Designation: D 1871 – 98

Standard Test Methods for Adhesion of Single-Filament Steel Wire to 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. Scope

1.1 These test methods cover procedures for testing the strength of adhesion of single-filament wire to vulcanized rubber compounds. The methods apply to, but are 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 test methods are applicable to single-filament wires used in reinforced rubber products as single filaments and are normally used to evaluate the adhesion of samples of wire to a standard rubber applied under specified conditions. They are 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 These test methods are 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.

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]

E 456 Terminology Relating to Quality and Statistics[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *adhesion*, *n*—the property denoting the ability of a material to resist delamination or separation into two or more layers.

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

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 123. For definitions of other

[1] These test methods 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 10, 1998. Published July 1998. Originally published as D 1871 – 61 T. Last previous edition D 1871 – 94.

[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.

rubber terms used in these test methods, refer to Terminology D 1566. For terminology on testing and statistical concepts, refer to Terminology D 4392 or E 456.

4. Summary of Test Methods

4.1 *Method 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 test methods are considered satisfactory for acceptance testing of commercial shipments of wire since they have 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 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 differences in reported test results when using these test methods for acceptance testing of commercial shipments, the purchaser and supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens which are as homogeneous as possible and which are from a lot of material of the type in question. The test specimens then should be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before testing is begun. 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 in the light 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*,[6] 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 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), 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*,[6] 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[7] or to prevent premature filament breakage.

6.4 *Vulcanizing Press*, large enough to accommodate the mold, and capable of exerting at least 90 kN (20 000 lbf) total force on the mold.[8] Electrical or steam heat for the top and bottom platens shall be provided, of sufficient capacity for maintaining the mold components at the temperature 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.

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

[6] Suitable molds and block holder are available from National-Standard Co., Machinery Systems Division, Rome, NY 13440.

[7] 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.

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