



Designation: D 4393 – 00

Standard Test Method for Strap Peel Adhesion of Reinforcing Cords or Fabrics to Rubber Compounds¹

This standard is issued under the fixed designation D 4393; 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 test method covers the determination of peel adhesion of reinforcing fabrics that are bonded to rubber compounds. It is applicable to either woven or parallel cord textile structures from both natural and manmade fibers and to parallel steel cord structures.

1.2 This test method is primarily used to evaluate tire cords and tire cord fabrics, including steel tire cords, using a suitable tire cord adhesive and a suitable rubber compound. This test method may be used to evaluate tire cord adhesives (fabric dip), metallic (usually brass) coatings on steel cord, and the process of adhesive reaction on the cord using one consistent form of tire cord or fabric and one consistent rubber compound. This test method may be used to evaluate cords and fabrics in industrial hose and belting products and other cord or fabric reinforced rubber products.

1.3 Variables that may contribute to differences in results of this test method include adhesive type, adhesive application procedure, adhesive cure, fiber type, construction of cords or reinforcing fabrics, rubber type, rubber cure, rubber thickness, and cord spacing.²

1.3.1 The deleterious effect of ozone in combination with atmospheric moisture on the ability of adhesives to bond with rubber requires assiduous protection of cords prior to rubber embedment.³

1.4 This test method is written in SI units. The inch-pound units in parentheses are provided in this test method are not necessarily exact equivalents of the SI units. Either system of units may be used in this test method.

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:

- D 76 Specification for Tensile Testing Machines for Textiles⁴
- D 123 Terminology Relating to Textiles⁴
- D 1566 Terminology Relating to Rubber⁵
- D 2138 Test Methods for Rubber Property—Adhesion to Textile Cord⁶
- D 2229 Test Method for Adhesion Between Steel Tire Cords and Rubber⁴

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 *adhesion, n—in tire fabrics*, the force required to separate a textile material from rubber or other elastomer by a definite prescribed method.

3.1.3 *chafer fabric, n—in tire fabrics*, a woven fabric usually coated with unvulcanized rubber compound, which is laid around the bead of a tire before vulcanization.

3.1.4 *curing, n*—See the preferred term *vulcanization*.

3.1.5 *fabric dip, n—for tire fabrics*, a chemical composition which is applied to a textile cord or fabric to improve its adhesion to rubber compounds.

3.1.6 *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.

3.1.7 *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.

3.1.8 *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.

3.1.9 *rubberize, v*—to impregnate or coat with rubber compound or both.

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² Iyengar, Y., “Adhesion Behavior of Nylon Tire Cord/Adhesive/Rubber Systems,” *Journal of Applied Polymer Science*, Vol 13, 1969, pp. 353–363.

³ Wenghoefer, H. M., “Environmental Effects on RFL Adhesion,” *Rubber Chemistry and Technology*, Vol 47, No. 5, December 1974, pp. 1066–1073.

⁴ *Annual Book of ASTM Standards*, Vol 07.01.

⁵ *Annual Book of ASTM Standards*, Vol 09.01.

⁶ *Discontinued 1990—Replaced by D 4776, D 4777.*

3.1.10 *steel cord, n*—a formed structure made of two or more steel filaments when used as an end product or a combination of strands or filaments and strands.

3.1.11 *steel filament, n*—the individual element in a steel strand or cord.

3.1.12 *stitch, v*—in making rubberized articles, to press uncured rubber compound into or around yarns or cords to form a composite of the materials and to remove entrapped air.

3.1.12.1 *Discussion*—Normally the yarns or cords in the article are parallel. The stitching tool is normally a rolling disk mounted on an axle for manipulation by hand or by machine. The outer edge of the disk is unsharpened but narrower than the intended space between parallel cords. Application of moderate force on this tool accomplishes high local pressure on the surface to which it is applied.

3.1.13 *straightness, n*—in steel cord, the property of a cord characterized by a lack of deviation from its central axis over short lengths of a cord.

3.1.14 *tack, n*—for rubber or rubber compounds, a property that causes two layers of these materials when pressed together to adhere at the area of contact.

3.1.15 *tire cord, n*—as used in this test method, a twisted or formed structure composed of one or more single or plied filaments, strands, or yarns of organic polymer or inorganic material(s).

3.1.16 *tire cord, fabric, n*—a fabric consisting of tire cord warp with widely spaced, single yarn filling.

3.1.17 *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, and elastic properties are conferred, improved, or extended over a greater range of temperature.

3.1.18 *weftless fabric, n*—as used in tire building, a sheet of parallel cords surrounded by uncured rubber compound.

3.1.18.1 *Discussion*—Fabric stability, sufficient to ensure that fabric can be moved and handled, is imparted by the unvulcanized rubber rather than by textile yarns (weft or picks) as in woven tire cord fabric.

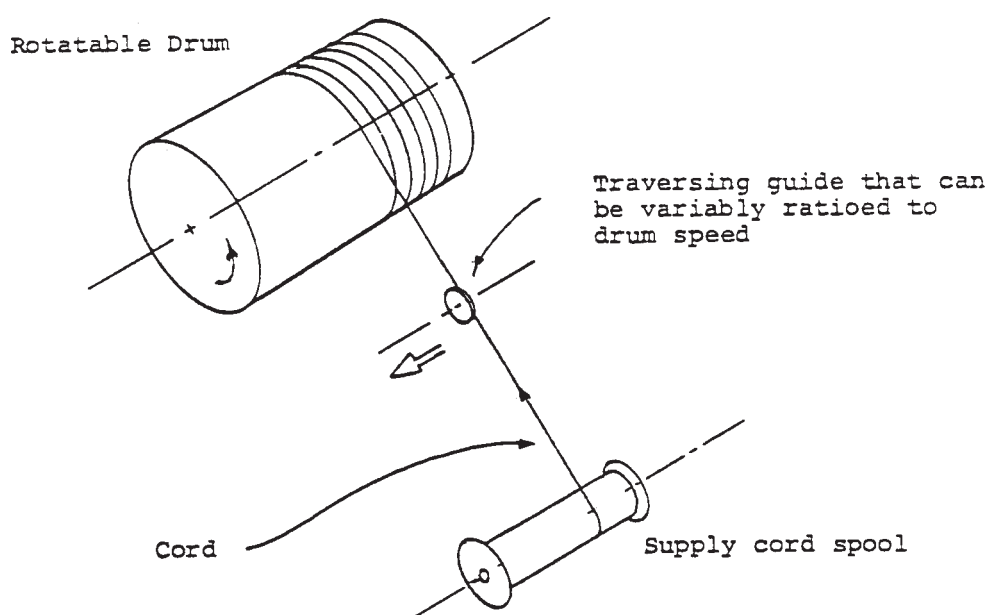
3.1.19 For definitions of other textile terms used in this test method, refer to Terminology D 123. For definitions of other terms relating to rubber, refer to Terminology D 1566.

4. Summary of Test Method

4.1 *Strap Peel Adhesion From Single Cord*—Two pieces of weftless fabric of sufficient size to cover the curing mold cavity are generated on a rotatable drum (Fig. 1). These two fabrics are laid one against the other, with cords in the same direction, to form the pad (Fig. 2). This pad has a nonstick fabric, such as holland cloth, separating the two fabric layers at one end for a sufficient distance to eventually permit adjacent ends of each fabric layer to be separated after curing and grasped separately in the jaws of a tensile testing machine. The pad is cured in a plunger-type mold (Fig. 3) and cut into straps in the long direction, parallel to that of the cords. The force to peel one fabric layer from the other is determined in a recording tensile testing machine.

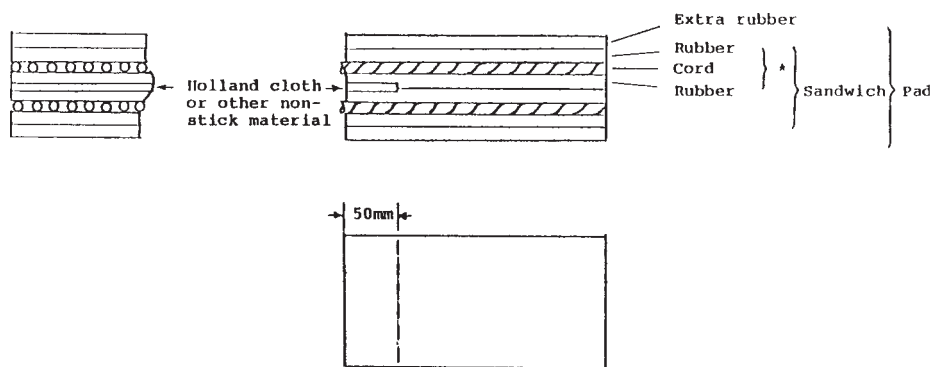
4.2 *Strap Peel Adhesion From Tire Cord Fabric*—Two pieces, approximately 100 mm (4 in.) square, are cut from woven fabric. These pieces are assembled on a clean flat surface with sheeted rubber compound and a separating material to accomplish a structure like that of Fig. 2. The assembled test pad is cured between heated platens rather than in the plunger-type mold of Fig. 3. Straps are cut from the cured pad in its long direction parallel to the cords, and the force to peel one fabric layer from the other is determined in a recording tensile test machine.

4.3 *Strap Peel Adhesion From Tire Chafer Fabric, Conveyor Belt Duck, Multi-warp Conveyor Belt, and Other Adhesive Treated Fabrics Other Than Tire Cord Fabric*—Test pads are prepared as in 4.2. Straps may be prepared and cut to



NOTE 1—Laydown of cord to a specified number of cords per metre uses the principles of thread cutting on a machining lathe.

FIG. 1 Rotatable Drum and Guide Arrangement



* One layer of weftless fabric pre-assembled on a rotatable drum in the example of pad building from a single cord.

FIG. 2 Assembly of Components into a Pad from Which Seven Adhesion Specimens (Straps) May Be Cut After Curing

accomplish a peel force in either the warp direction or 90° to (across) the warp direction, as agreed between buyer and seller. Separate straps are prepared for warp and across-warp direction except in special cases (see 10.4).

4.4 Strap Peel Adhesion Simulating Composites Cut From Cross-ply Tires—Four layers of weftless or woven fabric are assembled with each adjacent cord layer insulated by rubber and assembled to provide cord direction in each layer 90° to each adjacent layer. Straps are cut to provide peeling between the two middle cord layers with peel force direction 45° to the longitudinal axis of the cords.

5. Significance and Use

5.1 Single Test Cord—Adhesive treating of cords singly or adhesive treating individual ends simultaneously (referred to as “multi-cord treating” as opposed to “fabric treating”) and winding the cords as single ends is the most common laboratory method of preparing reinforcement materials for evaluation in reinforced rubber articles such as tires, belts, and hoses. This system of adhesive treating facilitates the study of a large number of adhesion variables at minimum cost. This test method provides a good comparison of variables on adhesion because it produces both an average numerical value of peel force over several linear centimetres of cord and provides convenient specimens for assessing appearance (see 11.3) of the peeled area as well. It may be used for purchase specification requirements for adhesive treated cords, steel tire cord, adhesives, rubber compounds, or manufacturing control of such products.

5.1.1 Preparation of weftless fabric from single cord is not recommended for acceptance testing of commercial shipments of tire cord fabric because single cords of long length cannot be conveniently obtained from fabric for drumwinding. See 5.2.2.

5.1.2 This test method is usually not preferred for acceptance testing of commercial shipments of adhesive treated cord, such as single end cord for hose. The more usual and convenient method for acceptance testing of such single cords is to prepare from a shipment a test piece or article in the same manner as the commercial article to be produced and to test cord-adhesion characteristics in this piece in a manner that compares its adhesion characteristics against a previously

established, acceptable control. “H” and “U” tests (Test Methods D 2138) provide convenient and rapid adhesion results for acceptance testing of textile cords if needed. For steel cord, Test Method D 2229 provides convenient and rapid adhesion results.

5.2 Using Woven Fabric—The woven fabric method of 4.2-4.4 is often chosen for rapid adhesion testing of textile woven fabric being adhesive treated in large volume. Fabric is tested “as is” and, through experience, constitutes a valuable process control tool. The same basic test can be conveniently executed by the receiving customer for process control purposes by sampling rubberized fabric from that to be processed into finished rubber articles.

5.2.1 This test method may be used for acceptance testing of commercial shipments of adhesive treated fabric, but duplicate numerical values for peel force and appearance are not to be expected between two testing locations. Rubber compound differences are only one of many parameters affecting peel force and appearance. Nevertheless, the expected range of values which characterize acceptable adhesion can be determined in any cord-rubber combination with experience. For this reason, the buyer normally establishes a minimum level of adhesion to be obtained by the seller in the seller’s laboratory using either the seller’s standard rubber compound or the buyer’s rubber compound on the fabric made to the buyer’s specification.

5.2.2 In case of a dispute arising from differences in reported test results when using Test Method D 4393 for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is statistical bias between their laboratories. Competent statistical help 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 should then 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 began. If a bias is found, the test