Designation: D5446 – 08 (Reapproved 2013)

Standard Practice for Determining Physical Properties of Fabrics, Yarns, and Sewing Thread Used in Inflatable Restraints[1]

This standard is issued under the fixed designation D5446; 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 practice is a listing of the test methods commonly employed in determining the physical properties of fabrics and yarns used in the manufacture of inflatable restraints.

1.2 Fabrics used in the manufacture of inflatable restraints may be coated or uncoated, and may be comprised of spun yarns, continuous filament yarns, or a combination thereof.

1.3 Fabrics used in the manufacturer of inflatable restraints may be either flat or one piece woven. For the one-piece woven, follow the sampling section of D5446 and the individual test method.

1.4 In Section 9, this practice lists is alphabetical order the procedures associated with conducting physical testing of the following fabric or yarn properties of concern to the design and manufacture of inflatable restraints.

Yarn	Section
Denier (Yarn Number)	9.3.1
Fiber Content	9.3.2
Finish (Extractable Material)	9.3.3
Strength and Elongation	9.3.4
Twist	9.3.5
Fabric	
Air Permeability	9.3.6
Abrasion Resistance	9.3.7
Blocking	9.3.8
Bow and Skew	9.3.9
Breaking Force & Elongation	9.3.10
Burst Strength	9.3.11
Coating Adhesion	9.3.12
Coating Weight	9.3.13
Count of Woven Fabric	9.3.14
Dynamic Air Permeability	9.3.28
Edgecomb Resistance	9.3.29
Flammability	9.3.15
Fogging (Volatility)	9.3.16
Length	9.3.17
Mass per Unit Area	9.3.18
Non-Fibrous Material	9.3.19
Odor	9.3.20
Packability	9.3.30
pH	9.3.21
Stiffness	9.3.22
Tear Strength	9.3.23
Thickness	9.3.24
Warp Size Content & Residual Sizing	9.3.25
Width	9.3.26
Sewing Thread	9.3.27

1.5 This practice may be used in conjunction with Practice D5427 which prescribes standard practices for the accelerated aging of inflatable restraint fabrics when comparative results of physical properties before and after accelerated aging are required.

1.6 Procedures and apparatus other than those stated in this practice may be used by agreement of purchaser and supplier with the specific deviations from the standard practice acknowledged in the report.

1.7 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independent of the other.

1.8 *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 Note 3.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles
D204 Test Methods for Sewing Threads
D276 Test Methods for Identification of Fibers in Textiles
D737 Test Method for Air Permeability of Textile Fabrics
D751 Test Methods for Coated Fabrics
D1059 Test Method for Yarn Number Based on Short-Length Specimens (Withdrawn 2010)[3]
D1388 Test Method for Stiffness of Fabrics
D1422/D1422M Test Method for Twist in Single Spun Yarns by the Untwist-Retwist Method

[1] This practice is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.20 on Inflatable Restraints.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

D1423 Test Method for Twist in Yarns by Direct-Counting
D1424 Test Method for Tearing Strength of Fabrics by Falling-Pendulum (Elmendorf-Type) Apparatus
D1777 Test Method for Thickness of Textile Materials
D1907 Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method
D2256 Test Method for Tensile Properties of Yarns by the Single-Strand Method
D2257 Test Method for Extractable Matter in Textiles
D2261 Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)
D3773 Test Methods for Length of Woven Fabric
D3774 Test Method for Width of Textile Fabric
D3775 Test Method for Warp (End) and Filling (Pick) Count of Woven Fabrics
D3776 Test Methods for Mass Per Unit Area (Weight) of Fabric
D3786 Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method
D3882 Test Method for Bow and Skew in Woven and Knitted Fabrics
D3990 Terminology Relating to Fabric Defects
D4032 Test Method for Stiffness of Fabric by the Circular Bend Procedure
D4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)
D4851 Test Methods for Coated and Laminated Fabrics for Architectural Use
D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
D5427 Practice for Accelerated Aging of Inflatable Restraint Fabrics
D5587 Test Method for Tearing Strength of Fabrics by Trapezoid Procedure
D6476 Test Method for Determining Dynamic Air Permeability of Inflatable Restraint Fabrics
D6478 Test Method for Determining Specific Packability of Fabrics Used in Inflatable Restraints
D6479 Test Method for Determining the Edgecomb Resistance of Woven Fabrics Used in Inflatable Restraints
D6613 Practice for Determining the Presence of Sizing in Nylon or Polyester Fabric
D6799 Terminology Relating to Inflatable Restraints
F778 Methods for Gas Flow Resistance Testing of Filtration Media

2.2 *Federal Standards:*[4]
Motor Vehicle Safety Standard 302—Flammability

2.3 *SAE Standards:*[5]
J912-A Resistance to Blocking
J1351 Determination of Odor

2.4 *Ford Motor Company Standards:*[6]
FLTM BO116-03 Fogging Standard
FLTM BN13-1 Coating Adhesion

2.5 *AATCC Methods:*[7]
Method 81 pH of Water—Extract from Wet Processed Textiles

3. Terminology

3.1 *Definitions:*

3.2 For all terminology relating to D13.20, Inflatable restraints, refer to Terminologies D3990 and D6799.

3.2.1 The following terms are relevant to this standard: coated fabric, inflatable restraint.

3.3 For all other terms related to textiles, see Terminology D123.

4. Summary of Test Method

4.1 Test specimens are taken from sample rolls of fabric and tested using prescribed laboratory procedures, conditions and equipment by the supplier to determine the physical properties of the fabric in accordance with the requirements of the purchaser.

5. Significance and Use

5.1 Every ASTM test method listed in 2.1 contains a section describing its particular significance and use. Other test methods listed in 2.1 of this practice may contain sections pertaining to their particular significance and use.

5.2 The physical testing procedures in this practice can be used in conjunction with lot sampling procedures as a basis for acceptance testing of commercial shipments of inflatable restraint fabrics. They may be used to establish the criteria by which inflatable restraint fabrics will be tested by the supplier to determine whether a lot of material is acceptable for shipment to the purchaser.

5.3 This practice addresses all the physical properties that describe inflatable restraint fabrics and their commonly used test methods. Unless otherwise specified by agreement of purchaser and supplier, these standard test methods shall constitute the test conditions, procedures, and equipment used to determine the physical properties of fabrics used in inflatable restraints. It is intended to be used as a guideline in establishing a written material specification. The specification or agreement of purchaser and supplier may deviate from the practices described herein when (based on experience) considerations of fabric properties, material handling equipment, or inflatable restraint system design dictate otherwise.

6. Apparatus

6.1 Periodic laboratory certification of test equipment used in accordance with this practice is required to reduce test variability due to precision and bias.

[4] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20525.
[5] Available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.
[6] Available from Ford Motor Company, Engineering Department, Body Engineering Building, Room 1145, 21500 Oakwood Boulevard, Dearborn, MI 48124.
[7] Available from American Association of Textiles Chemists and Colorists, PO Box 12215, Research Triangle Park, NC 27709.

6.2 For inflatable restraints, all test equipment used in accordance with the procedures referenced in this practice shall be certified for calibration annually by an independent agency or equipment manufacturer whose results are traceable to National Institute of Science and Technology (NIST) or other national standards laboratory. The test parameters of the equipment shall be tested within the operating ranges covered in the material specification or equivalent document.

7. Sampling

7.1 *Lot Sample:*

7.1.1 For the size of an acceptance sampling lot of fabric for inflatable restraints, use the number of fabric rolls in a shipment of a single fabric style unless otherwise agreed upon between the purchaser and supplier. If the fabrics are one piece woven, use the number of units in the shipment as the acceptance sampling lot.

7.1.2 Unless otherwise agreed upon by purchaser and supplier, take as a lot sample all of the rolls or one piece woven units in a shipment of fabric. Consider rolls of fabric to be the primary sampling units.

7.1.3 For the size of an acceptance lot of yarn, use the lot determination and sample plan agreed upon by purchaser and supplier.

7.2 *Laboratory Sample:*

7.2.1 An entire roll of fabric or a full-width cut from the end of a roll within a lot sample or one piece woven units constitutes a laboratory sample depending on which physical property is to be tested.

7.2.1.1 For fabric width, fabric bow, and fabric length, the rolls in the lot sample serve as the laboratory sample.

7.2.1.2 For all other physical properties, take as the laboratory sample a full width cut of fabric 2 m (2 yd) long from the end of each roll in the lot sample if there is no evidence that the fabric is distorted; if there is evidence of physical distortion on the outside of the fabric roll, take a sample cut from the resulting end of the roll after removing and discarding the distorted portion of fabric.

7.2.2 An entire yarn package constitutes a laboratory sample for yarn testing.

7.3 *Test Specimens:*

7.3.1 Test specimens are the pieces of yarn or fabric units that actually undergo testing. The fabric units may be entire fabric rolls , one piece woven units or fabric pieces cut from the laboratory sample in accordance with physical testing requirements of a specific test method.

7.3.2 For fabric width, fabric bow, and fabric length, the rolls in the lot sample serve as the test specimens. For all other physical properties to be tested, the test specimens are the fabric pieces cut from the laboratory sample in accordance with the respective test method.

7.3.3 Take specimens from different positions across the roll width or one piece woven units when testing physical properties oriented in the warp direction; take specimens from different positions along the roll length or one piece woven units when testing physical properties oriented in the filling direction.

7.3.4 Take no test specimen closer to the selvage of the fabric than 1/10 the width of the fabric or 125 mm (5 in.), whichever is smaller.

8. Conditioning

8.1 Test specimens shall be preconditioned as directed by the particular test method or as agreed upon between the purchaser and supplier.

8.2 Prior to testing a physical property, the test specimens shall be brought to moisture equilibrium at ambient atmospheric pressure, at 21 ± 1°C (70 ± 2°F), and at 65 % ± 2 % relative humidity, unless directed to do otherwise by the test procedure or an agreement by purchaser and supplier.

8.3 Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weightings made at intervals of not less than 2 h does not exceed 0.1 % of the mass of the specimen.

NOTE 1—Certain fibers and coatings may exhibit slow rates of achieving moisture equilibrium. When this occurs, a preconditioning cycle such as described in Practice D1776 may be agreed upon between contractual parties.

9. Procedures

9.1 Secure test specimens from laboratory samples in accordance with the sampling section (Section 7) of this practice for each test required by the material specification or agreement of purchaser and supplier.

9.2 Precondition and condition the test specimens in accordance with the conditioning section (Section 8) of this practice for each test required by the material specification or agreement of purchaser and supplier.

9.3 Test the specimens in accordance with each test method specified.

9.3.1 Determine the denier or yarn number in accordance with Test Method D1907 for packaged yarn or Test Method D1059 for beamed yarn or yarns removed from fabric test specimens.

9.3.1.1 When using Test Method D1907, make one determination from each package in the laboratory sample.

9.3.1.2 When using Test Method D1059, use twenty-five (25) specimens selected from each laboratory sample in both the warp and filling directions.

9.3.2 Determine the fiber content of the yarn in accordance with Test Method D276, making one determination from each yarn package in the laboratory sample.

9.3.3 Determine the finish or extractable material content in yarn in accordance with Test Method D2257, using one test specimen of ten grams removed from each laboratory sample.

9.3.4 Determine the single-end strength and elongation properties of yarns removed from yarn packages, beams, and fabric specimens in accordance with Test Method D2256, using ten test specimens from each laboratory sample.

9.3.5 Determine the amount and direction of twist in yarns in accordance with Test Method D1423.

9.3.5.1 Determine the twist in single spun yarns on packages and yarns removed from beams and fabric samples in

accordance with Test Method D1422/D1422M, using ten test specimens selected from each laboratory sample.

9.3.5.2 Determine the twist in single, ply and cabled filament yarn or ply and cable twist in spun yarns on packages and yarns removed from beams and fabric samples in accordance with Test Method D1423, using ten test specimens selected from each laboratory sample.

9.3.6 Determine the fabric air permeability of each unit in the lot sample in accordance with Test Method D737, using five test specimens selected from each laboratory sample so that no two specimens contain the same warp or filling yarns. For additional information on calibration and use of air permeability test equipment, see Test Method F778.

9.3.7 Determine the fabric abrasion resistance for each unit in the lot sample in accordance with Test Method D4157, using five test specimens selected from both the warp and filling directions of the fabric rolls.

9.3.8 Determine the blocking of a coated fabric in accordance with Test Method SAE J912-A using five test specimens selected from each laboratory sample so that no two test specimens contain the same warp or filling yarns.

9.3.9 Determine the fabric bow and skew of each unit in the lot sample in accordance with Test Method D3882 in three places spaced as widely as possible along the roll length. Make no measurement closer to the ends of the roll than 1 m (1 yd).

9.3.10 Determine the fabric breaking force and elongation in accordance with Test Method D5034 in five places in both the warp and filling directions.

9.3.10.1 Use a tensile testing machine that exhibits either a constant rate of extension (CRE) or a constant rate of traverse (CRT), that is designed for the tensile forces anticipated, and that is operated at a rate of 300 mm/min (12 in./min). Select the force range of the testing machine such that the break occurs between 10 % and 90 % of full scale load.

9.3.10.2 Coat one side of uncoated specimens in accordance with Test Method D751. Use jaw and specimen size as agreed upon by purchaser and supplier.

9.3.10.3 Calculate the average tensile force and elongation at break for each testing direction using the five highest peak forces recorded.

9.3.11 Determine the fabric burst strength in accordance with Test Method D3786, using five specimens selected from each laboratory sample so that no two specimens contain the same warp or filling yarns.

9.3.12 Determine the coating adhesion of a coated fabric in accordance with Test Method D4851, or Ford Motor Company FLTM BN-13-1, using five specimens selected from the laboratory sample.

NOTE 2—Assessment of adhesion may be subjective. Proper interpretation of adhesion test results shall be agreed upon by purchaser and supplier.

9.3.13 Determine the coating weight of a coated fabric in accordance with Test Method D3776, Option C, using five specimens selected from each of the laboratory samples. The coating weight is calculated as the difference in weight per unit area before and after the fabric has been coated.

9.3.14 Determine the fabric count for test specimens in accordance with Test Method D3775, making five determinations each in the warp and filling directions.

9.3.15 Determine the flammability of test specimens in accordance with Federal Motor Vehicle Safety Standard 302, using five test specimens each from the warp and filling directions.

9.3.16 Determine the fogging (volatility) of the fabric in the lot sample in accordance with Ford Test Method BO116-03 using three specimens selected from the laboratory sample.

9.3.17 Determine the length of each roll in the lot sample in accordance with Test Method D3773 using Option B, Drum Method, or Option C, Clock Method. Total the lengths of the rolls measured.

9.3.18 Determine the mass (weight) per unit area of the fabric in the lot sample in accordance with Test Method D3776 Option C, in five places from each laboratory sample.

9.3.19 Determine the non-fibrous content of the fabric in the lot sample in accordance with Test Method D2257, using one specimen selected from the laboratory sample and chloroform as the solvent.

NOTE 3—**Precaution:** As with all volatile solvents, the use of adequate ventilation under a hood is recommended when using chloroform.

9.3.20 Determine the odor of the fabric in the lot sample in accordance with SAE Practice J 1351 using one specimen selected from the laboratory sample.

9.3.21 Determine the fabric pH in accordance with AATCC Method 81 for each unit in the lot sample using one 10 g test specimen taken from each laboratory sample.

9.3.22 Determine the fabric stiffness for each unit in the lot sample using Test Method D4032, using five specimens each from the warp and filling directions selected from each laboratory sample. Use Test Method D1388 Option 2, Cantilever Method, if directional stiffness is required.

9.3.23 Determine the fabric tear strength for each unit in the lot sample using Test Methods D2261 or D1424 if tongue tear is required, or D5587 if trapezoid tear is required.

9.3.23.1 From the laboratory sample, take five specimens each from the warp and filling directions. Coat one side of uncoated test specimens in accordance with Test Method D751.

9.3.23.2 Use a tensile testing machine that exhibits either a constant rate of extension (CRE) or a constant rate of traverse (CRT), that is designed for the tear forces anticipated, and that is operated at a rate of 300 mm/min (12 in./min). Select the force range of the testing machine such that the break occurs between 10 % and 90 % of full scale load.

9.3.23.3 Calculate the average tear strength for each tear direction using the five highest peak forces recorded in each test.

9.3.24 Determine the thickness of the fabric in each roll in the lot sample in accordance with Test Method D1777 from ten specimen areas in each laboratory sample. Use a gage with a presser foot with a diameter of 9.5 ± 0.025 mm (0.375 ± 0.001 in.) that is weighted to apply a total force of 1.7 ± 0.3 N (6 ± 0.1 oz) equivalent in pressure to 23.4 kPa (3.4 psi), unless otherwise specified.

9.3.25 Determine the presence of sizing in the lot sample using Practice D6613 using one determination from each lab sample.

9.3.26 Determine the fabric width for each roll in the lot sample in accordance with Test Method D3774 Option B (Laboratory Sample Removed from Full Roll or Bolt), using five determinations from each laboratory sample.

9.3.27 Evaluate sewing thread in accordance with Test Method D204.

9.3.28 Determine the dynamic air permeability for each unit in the lot sample in accordance with Test Method D6476 using five determinations from each laboratory sample.

9.3.29 Determine the edgecomb resistance for each unit in the lot sample in accordance with Test Method D6479 using five determinations in both the warp and filling directions.

9.3.30 Determine the packability for each unit in the lot sample in accordance with Test Method D6478 using one determination from each unit.

10. Report

10.1 State that the fabric lot was tested in accordance with Test Method D5446 for testing the physical properties of fabrics used in inflatable restraints. Describe the material or product sampled and the method of sampling used.

10.2 The purchaser and supplier shall determine the exact form of the laboratory report. Unless otherwise specified, the form shall provide the following information:

10.2.1 applicable specification or reference to agreement between purchaser and supplier describing material requirements,

10.2.2 the description or designation of the test, including option(s) or method(s) used,

10.2.3 fabric designation,

10.2.4 identification of lot and lot samples,

10.2.5 specification of performance parameters,

10.2.6 results of each test,

10.2.7 name of tester,

10.2.8 date of test, and

10.2.9 deviations from standard test method procedures and apparatus.

11. Conformance

11.1 The test results of the fabric physical testing must conform to allowable ranges listed in the applicable material specification or other agreement between purchaser and supplier in order to warrant release of the shipment of material.

11.2 Non-conformity shall be reported by the supplier to the purchaser in writing. A material lot that fails to conform to physical testing requirements as specified or as otherwise agreed upon may only be released for shipment upon written consent of the purchaser.

12. Precision and Bias

12.1 No statement is made about either the precision or bias of the ASTM test methods referenced in Test Method D5446, Standard Test Methods for Determining the Physical Properties of Fabrics Used in Inflatable Restraints, since a statement regarding precision and bias is included within each ASTM test method.

12.2 Other test methods referenced in Section 2 do not include precision and bias statements. In case of a dispute arising from differences in reported test results when using these test methods, the purchaser and the supplier shall conduct comparative tests to determine if there is a statistical bias between their laboratories. As a minimum, the two parties shall take a group of test specimens which are as homogeneous as possible and from the same lot of material. The test specimens shall then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories shall be compared using Student's t-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause shall be found and corrected or the purchaser and supplier shall agree to interpret future results in light of the known bias.

13. Keywords

13.1 airbag; fabric physical testing; inflatable restraint; physical properties ; one piece woven