Designation: D 1871 – ~~98~~02

Standard Test Methods for Adhesion ~~of Single-Filament Steel~~ Between Tire Bead Wire ~~to~~ and Rubber[1]

This standard is issued under the fixed designation D 1871; 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] The~~is~~ test method is ~~are~~ under the jurisdiction of ASTM Committee D~~-~~13 on Textiles and are the direct responsibility of Subcommittee D13.19 on Tire Cord and Fabric. Current edition approved ~~June~~ Sept. 10, ~~1998.~~ 2002. Published ~~July 1998.~~ Octber 2002. Originally published as D 1871 – 61 T. Last previous edition D 1871 – 9~~4~~8.

1. Scope

1.1 The~~is~~ test method~~s~~ cover procedures for testing the strength of adhesion of single-filament wire to vulcanized rubber compounds. The method~~s~~ apply~~ies~~ to, but ~~are~~ is not limited to, wire made from brass, bronze, or zinc coated steel wire. The adhesion strength is expressed as the magnitude of the pull-out force for the single filament of ~~wire or the force generated by strip peeling.~~

~~1.2 These~~ wire.

1.2 This test ~~methods are~~ method is applicable to single-filament wires used in reinforced rubber products as single filaments and ~~are~~ is normally used to evaluate the adhesion of samples of wire to a standard rubber applied under specified conditions. ~~They are~~ It is primarily used to evaluate tire bead wire ~~or hose reinforcing wire~~ and may be applied, with modifications and by agreement between supplier and customer, to various wire types used in rubber product reinforcing.

1.3 The~~is~~ test ~~methods are~~ method is written in SI ~~units. The inch-pound units which are provided in these methods are not necessarily exact equivalents of the SI units. Either system of units may be used in these methods. In case of referee decisions the SI units will prevail.~~ units.

1.4 *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. See 6.5.1.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 76 Specification for Tensile Testing Machines for Textiles[2]
D 123 Terminology Relating to Textiles[2]
D 1566 Terminology Relating to Rubber[3]
D 2906 Practice for Statements on Precision and Bias for Textiles[2]
D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[3]
D 4392 Terminology for Statistically Related Terms[4]
D 6477 Terminology Relating to Tire Cord, Bead Wire, Hose Reinforcing Wire, and Fabrics[5]
E 456 Terminology Relating to Quality and Statistics[6]

3. Terminology

3.1 *Definitions:*

~~3.1.1 *adhesion, n*—the property denoting the ability~~

3.1.1 For definitions of ~~a material to resist delamination or separation into two or more layers.~~

~~3.1.2 *curing, n*—see the preferred term *vulcanization.*~~

[2] *Annual Book of ASTM Standards,* Vol 07.01.
[3] *Annual Book of ASTM Standards,* Vol 09.01.
[4] *Discontinued 1993*—See 1992 *Annual Book of ASTM Standards,* Vol 07.02.
[5] *Annual Book of ASTM Standards,* Vol ~~14.02.~~ 07.02.
~~[6] Suitable molds and block holder are available from National-Standard Co., Machinery Systems Division, Rome, NY 13440.~~
[6] *Annual Book of ASTM Standards,* Vol 14.02.

3.1.3 *holland cloth*, *n*—a completely filled woven fabric having a smooth gloss finish on both sides used as a separating medium for sheeted rubber compounds.

3.1.4 *hose reinforcing wire*, *n*—a single filament of steel wire with a metallic coating (usually brass) used in the reinforcement of a rubber or other elastomer hose.

3.1.5 *mill grain*, *n—in rubber*, grain which is imparted to rubber sheeting while being mixed or conditioned in a rubber mill and which is parallel to the direction the rubber moves in the mill.

3.1.6 *rubber*, *n*—a material that is capable of recovering from large deformations quickly and forcibly, and can be, or already is, modified to a state in which it is essentially insoluble (but can swell) in boiling solvent, such as benzene, methylethyl ketone, and ethanol-toluene azeotrope.

3.1.7 *rubber compound*, *n— as used in the manufacture of rubber articles*, an intimate mixture of elastomer(s) with all the materials necessary for the finished article.

3.1.8 *tire bead*, *n*—the part of a tire that comes in contact with the rim and is shaped to secure the tire to the rim.

3.1.9 *tire bead wire*, *n*—a monofilament of steel wire with a metallic coating, usually bronze, used in forming a tire bead.

3.1.10 *vulcanization*, *n*—an irreversible process, usually accomplished through the application of heat, during which a rubber compound, through a change in its chemical structure (for example, cross linking) becomes less plastic and more resistant to swelling by organic liquids while elastic properties are conferred, improved, or extended over a greater range of temperatures.

3.1.10.1 *Discussion*—Although *vulcanization* is preferred to *curing*, the terms *cured* and *uncured* are widely used as synonyms for *vulcanized* and *unvulcanized*.

3.1.11 For definitions of textile terms used in these test methods, refer to Terminology D 1276477

3.1.2 For definitions of other rubber terms used in these test methods, refer to Terminology D 1566

3.1.3 For terminology on testing and statistical concepts, refer to Terminology D 4392 or E D 456.

3.1.4 For definitions of textile terms used in these test methods, refer to Terminology D 123.

4. Summary of Test Methods

4.1 *Method 1*—The

4.1 The wires are vulcanized into a block or pad of rubber and the force necessary to pull the wires out of the rubber is measured. The direction of pull-out is axial, that is, along the wire.

4.1.1 Method 1 uses a 12.5-mm (½-in.) thick rubber block and 50-mm (2-in.) embedment length. Inserts may be used to obtain shorter lengths of embedment.

4.2 *Method 2*—The test material is wound onto a drum, test compound is applied, the specimen is vulcanized by a diaphragm pressure method, and adhesion results are obtained by strip peeling a 25-mm (1-in.) wide strip.

5. Significance and Use

5.1 To contribute to the mechanical properties required in a product, tire bead wire and hose reinforcing material must have good adhesion to the rubber matrix. This allows the rubber to absorb part of the energy, distributing it uniformly between the reinforcing material and the rubber compound. These This test methods are method is considered satisfactory for acceptance testing of commercial shipments of wire since they have it has been used extensively in the trade for this purpose with Method 1 being used for tire bead wire and Method 2 being used for hose reinforcing wire. These purpose. This test methods may be used for purchase specification requirements or manufacturing control of such products.

5.1.1 In case of a dispute arising from bead wire.

5.1.1 If there are differences of practical significance between reported test results when using these test methods for acceptance testing of commercial shipments, the purchaser and supplier should conduct two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between their laboratories. Competent them, using competent statistical assistance is recommended for the investigation of bias. assistance. As a minimum, the two parties should take a group of test specimens which samples should be used that are as homogeneous as possible and which possible, that are drawn from a lot of the material of from which the type in question. The disparate test specimens then should be 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 average test results from the two laboratories should be compared using Student's *t*-test a statistical test for unpaired data and an acceptable data, at a probability level chosen by prior to the two parties before testing is begun. series. If a bias is found, either its cause must be found and corrected, or the purchaser and the supplier must agree to interpret future test results for that material must be adjusted in the light consideration of the known bias.

5.2 The characteristics of single filament steel wires that affect the adhesion property are wire diameter, coating composition, and coating mass. The storage conditions, age, and vulcanization conditions of the rubber compound will affect the test results and must be specified by the supplier of the rubber compound.

5.3 The two methods simulate vulcanization conditions found in industrial applications. Method 1 simulates the conditions of high pressure (greater than 100 psi) vulcanization such as found in tire manufacturing and Method 2 simulates the lower pressure vulcanization conditions used in hose manufacturing.

~~METHOD 1—RUBBER BLOCK PROCEDURE~~

6. Apparatus and Materials

6.1 *Mold*,[7] designed as shown in Fig. 1 for a 12.5-mm ~~(0.5-in.)~~ thick block of rubber, 200 mm ~~(8 in.)~~ long, and 50 mm ~~(2 in.)~~ wide, with 15 beveled slots across the width of the mold spaced 12.5 mm ~~(0.5 in.)~~ apart at the middle of the mold thickness, and with top and bottom plates for the mold. If more than five wires break when testing with the standard mold, the purchaser and the supplier may agree to use a mold cavity that is less than 50 mm ~~(2 in.)~~ wide.

6.2 *Tensile Testing Machine*, CRE (Constant-Rate-of-Extension) type, of such capacity of the load cell in use that the maximum force required to pull out the wires shall not exceed 85 % nor be less than 15 % of the rated capacity. The rate of travel of the power actuated grip shall be 50 ± 5 ~~mm/min (2 ± 0.2 in./min),~~ mm/min, or up to 150 ± 15 mm/min ~~(6 ± 0.6 in./min)~~ by agreement between the purchaser and the seller. The specifications and methods of calibration and verification shall conform to Specification D 76.

6.3 *Top Grip*,[7] designed as shown in Fig. 2 shall be a special holder made for the vulcanized block sample. The bottom grip may be any type clamp of sufficient capacity to handle the specimen and designed to prevent its slippage in the grip[8] or to prevent premature filament breakage.

6.4 *Vulcanizing Press*, large enough to accommodate the mold, and capable of exerting at least ~~90~~ 70 kN ~~(20 000 lbf)~~ total force on the mold.[9] Electrical or steam heat for the top and bottom platens shall be provided, of sufficient capacity for maintaining the mold components at ~~the~~ a temperature within 3°C of the requirements for the rubber compound being used.

6.5 *Solvent*, used for the preparation of the rubber and wire in this test method shall be such that the surface of the rubber will be freshened and the wire surface cleaned without adversely affecting the adhesion. If remilled or freshly milled compound is used, the use of a solvent can be left to mutual agreement between the user and the supplier of the compound.

~~[7] Series 2710 screw action grips, Series 2716 wedge action grips from Instron Corp., 2500 Washington St., Canton, MA 02021,~~

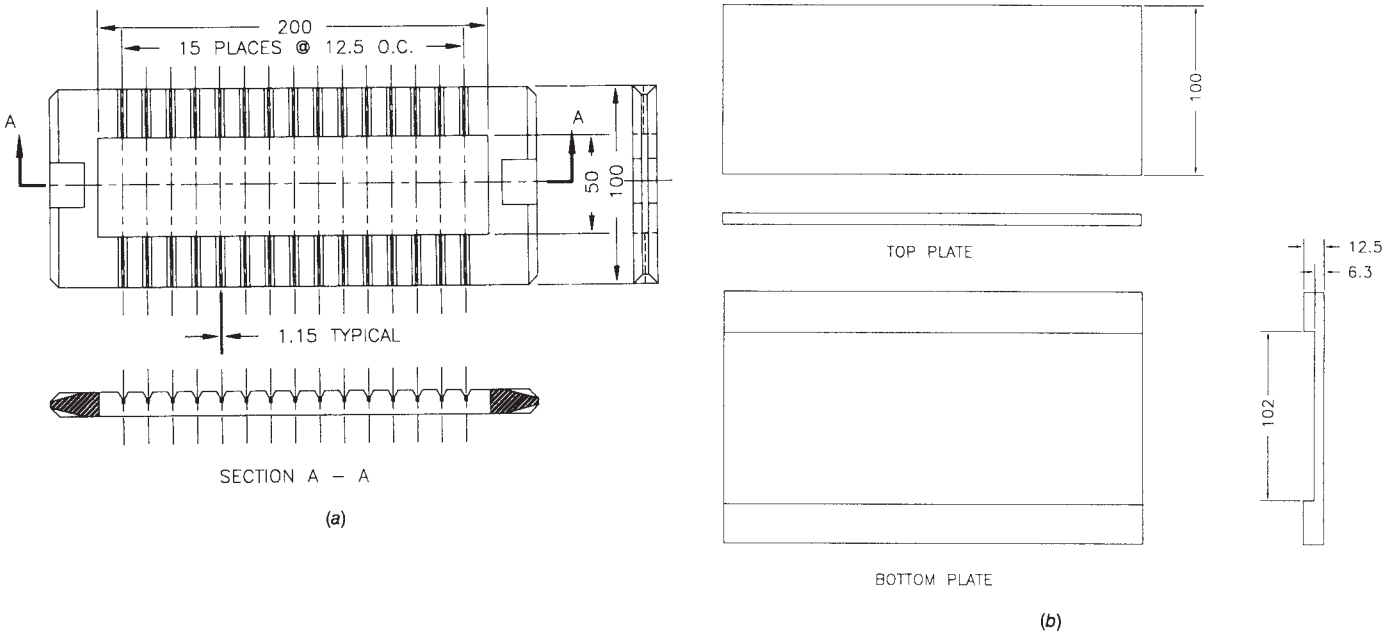
[7] Suitable molds and ~~Scott A420 clamps~~ block holder are available from ~~GCA/Precision Scientific, 3737 W. Cortland St., Chicago, IL 60647, have been found practical for testing single filament wire.~~ Bartell Machinery Systems Corp, Rome, NY 13440.

~~[8] Suitable vulcanizing presses are manufactured by Given P-H-I, Pasadena Presses, 1100 John Reed Court, City of Industry, CA 91745.~~

[8] Series 2710 screw action grips, Series 2716 wedge action grips from Instron Corp., 2500 Washington St., Canton, MA 02021, and Scott A420 clamps from GCA/Precision Scientific, 3737 W. Cortland St., Chicago, IL 60647, have been found practical for testing single filament wire.

~~[9] Supporting data~~

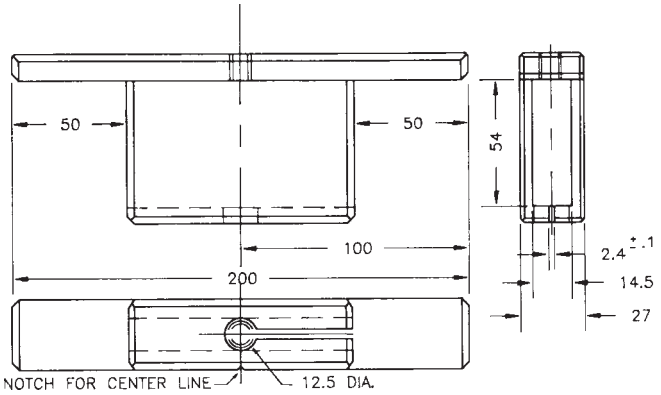
[9] Suitable vulcanizing presses are ~~available from ASTM Headquarters. Request RR: D13-1085.~~ manufactured by Given P-H-I, Pasadena Presses, 1100 John Reed Court, City of Industry, CA 91745.



TOLERANCES
All dimensions ±0.2
Angular ±½ °
Except where noted

NOTE 1—Material—Steel.
NOTE 2—Break all sharp corners.
NOTE 3—All dimensions in millimetres except where noted.

FIG. 1 Mold with Top and Bottom Plates ~~(Method 1)~~



TOLERANCES
All dimensions ±0.2
Except where noted

NOTE 1—Material—Steel.
NOTE 2—Break all sharp corners.
NOTE 3—All dimensions in millimetres except where noted.

FIG. 2 Top Grip ~~(Method 1)~~

6.5.1 A suitable solvent has been found to be lead-free gasoline (normal heptane) with a distillation range from 40 to 141°C and a maximum recovery of 97 %, available from most solvent suppliers. **Precaution**—Adequate health and safety precautions should be observed in the handling and use of any solvent selected for use in this test method.

6.6 *Rubber Compound*, shall be furnished by the purchaser of the wire, together with pertinent information on the temperature and time for the cure of that particular rubber as well as aging time limits for holding the block between vulcanizing and testing, but not less than 16 h. Since the adhesion between rubber and wire is influenced by the age and storage conditions of the uncured rubber compounds, the purchaser of the wire shall also specify the conditions of storage and any time limit for such storage of the batch. The rubber compound may be provided in sheet form, 7 mm ~~(0.28 in.)~~ thick on a non-hygroscopic backing, such as a plasticizer free plastic material, or may be provided unmilled in a form requiring milling immediately prior to use.

6.7 *Mold Release Lubricant*, A suitable mold release lubricant may be applied to the empty mold to facilitate test block removal. Excess lubricant shallbe wiped from the mold and particularly from the slots provided for the wires. The lubricant shall not be applied when exposed wires are in the area, and should only be used when absolutely necessary. Use of mold release lubricant should be recorded on the test report.

7. Sampling

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of reels, coils, spools, or other shipping units of wire directed in an applicable material specification or other agreement between purchaser and the supplier. Consider reels, coils, spools, or other shipping units of wire to be the primary sampling units.

NOTE 1—A realistic specification or other agreement between the purchaser and the supplier requires taking into account the variability between and within primary sampling units so as to provide a sampling plan which at the specified level of the property of interest has a meaningful producer's risk, acceptable quality level, and desired limiting quality level.

7.2 *Laboratory Sample*—Use the primary sampling units in the lot sample as a laboratory sample. These samples of reels, coils, spools, or other shipping units of wire are customarily taken by the manufacturer and provided to the purchaser with the lot shipment.

7.3 *Test Specimens*—Prepare three specimens from each laboratory sample by cutting 250 to 300-mm ~~(10 to 12-in.)~~ lengths of the wire and laying them out on a clean surface such as cloth or paper. The wires should be touched only at their ends, in no case on that portion that is to be embedded in the test pad. Unless otherwise specified, the wires shall be tested "as is," representing the condition in which the wire lot and samples were received. If "washing" the surface of the wire before test is specified, gently wipe the wire with a soft cloth dampened with the solvent.

8. Procedure

8.1 *Rubber Compound*—Cut the rubber sheet to the size of the mold cavity, unless it has been precut to that size for storage; two pieces are required for each block. Lay these out and freshen their top surfaces with the solvent, applied with a soft cloth or brush. Plan the freshening for a drying time to be at least 10 but not over 20 min before the building step of the procedure. If the compound has been milled immediately prior to use, freshening is not required.

8.2 *Block Building*—Preheat the mold, including top and bottom plates, to the cure temperature of the rubber to be used.

8.2.1 Remove the mold from the preheating and take off the top plate.

8.2.2 With its freshened side ~~UP,~~ up, press the bottom piece of rubber into the mold with a metal or wooden peg.

8.2.3 Lay the wires, one by one, into the tapered slots, making note of their identification, for example, the sample reel number, for later matching of the test results. Position the wires with about 25 mm ~~(1 in.)~~ sticking out from one side of the mold and about 150 mm ~~(6 in.)~~ from the other. Do not let the fingers touch the wires within the 50 mm ~~(2 in.)~~ length that will be in contact with rubber.

NOTE 2—Slots 1 and 15 should be filled with dummy lengths of wire which will be subsequently pulled, but their test values should not be recorded nor included in the calculations.

8.2.4 Place the top piece of rubber in the mold with its freshened side ~~DOWN~~ down and press it firmly in place with a metal or wooden peg.

8.2.5 Replace the top plate, put the mold in the press, and apply a force of at least ~~90~~ 70 kN ~~(20 000 lbf)~~ to the mold. This force when applied to the mold in Fig. 1 is equal to a pressure of 3.5 mPa. Excessive force is not necessary and may damage the mold. Vulcanize the block under pressure for the time and temperature conditions of the rubber compound being used.

8.2.6 It is important that the time from removal of the mold from the heat and replacing it in the press not exceed 3 min. This time limit also applies during the building of blocks subsequent to the first one, where the mold is already hot and when a cured block must be removed from the mold before it can be filled.

8.2.7 It is an acceptable practice to prebuild the test pad in a cold mold following the above block building procedures (see 8.2.2-8.2.4), and apply sufficient pressure to hold the assembled pad together. This pressure may be applied by stitching layers together or applying pressure in a cold press. The prebuilt pad is then placed in a preheated mold for vulcanization. Maximum storage time of a prebuilt pad before vulcanization is 90 min.

8.3 *Preparation of Vulcanized Block*—Remove the mold from the press and push out the vulcanized block. If there are other blocks to prepare, proceed with the building operations as outlined in 8.2. Let the cured blocks condition at room temperature, 23 ± ~~2°C (73 ± 3.6°F),~~ 2°C, for the required time limits specified by the rubber supplier, but not less than 16 h. Cut off the 25-mm ~~(1-in.)~~ lengths of protruding wire close to the edge of the block. Extraneous flash adjacent to the sample wires should be cut off using a razor-blade or surgical knife, taking care not to damage the wire. Trim off the extraneous flash from both edges of the block.

8.4 *Testing*—Push the block into the top grip of the testing machine until the first wire is in the center of the 12.5-mm hole. Note that for ease of wire centering the grips may be reversed from the description contained in this section. Make sure the load-reading attachment of the tester is zero. Then clamp the first wire in the bottom grip and start the machine. When the wire pulls out, stop the machine, note the pull-out force to the nearest 5 N ~~(1 lbf)~~ and release the wedges. Pull the tested wire out of the block by hand and slide the block in the holder until the next wire is centered. Clamp it in the wedges, start the machine, pull the wire out, and note its pull-out force. Repeat the procedure with the other wires of the block. Continue sliding each subsequent wire into the wedges until they move too far to grasp the wire length. Then return the moving grip to its starting position and start it again. The moving grip may be returned to its starting position after each pull if this is found to be more convenient for adequate sample positioning.

9. Calculation

9.1 Calculate the average pull-out force for the wires representing one laboratory sample, and for the samples representing one lot.

9.2 Calculate the lot sample standard deviation and coefficient of variation, if requested by the purchaser.

10. Report

10.1 State that the tests were performed as directed in Test Methods ~~D 1871, Method 1.~~ D 1871. Describe the material or product sampled and tested.

10.2 Report the following information:

10.2.1 Identification of wire samples, individual test results, the sample averages, and standard deviation and coefficient of variation, if calculated,

10.2.2 Identification of rubber compound, and its vulcanizing conditions,

10.2.3 Type of tensile test machine used, and rate of extension, and

10.2.4 Any deviation from the standard test procedure, including using a mold that is less than 50 mm (2 in.) wide.

11. Precision and Bias [10]

11.1 ~~*Summary—Method 1*—In comparing two averages of three observations, the difference between the averages should not exceed the following amounts in 95 out of 100 cases when all of the observations taken by the same well-trained operator using the same piece of equipment and specimens are randomly drawn from the same sample of material and tested on the same day:~~

~~[10] Detail drawings may be obtained~~

[10] Supporting data are available from ~~The Goodyear Tire and Rubber Co., General Products Development Center, Dept. 470-C, 1144 E. Market St., Akron, OH 44316.~~ ASTM Headquarters. Request RR: D13-1085.

~~1.295 mm (0.051 in.) diameter wire 174 *N* (1)~~

~~Since the pull-out force is affected significantly by the diameter of the bronze plated steel wire, larger or smaller differences are likely to occur when testing bead wire with diameters outside the range of specimens used in the interlaboratory evaluation which generated these data. The true value of adhesion of bronze plated tire bead wire to rubber can only be defined in terms of a specific test method. Within this limitation, Test Method D 1871 has no known bias and is considered a referee method.~~

~~11.2~~ *Interlaboratory Test Data*—An interlaboratory evaluation was conducted in 1992 in which randomly drawn samples of two wire diameters of tire bead wire and one rubber compound were tested in 16 laboratories in accordance with Test Methods ~~D 1871, Method 1.~~ D 1871. Each laboratory used two operators, each of whom tested the two materials on two separate days. In addition, separate testing was performed at each laboratory to identify assignable variation to specific parts of the test method. Initial analysis of the data indicated that the results from one of the laboratories was a statistical outlier and upon investigation the cause for this condition was determined to be failure to follow the test method properly. The data for the one laboratory was deleted prior to further analysis. In addition, some laboratories reported wire breaks in the test grip before pull-out from the test pad. For this reason, the 0.965 mm ~~(0.038 in.)~~ sample was considered a no test and critical difference values are reported only for the 1.295 mm ~~(0.051 in.)~~ diameter wire.

11.3~~2~~ *Precision*— Two test results should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 1.

NOTE 3—The tabulated values of the critical differences and confidence limits should be considered to be a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained so as to be as nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories.

11.~~4~~3 *Bias*—The procedure in ~~Method 1 of these~~ this test methods has no known bias because the value of adhesion can be defined only in terms of a test method.

~~METHOD 2—DRUM CURED PAD PROCEDURE~~

~~12. Apparatus and Materials~~

~~12.1 *Drum Holder*, designed as shown in Fig. 3 to hold and rotate the drum around the central axis while the reinforcing material (wire) is being level wound on the surface of the drum.~~

~~12.2 *Curing Drum*, as shown in Fig. 4, having a length of at least 152 mm (6 in.) with a diameter of at least 76 mm (3 in.) and shall be capable of withstanding the maximum steam supply pressure.[10]~~

~~12.3 *Cylinder Diaphragm Mold*, shall conform to the requirements of Fig. 5.~~

~~12.4 *Tensile Testing Machine*—See 6.2.~~

~~12.5 *Grinder*,[11] grinding tool used to cut through the wires along the attachment rod.~~

~~12.6 *Rubber Compound*, shall be furnished by the purchaser of the wire, together with all pertinent information regarding vulcanization, uncured storage, and cured aging condition of the particular compound being used in the test. The rubber compound shall be provided in sheet form at a thickness of 2.5 ± 0.3 mm (0.10 ± 0.01 in.).~~

~~13. Sampling~~

~~13.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of reels, coils, spools, or other shipping units of wire directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider reels, coils, spools, or other shipping units of wire to be the primary sampling units. (Note 1.)~~

~~13.2 *Laboratory Sample*—Use the primary sampling units in the lot sample as a laboratory sample.~~

~~13.3 *Test Specimens*—Prepare one specimen from each primary sampling unit as directed in 14.1.1. The number of primary sampling units to be tested shall be directed in an applicable material specification or by agreement between the purchaser and the supplier.~~

TABLE 1 Critical Differences for Two Averages for the Conditions Noted, 95 % Probability Level, Pull-Out Force (Newtons)

Wire Diameter	Number of Test Results in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
~~1.295 mm (0.051 in.)~~	~~2~~	~~289~~	~~308~~	~~439~~
1.295 mm	2	289	308	439
	3	174	204	374
	4	145	179	360
	5	129	167	354

14. Procedure

14.1 *Pad Preparation*—After inserting the drum in the drum winder, prepare the rotatable drum for winding on the test reinforcing material (wire) by attaching it to the rod provided on the drum surface.

14.1.1 Wind each specimen to be tested to a width of at least 38 mm (1.5 in.) on the drum, making certain that the test specimen has been kept free of contamination. Wind the wire on the drum with each wrap touching the adjacent wraps. The 38-mm width is needed to get a representative 25-mm (1-in.) strip for adhesion testing after vulcanization.

14.1.2 After winding the wire on the drum, apply the rubber test compound or compounds (two may be safely used on each drum), which have been sheeted out to a thickness of 2.5 ± 0.3 mm (0.10 ± 0.01 in.), over the test specimen on the drum. Place the mill grain of the test compound parallel to the direction of the wire lay. Hold the stock in position with suitable tape. Tape is necessary only to hold the rubber in place until the drum is inserted into the cylinder diaphragm mold (Fig. 5).

14.1.3 A strip of holland cloth, cellophane, or similar material placed between the rubber stock and test specimen at the end of the test area will facilitate testing by providing an easy starting point.

14.2 *Vulcanizing*—Dust the outside of the uncured rubber with talc to prevent sticking, then insert the prepared drum into the cylinder diaphragm mold and connect a 175-kPa (25-psi) air line to the diaphragm mold. Vulcanizing as described in this section (14.2.1-14.2.5) normally uses steam, however other methods of heating may be used, provided that the heat transfer is properly and uniformly controlled.

14.2.1 Connect the bottom or outward end of the drum by means of a quick-disconnect fitting to a drain line equipped with a suitable condensate trap system and temperature control equipment.

14.2.2 Connect the top inlet end of drum to a steam line by means of a quick-disconnect fitting. The steam line should have a pressure gage and valve suitable for regulation of the incoming steam.

14.2.3 Open the steam valve and allow steam to pass through the system until condensate is at a minimum.

14.2.4 Regulate the steam supply to maintain a constant curing temperature and vulcanize the pad under pressure for the time and temperature conditions of the rubber compound being used and as specified by the rubber supplier.

14.2.5 At the end of vulcanization, shut off the steam, open the bottom valve, blow down, disconnect and remove the drum from the diaphragm mold and place in the drum winder.

14.3 *Testing*—Cut the vulcanized pad from the drum with a hand grinder by cutting through the wires along the attachment rod on the drum surface.

14.3.1 Condition the pad at room temperature a minimum of 16 h before cutting out the 25-mm (1-in.) wide test strips.

14.3.2 Cut the conditioned test strips by centering a 25-mm (1-in.) template on the 38-mm (1.5-in.) strip and cut along each side of the template with a sharp knife.

14.3.3 Separate the wire from the rubber at the end of the test specimen by the tab provided (see 14.1.3 and Fig. 6). Make sure the reading attachment of the tester is at zero. Place the exposed ends of the wire in the upper clamp of the testing machine and the rubber in the lower clamp. Start the machine at a cross head speed of 25 mm/min (1 in./min). Separate the pad components for a minimum length of 65 mm (2.5 in.). Stop the machine and remove the peeled specimen. Repeat the procedure for the remaining strips cut from the vulcanized pad.

15. Calculation

15.1 Determine the adhesion in newtons or pounds-force for each wire sample tested. Since there is a characteristic peak in force at the beginning of the rubber and wire separation ignore the first 10 mm (0.4 in.) after the first high peak and interpret the high and low peaks (oscillations) of the separation force in the next 50 mm (2 in.) of the specimen by one of the following options:

15.1.1 *Option 1*—Establish a midline between the high and low peaks of force.

15.1.2 *Option 2*—Establish an average of the upper peaks of the oscillating force.

15.1.3 *Option 3*—With computerized read-out, measure the work (area) beneath the oscillations and calculate the average level of force multiplied by the cross-head travel (distance) to produce this work area; or, if the tensile testing machine has such capability, average separation force may be read from the instrument display.

15.2 Visually inspect the wire surface that has been separated from the rubber strip, and determine the percentage of the wire on which rubber remains.

15.3 Calculate the standard deviation and coefficient of variation if requested.

16. Report

16.1 State that the tests were performed as directed in Test Methods D 1871. Describe the material or product sampled and tested.

16.2 Report the following information:

16.2.1 Identification of wire samples, individual test results and calculation option used, sample averages, and standard deviation and coefficient of variation, if calculated,

16.2.2 The percentage of rubber determined to remain on the peeled area of the test sample,

16.2.3 Identification of rubber compound and its vulcanizing conditions,

16.2.4 Type of tensile test machine used and the speed of peeling, and

16.2.5 Any deviation from the standard test procedure.

17. Precision and Bias

17.1 *Precision*—The precision of Method 2 cannot be determined in a valid manner at this time because of the limited number of laboratories utilizing this test method. Any two or more parties using this test method should refer to 5.1.1 and determine if there is any statistical bias existing between their laboratories.

17.2 *Bias*—No justifiable statement can be made on the bias of the measurement of adhesion since the true value cannot be established by an acceptable referee method.

18. Keywords

18.1 adhesion; beadwire; tire beads