the steel cord, or less than the cohesion of the rubber, that is, lack of rubber coverage.

6. Apparatus

6.1 *Mold* (Figs. 2 and 3)—The mold is designed to produce four test blocks with the preferred dimensions, each containing 15 steel cords. The blocks are 200 mm long and 12.5 mm thick (embedded cord length). When testing cords equal to or less than 1.7-mm diameter, the mold in Fig. 2 and Fig. 3 should be used to produce blocks, and when testing cords with a diameter greater than 1.7 mm, the mold should be suitably modified. Molds designed to produce any other number of test blocks of the required dimensions are acceptable, and molds designed to produce blocks with different embedded cord length are permitted.

6.2 If more than one third of the cords break at the 12.5-mm embedment, it may be advisable to reduce the embedment by use of a suitable mold insert.

6.3 Testing Machine:

6.3.1 A constant-rate-of-extension (CRE) type tensile testing machine conforming to the requirements of Specification D 76 for textiles shall be used for measuring the pull-out force. The rate of travel of the power actuated grip shall be 50 mm/min. Other rates of travel up to 150 mm/min may be used as agreed upon by the purchaser and the supplier.

6.3.2 The top grip shall apply force to the cord during testing that is normal to the face of the test block.

6.3.3 The bottom grip (Fig. 4) shall be a special holder made for the vulcanized test block.

6.4 *Press*—A curing press, large enough to take the mold, and capable of a minimum pressure of 3.5 MPa over the total

area of the mold plate. Electrical or steam heat for the top and bottom platens shall be provided, of sufficient capacity for maintaining the mold components at the temperatures required for the rubber compound being used.

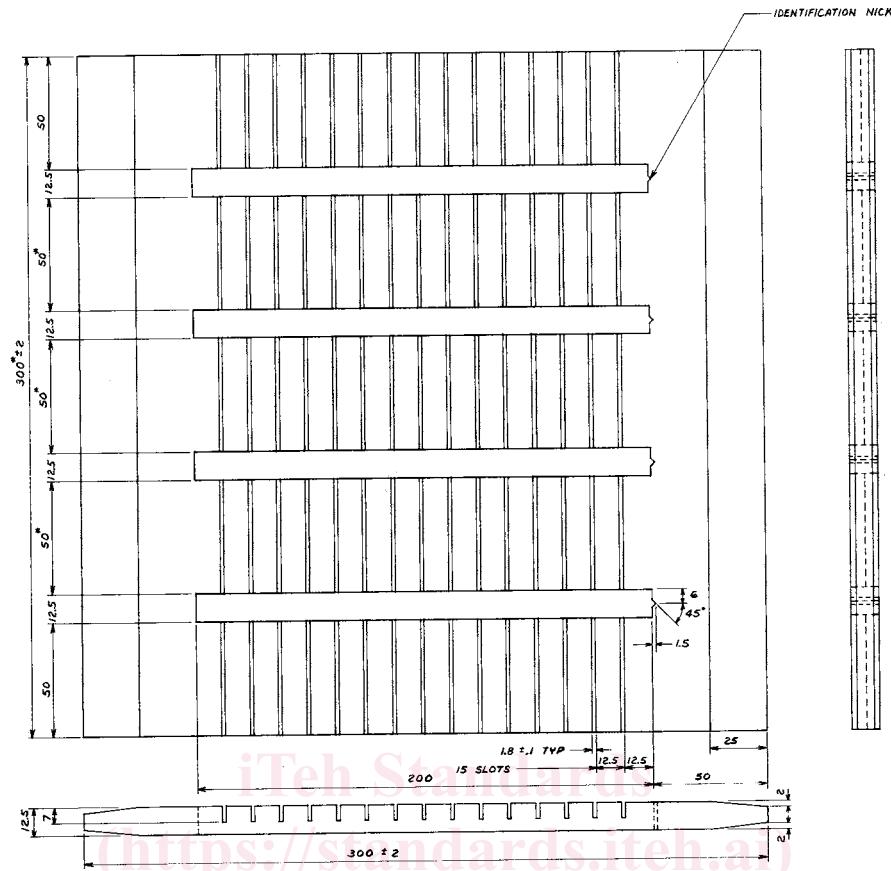
6.5 Desiccator.

7. Materials and Reagents

7.1 *Solvent*—A solvent may be used to freshen the surface of the rubber when necessary, provided such solvent treatment does not affect adhesion of the cord in the vulcanized block. A suitable solvent has been found to be a special lead-free gasoline (normal heptane), with a distillation range from 40 to 141°C and a maximum recovery of 97 %.

7.2 *Rubber Compound*—The rubber compound shall be furnished by the user of the cord, together with pertinent information of the temperature and time for the vulcanization of the particular rubber, as well as the conditioning period between vulcanization and testing. Because the performance of the rubber stock is affected by its age and storage conditions, the user of the cord shall also specify storage conditions and any time limits for storage of a particular rubber, or approve the storage conditions utilized by the producer. The rubber shall be provided in sheet form at least 215 mm wide and either 7 – 0, + 1 mm thick or 3.5 – 0, + 0.5 mm thick, sheeted onto nonhygroscopic backing, such as a plasticizer-free plastic material.

7.3 *Mold Release Lubricant*—A suitable mold release lubricant may be applied to the empty mold to facilitate test block removal. Excess lubricant shall be wiped from the mold and particularly from the slots provided for the cords. The lubricant should not be applied when exposed cord is in the area, and



TOLERANCES
 All dimensions ± 0.2
 Angular $\pm 2^\circ$
 Except where noted

NOTE 1—All dimensions in millimetres except where noted.

NOTE 2—Material—Mild steel.

NOTE 3—Mold should be coated permanently with a polytetrafluoro-ethylene, such as Teflon®, or preferably, with a stainless steel reinforced polytetrafluoro-ethylene with a polyamid binder, such as Excalibur®.

NOTE 4—Dimensions with “*” may be altered to accommodate test grips.

FIG. 2 Four-Cavity Steel Cord Adhesion Mold

should only be used when absolutely necessary. Use of a mold release lubricant should be recorded on the test report.

NOTE 1—The use of mold release lubricant is not recommended. The mold should be permanently coated with Teflon® or preferably, with a stainless steel reinforced nonstick coating, such as Excalibur®.³

8. Hazards

8.1 Refer to the manufacturer’s material safety data sheets (MSDS) for information on handling, use, storage, and disposal of chemicals used in this test.

8.2 Wear heat resistant gloves when working at the hot press and handling hot forms.

9. Sampling and Specimen Preparation

9.1 Obtain lot and laboratory samples in accordance with Practices E 105 and E 122.

9.2 Cut specimens from each laboratory sampling unit into lengths that are greater than the total mold length. To eliminate flare, use procedures in 9.2.1 or 9.2.2. Choose the number of specimen to achieve the desired level of test result precision. The relationship between the sample size and test precision is shown in Table 2.

9.2.1 Simultaneously cut and fuse the cut ends using a small portable welding device.

9.2.2 Tape the samples at the ends of the required specimen length and cut through the sample where it has been taped leaving the new ends of both sample and specimen taped.

9.3 Handle samples and specimens with care to prevent changes in surface conditions of the steel cord. Wear clean gloves when handling samples and specimens. If the tests blocks cannot be constructed within 8 h store the cords in a desiccator at $23 \pm 2^\circ$.

10. Procedure

10.1 Test Block Construction:

³ Excalibur® is a registered trademark of the Whitford Corporation, West Chester, PA.