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Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics[1]

This standard is issued under the fixed designation D 2724; 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 characterizing the delamination, strength of bond, appearance, and shrinkage propensity of bonded, fused, and laminated apparel fabrics after drycleaning and laundering.

1.2 The values stated in SI units are to be regarded as standard; the values in parentheses are provided as information only.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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 Textiles[2]

D 123 Terminology Relating to Textiles[2]

E 337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)[3]

2.2 *AATCC Standard:*

124 Appearance of Durable Press Fabrics After Repeated Home Launderings[4]

2.3 *Federal Trade Commission Trade Regulation Rule:*

16 CFR 423 Care Labeling of Textile Wearing Apparel and Certain Piece Goods[5]

3. Terminology

3.1 *blister, n—in bonded, fused, or laminated fabrics,* a bulge, swelling, or similar surface condition on either the face fabric or the backing fabric characterized by the fabric being raised from the plane of the underlying component over a limited area to give a puffy appearance.

3.2 *bonded fabric, n*—a layered fabric structure wherein a face or shell fabric is joined to a backing fabric, such as tricot, with an adhesive that does not significantly add to the thickness of the combined fabrics.

3.2.1 *Discussion*—In this context a thin layer of foam is considered an adhesive when the cell structure is completely collapsed by a flame.

3.3 *bond strength, n— of bonded, fused, or laminated fabrics,* the tensile force expressed in ounces per 25 mm (1 in.) of width, required to separate the component layers under specified conditions.

3.4 *bubble*—See preferred term *blister*.

3.5 *crack mark, n—in bonded, fused, or laminated fabrics,* a sharp break or crease in the surface contour of either the face fabric or the backing fabric that becomes evident when the bonded, fused, or laminated composite is rolled, bent, draped, or folded.

3.5.1 *Discussion*—Crack marks are usually the result of combining tight fabric constructions at least one of which does not have sufficient residual stretch to allow the combined fabrics to be bent in an arc without producing crack marks on the concave side of the arc. Crack marks also occur when bonded fabrics are allowed to remain in a creased or wrinkled state before full adhesive cure has taken place. Other causes include the use of excessive adhesive in bonding, or excessive foam thicknesses and excessive foam collapse in flame lamination.

3.6 *foam tear, n*—a condition wherein the foam portion of a laminated fabric ruptures prior to the failure of the bond.

3.7 *fused fabric, n*—a type of bonded fabric made by adhering a fusible fabric to another fabric, such as for use as an interlining.

3.8 *fusible fabric, n*—a utilitarian fabric which has a thermoplastic adhesive applied to one side, sometimes in a pattern of dots, so that the surface can be bonded to another fabric surface by the use of heat and pressure.

3.9 *interlining, n*—any textile which is intended for incorporation into an article of wearing apparel as a layer between an outer shell and an inner lining.

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[1] These test methods are under the jurisdiction of ASTM Committee D13 on Textiles, and are the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General.

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[2] *Annual Book of ASTM Standards,* Vol 07.01.

[3] *Annual Book of ASTM Standards,* Vol 11.03.

[4] Available from American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

[5] As amended effective January 2, 1984, Section A236, available from U.S. Government Printing Office, North Capital and H Streets NW, Washington DC, 20401.

3.10 *laminated fabric, n*—a layered fabric structure wherein a face or outer fabric is joined to a continuous sheet material, such as polyurethane foam, in such a way that the identity of the continuous sheet material is retained, either by the flame method or by an adhesive, and this in turn normally but not always, is joined on the back with a backing fabric such as tricot.

3.11 *lot, n—in bonded, fused, or laminated fabric*, a single run on the bonding or laminating machine in which the processing is carried out without stopping or changing processing conditions, and consisting of either a single dye lot or a single gray goods lot.

3.12 *puckering, n— in bonded, fused, or laminated fabrics*, a wavy, three-dimensional effect typified by closely spaced wrinkles, on either the face fabric or the backing fabric or both.

3.12.1 *Discussion*—Puckering may be due to (*1*) differential shrinkage of the component layers, (*2*) differences in tension when the component layers are combined, or (*3*) selective lineal delamination.

3.13 *solvent relative humidity, n*—the humidity of air over a drycleaning bath and in equilibrium with the solvent and its small amount of water.

3.13.1 *Discussion*—Every drycleaning solvent bath containing detergent can require a different absolute water content to reach the Federal Trade Commission (FTC) specified level of solvent relative humidity for a normal drycleaning. The actual solvent relative humidity in the air over a solvent must be measured by an hygrometer after equilibrium has been reached between the water content of air and the solvent.

3.14 For definitions of other textile terms used in this test method, refer to Terminology D 123.

4. Summary of Test Methods

4.1 Bench marks are placed at specified distances on the fabrics, which are then measured, and subsequently drycleaned, or laundered and dried, or both, through a prescribed cycle that is repeated a specified number of times. The drycleaned or washed specimens are examined for appearance and delamination and measured to determine any accompanying shrinkage and, if desired, tested to determine the strength of the bond.

5. Uses and Significance

5.1 These test methods for the determination of properties of bonded, fused, or laminated apparel fabrics, are considered satisfactory for acceptance testing of commercial shipments of bonded and laminated apparel fabrics since the methods have been used extensively in the trade for acceptance testing.

5.1.1 In case of a dispute arising from differences in reported test results when using Test Methods D 2724 for acceptance testing of commercial shipments, the purchaser and the 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 that are as homogeneous as possible and that 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 the 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.

6. Apparatus and Materials

6.1 *Drycleaning Machine*,[6] single-unit, coin-operated type, capable of providing a complete automatic dry-to-dry cycle using perchlorethylene. It shall consist of a commercial rotating cage type, totally enclosed machine. The diameter of the rotating cage shall be not less than 600 mm (24 in.) and not more than 1080 mm (42 in.). Its depth shall be not less than 300 mm (12 in.). It shall be fitted with two to four lifters. The speed shall be such as to give a *g*-factor between 0.5 and 0.9 for cleaning and between 35 and 120 for extraction. The machine shall be equipped with thermometers for the measurement of the solvent temperature and the air drying temperature.

NOTE 1—The *g*-factor is calculated using Eq 1 or Eq 2:

$$g = 1.42n^2D/100\ 000 \quad (1)$$

$$g = 5.59n^2d/10\ 000\ 000 \quad (2)$$

where:

n = revolutions per minute,
D = cage diameter, in., and
d = cage diameter, mm.

6.2 *Domestic Automatic Washer*,[7] top-loading, spin-extracting type.

6.3 *Domestic Automatic Tumble Dryer*,[7] front-loading type.

6.4 *Aspirated Psychrometer*, which meets the requirements of Test Method E 337.

6.5 *Marking Device*[8]—A thin sheet of stainless steel or other rigid flat material in which a square opening 254 by 254 mm (10 by 10 in.) has been cut.

6.6 *Rule*, 305-mm (12-in.) or longer, preferably divided into tenths of an inch. A premarked device calibrated to give the percentage of shrinkage or growth may also be used.

6.7 *Sewing Machine*, suitable for sewing a single row of stitching, preferably with No. 00 mercerized cotton thread, 25 mm (1 in.) from the edge of the fabric specimen.

6.8 *Steam Iron*, hand type.

6.9 *Steam Press*,[9] a press, 600 by 1250 mm (24 by 50 in.), or larger, provided with 60 to 70 psig steam pressure at the press. Any steam press large enough for pressing a specimen 380 mm (15 in.) square may be used.

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[6] Sources of suitable equipment are: McGraw-Edison Co., Speed Queen Div., Ripon, Wis.; Philco-Bendix Corp., Fairfield, IO; American Permac, Inc., 175 Express St., Plainview, L. I.; Valley Industries Productions, Inc., 133 E. Jericho Turnpike, Mineola, NY; and Atlas Electric Devices, Chicago, IL.

[7] Kenmore Model 600 washer and dryer, available from Sears Roebuck and Co., are satisfactory for this purpose.

[8] Other suitable devices are available from Better Fabrics Testing Bureau, Inc., 101 W. 31 St., New York, NY, and from Cluett, Peabody and Co., Inc., Sanforized Div., Troy, NY.

[9] Sources of suitable equipment are: Hoffman Machine Co., Syracuse, NY; Pentax Co., Pawtucket, R. I.; Prosperity Co., Syracuse, NY; U. S. Testing Co., Hoboken, NJ.

6.10 *Tensile Testing Machine*, conforming to Specification D 76, either a constant rate of traverse type[10] or a constant rate of extension type, equipped with clamps having a width of 76.2 mm (3.00 in.) and preferably calibrated in kilograms with a range from 0 to 4.5 kg (0 to 160 oz). The constant rate of extension type machine is preferred because of the inherently lower machine-induced errors in this type of machine.

6.11 *Detergent*, home laundry type.

6.12 *Perchlorethylene*, commercial grade.

NOTE 2—**Warning:** Perchlorethylene is toxic, and the usual precautions for handling chlorinated solvents should be taken. It should be used only under well-ventilated conditions. The solvent is nonflammable.

6.13 *Drycleaning Detergent*,[11] anionic drycleaning detergent.

7. Sampling

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

NOTE 3—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of fabric and between specimens from a swatch from a roll of fabric so as to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take a full width swatch 1 m (1 yd) long from the end of each roll of fabric in the lot sample, after first discarding a minimum of 1 m (1 yd) of fabric from the very outside of the roll.

7.3 *Test Specimens*—Proceed as follows:

7.3.1 *Drycleaning and Laundering*—Cut four specimens from each swatch in the laboratory sample with each specimen being 380 by 380 mm (15 by 15 in.) in size, with the one side of the specimens from a single swatch parallel to the selvage. Locate two of the specimens from each swatch about ⅓ of the distance from one selvage and locate the other two specimens from each swatch about ⅓ of the distance from the other selvage. Locate each of the two specimens from one side of the swatch along a diagonal line on the swatch so that they will contain different warp ends and filling picks. Sew a straight line of stitching around each specimen 25 mm (1 in.) from each edge. Reserve the rest of the swatch for comparison with the drycleaned and laundered test specimens.

7.3.2 *Strength of Bond*—Prepare three test specimens, each measuring 76 mm (3 in.) wide, and 152 mm (6 in.) long, the length of the specimens corresponding to the length direction of the fabric. Do not take the test specimens closer to the selvage than a distance equal to 20 % of the fabric width.

NOTE 4—Samples that are 51 mm (2 in.) wide may be used as the minimum width.

8. Conditioning

8.1 Bring the samples from the prevailing atmosphere and condition them for at least 4 h in the standard atmosphere for testing textiles if shrinkage is to be determined. Preconditioning is not necessary.

9. Specimen Preparation

9.1 Using an indelible fineline marker, mark a 254 by 254 mm (10 by 10 in.) reference square centrally located on the face of each test specimen. Apply three sets of reference markings 254 ± 2 mm (10 ± 0.1 in.) apart, as measured with a rule, in the direction of the fabric length. Locate the markings within 25 mm (1 in.) of each end and at the midpoint of each side of the square. Similarly, apply three sets of markings in the direction of the fabric width. Any other method of accurately locating the 254-mm reference marks is satisfactory as long as the three marks on each side of the square are at least 105 mm (4 in.) apart.

10. Drycleaning Procedure

NOTE 5—Launderable fabrics are expected normally to be drycleanable, except where the face fabric is not drycleanable and is so labeled. For example, the fabric could contain a functional finish soluble in the solvent, or the fiber could be degraded by the solvent, which would be the case with poly(vinyl chloride) fiber.

10.1 *Solvent Preparation*—Prepare a standard detergent/drycleaning solvent mixture by adding sufficient detergent to the solvent to make a 1 % volume/volume solution. Add sufficient water to the solution to give a solvent relative humidity level of 75 % for the particular drycleaning detergent used. Put this solvent in the machine storage tank. The same solution can be used for repeated cleanings until it becomes dirty and needs replacing as long as the necessary water additions to maintain the solvent relative humidity constant are made prior to each test run. This is so because the specimens being run could conceivably alter the solvent relative humidity for succeeding test runs while the detergent level would remain constant.

10.2 *Sample and Dummy Load Preparation*— Prepare a load consisting of all specimens to be tested and made up to 3.6 kg (8 lb) total with dummy load of approximately 380 by 380-mm (15 by 15-in.) fabric pieces of similar material. Condition this load at least 4 h in the standard atmosphere for testing textiles. After the drycleaning operation, condition the load again before running through each additional drycleaning cycle. Conditioning before each drycleaning cycle is intended to minimize depletion of water from the drycleaning solution specified in 10.1.1 which may affect shrinkage results.

10.3 *Drycleaning Procedure*—Run through the complete dry-to-dry cycle in the machine. Run the solvent phase of the drycleaning cycle with the solvent no higher than 32°C (90°F). During the drying phase of the drycleaning cycle, either the air outlet temperature should not exceed 60°C (140°F) or the inlet air temperature should not exceed 80°C (175°F). If heat-sensitive fibers, for example, modacrylic fibers, are involved, the outlet air temperature should not exceed 40°C (105°F) or

[10] Model X-5, available from Edward H. Benz Co., 283 Whiteford Ave., Providence, RI 02908, has been found satisfactory.

[11] Formula 886, petroleum sulfonate type or staticol, amine sulforate type, available from R. R. Street, Inc., 561 W. Monroe St., Chicago, IL; or Perksheen 324, amine sulfonate type, available from Adco, Inc., 900 W. Main St., Sedalia, MO, have been found suitable for this purpose.

the inlet air temperature should not exceed 60°C (140°F). After the complete drycleaning cycle, remove the sample from machine for examination and reconditioning.

10.4 Repeat the drycleaning operation through two additional cycles. At the end of the third cycle remove the test specimens from the machine, lay on a flat surface, smooth the test specimens by hand, and examine. Press the test specimens using the steam press according to the following cycle:

10.4.1 Five seconds steam with head up.

10.4.2 Five seconds dry hot press with head down, 145 to 151°C (293 to 303°F) of steam pressure at the press.

10.4.3 Five seconds vacuum, steam off, head down.

10.4.4 Five seconds vacuum, steam off, head up.

10.4.5 Allow the pressed specimens to condition in the standard atmosphere for testing textiles for at least 4 h.

10.5 Measure the distance between each of the six sets of reference marks on each test specimen.

10.6 Lay the fabric flat on a table or board with a surface rough enough so that the fabric side touching the table will not readily slide. Examine each test specimen for any evidence of delamination. Place the fingers on the specimen and attempt to slide the upper fabric layer over the bottom or intermediary substrate. If in doubt, make a small cut through the specimen with scissors to determine if any separation of substrates has occurred. Turn the fabric over and make the same type of examination on the other side.

10.7 Examine the face fabric for any alteration in appearance as compared with the original sample. This may be done with conventional room lighting, or with "Lighting Equipment for Viewing Test Specimens," as described in Fig. 1 of AATCC Method 124 – 1984. Examine only the area of the test specimen bounded by the stitching.

11. Laundering Procedure

11.1 *Machine Laundering*—Wash the test specimens in the automatic home laundry machine, using 50 g of laundry detergent, or a sufficient amount to give a safe suds level, at the applicable domestic automatic temperature and procedure under which the fabric is to be marketed. In the absence of this information use the "normal" cycle and high water level settings and determine the washing temperature according to the fabric type and construction as follows:

11.1.1 Face fabrics containing 20 % or more of wool, acetate, modacrylic, or acrylic fibers, 41 ± 3°C (105 ± 5°F).

11.1.2 Face fabrics of tricots, circular knits, woven nylon, and print fabrics other than those described under 11.1.1, 49 ± 3°C (120 ± 5°F).

11.1.3 All other woven face fabrics, 60 ± 3°C (140 ± 5°F).

11.2 *Load for Machine Laundering*—Use a total load of 1.8 kg (4 lb) including test specimens plus a dummy load of approximately 380 by 380 mm (15 by 15 in.) fabrics of similar fabric construction. Load all fabrics in the flat position.

11.3 *Hand Laundering*—If the fabrics are to be designated "Hand Washable," dissolve 20 g of laundry detergent in 7.6 L (2 gal) of water at 41 ± 3°C (105 ± 5°F) in a 9.5-L (10-qt) pail and then add two test specimens. Wash by lifting each specimen out of the bath followed by immediate reimmersion at least ten times. Just before the final reimmersion, lightly rub by hand the center of each specimen separately for a period of 1 min. Rinse by transferring the specimens to 7.6 L of water at 41 ± 3°C (105 ± 5°F) and gently agitating the specimens by hand for a period of 2 min with no twisting or wringing. Remove the specimens and dry as directed in 11.6.

11.4 *Tumble Drying*—Immediately after the first wash cycle, as directed in 11.1, remove the test specimens and dummy load from the laundry machine and transfer to the tumble dryer. Run the dryer at the "moderate" setting and dry for the minimum time required for adequately drying the fabrics being tested. Remove the test specimens and dummy load immediately following the shut-off and examine.

11.5 Repeat the washing and drying cycles as directed in 11.1 and 11.4 four more times. After the fifth cycle, remove the test specimens, lay on a flat surface, smooth by hand, and examine. Press the face fabric side lightly with a sliding action using the hand steam iron, with no pressure other than the weight of the iron. If no ironing temperature is specified for the face fabric, use the safe ironing temperature guide appearing in Table 1. Allow the specimens to condition on a flat surface in the standard atmosphere for testing textiles for a minimum of 4 h before rating and measuring as directed in 10.5-10.7.

11.6 *Drip Drying*—Remove the specimens from the pail or from the automatic washer just before the water begins to drain for the final spin-dry cycle, squeeze by hand without wringing or twisting, and hang each specimen by two adjacent corners, with the fabric length in the vertical direction, in still air at room temperature until dry and examine.

11.7 Repeat the washing and drying cycles as directed in 11.2 or 11.3, and 11.6, four more times. After the fifth cycle,

TABLE 1 Safe Ironing Temperature Guide

Class 0	Class I	Class II	Class III	Class IV
Below 121°C (250°F)	121 to 135°C (250 to 275°F)	149 to 163°C (300 to 325°F)	177 to 191°C (350 to 375°F)	204°C (400°F) and Above
Modacrylic 93 to 121°C (200 to 250°F)	Acetate	Triacetate (unheat set)	Nylon 66	Cotton
	Olefin (polypropylene)	Acrylic	Polyester	Fluorocarbon Glass
Olefin (polyethylene) 79 to 121°C (175 to 250°F)	Silk	Azlon Nylon 6		Hemp, Jute Ramie
Rubber 82 to 93°C (180 to 200°F)		Spandex Wool		Linen Rayon, Viscose
Saran 66 to 93°C (150 to 200°F) Vinyon 54°C (130°F)				Triacetate (heat set)

TABLE 2 Components of Variance Shrinkage

		Single-Operator Component Percentage Points	DF	Between-Laboratory Component Percentage Points	DF
Drycleaning	length shrinkage	0.68	45	0.97	4
	width shrinkage	0.59	45	0.77	4
Hand wash-line dry	length shrinkage	1.00	20	1.48	4
	width shrinkage	0.33	20	1.11	4
Machine wash-tumble dry	length shrinkage	0.56	25	0.79	4
	width shrinkage	1.00	25	1.18	4

TABLE 3 Critical Differences, Percentage Points, Between Average Percentages for the Conditions Noted

	Number of Observations in Each Average	Length Shrinkage		Width Shrinkage	
		Single-Operator Precision	Between-Laboratory Precision	Single-Operator Precision	Between-Laboratory Precision
Drycleaning	2	1.4	4.2	1.2	3.6
	4	1.1	4.1	1.0	3.3
	6	0.8	4.0	0.7	3.2
Hand wash-line dry	2	2.1	6.3	0.6	4.4
	4	1.5	6.1	0.5	4.4
	6	1.2	6.0	0.4	4.3
Machine wash-tumble dry	2	1.2	3.4	2.1	5.2
	4	0.9	3.3	1.5	5.0
	6	0.7	3.2	1.2	4.9

lay on a flat surface, smooth the test specimens by hand, and examine. Press the face fabric side lightly with a sliding action using a hand steam iron with no pressure other than the weight of the iron. If no ironing temperature is specified for the face fabric, the safe ironing temperature guide appearing in Table 1 may be used. Allow the specimens to condition on a flat surface in the standard atmosphere for testing textiles for a minimum of 4 h before rating and measuring as directed in 10.5-10.7.

NOTE 6—All specimens hand washed as directed in 11.3 should be drip dried. Specimens machine washed as directed in 11.1.1 should be drip dried only when the fabrics are to be marketed as "Machine Wash, Drip Dry."

12. Calculation

12.1 Calculate the shrinkage or gain in each direction by averaging the three measurements in each direction on each test specimen and using these average measurements in accordance with Eq 3:

$$\text{Shrinkage, \%} = (A - B)100/A \quad (3)$$

where:

A = average original distance between bench marks, and
B = average final distance between bench marks.

12.2 Calculate the average length shrinkage and the average width shrinkage of both test specimens separately fordrycleaning and for each laundering and drying procedure used.

13. Precision and Bias

13.1 *Interlaboratory Test Data*[12]—An interlaboratory test, in which nine different bonded and laminated fabrics were used, was run during 1969. Five laboratories participated and calculated the percent shrinkage in length and width as a result of drycleaning, hand washing followed by line drying, and machine washing followed by tumble drying. The calculated components of variance expressed as standard deviations and the degrees of freedom on which they are based are shown in Table 2.

NOTE 7—The within-laboratory (multioperator) component was not determined separately and is included in the between-laboratory component.

13.2 *Precision*—Based upon the components of variance stated in Table 2, the average test results should be considered significantly different at the 95 % probability level if the difference equals or exceeds the differences listed in Table 3.

NOTE 8—The critical differences listed in Table 3 were calculated using the values of t that correspond to the degrees of freedom listed in Table 2.

13.3 *Bias*—The procedure in Test Methods D 2724 for measuring dimensional stability during drycleaning or laundering has no bias because the value of this property can be defined only in terms of a test method.

STRENGTH OF BOND (OPTIONAL)

14. Test Conditions

14.1 Bond strength tests may be made on the fabric as bonded or laminated, or after the three specified drycleaning cycles or after the five specified laundering cycles. These tests also may be made on dry specimens (conditioned in the standard atmosphere for testing textiles for a minimum of 4 h), or on wet specimens (saturated with perchlorethylene at room temperature following the drycleaning tests or saturated with water at room temperature following the laundering tests).

14.2 Alternatively, following the drycleaning tests, wet strength-of-bond tests may be made on flame-laminated fabrics with the specimens saturated in water instead of perchlorethylene. An interlaboratory test run in 1975[9] showed no significant differences between perchlorethylene and water in wet

[12] ASTM Research Report RR: D13-1003 is available on loan from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

tests on flamelaminated fabrics. However, there were significant differences on adhesive-bonded fabrics. Therefore, water is not a suitable substitute for perchlorethylene in wet tests on these fabrics.

15. Procedure for Bonded and Fused Fabrics

15.1 Manually separate the two layers of fabric along the 76.2 mm (3 in.) width of each test specimen for a distance of approximately 25 mm (1 in.) in the direction of the specimen length.

15.2 Set the lower clamp at a distance of 25 mm (1 in.) from the upper clamp. Secure the separated face fabric of a test specimen in the upper clamp of the tensile testing machine in such a way that the longitudinal axis of the specimen forms a right angle with the closed clamping surface. Secure the separated backing fabric in the lower clamp of the machine in such a way that the longitudinal axis of the specimen forms a right angle with the closed jaws of the lower clamp.

15.3 If the indicating scale on the machine is provided with a pawl and ratchet mechanism, disengage the mechanism to permit readings of variable force when the machine is placed in operation.

15.4 Operate the machine at a pulling speed of 5.1 ± 0.2 mm/s (12 ± 0.5 in./min).

15.5 Estimate the bond strength to the nearest 140 mN (0.5 ozf) as the average of at least the five highest and the five lowest peak loads of resistance per inch of width, registered for 100 mm (4 in.) of delamination.

15.6 Repeat the operations described in 15.2-15.5 for each of the remaining two test specimens.

15.7 Report the bond strength in ounces per inch of width as the average strength of the three test specimens.

16. Procedure for Laminated Fabrics

16.1 Manually separate the face fabric from the foam along the 76.2-mm (3-in.) width of each test specimen for a distance of approximately 25 mm (1 in.) in the direction of the specimen length.

16.2 Set the lower clamp at a distance of 25 mm (1 in.) from the upper clamp. Secure the separated face fabric of a test specimen in the upper clamp of the tensile testing machine in such a way that the longitudinal axis of the specimen forms a right angle with the closed clamping surface. Secure the separated foam or foam and backing fabric in the lower clamp of the machine in such a way that the longitudinal axis of the specimen forms a right angle with the closed jaws of the lower clamp.

16.3 Proceed as instructed in 15.3-15.7.

16.4 If foam is laminated to a backing fabric, retain each test specimen from 16.3 after the bond strength has been determined for face to foam. Manually separate the backing fabric from the foam as instructed in 16.1 except that the manual separation should be made at the opposite end of the test specimen separated for the face fabric-to-foam test.

16.5 Set the lower clamps at a distance of 25 mm (1 in.) from the upper clamp. Secure the separated foam or foam and face fabric of a test specimen in the upper clamp of the tensile testing machine in such a way that the longitudinal axis of the specimen forms a right angle with the closed clamping surface. Secure the separated backing fabric in the lower clamp of the machine in such a way that the longitudinal axis of the specimen forms a right angle with the closed jaws of the lower clamp.

16.6 Proceed as instructed in 15.3-15.7.

16.7 Examine both sides of the foam on the test specimens after testing for bond strength. Determine whether the foam portion ruptured during delamination allowing some foam to adhere to either fabric surface. If this has occurred, make the notation “foam tear” for that test specimen for the side or sides where “foam tear” occurred. If “foam tear” occurs on only one side of one test specimen, disregard this result and report the average bond strength for that side of the remaining two specimens. If “foam tear” occurs on the same side of two or three specimens, report the bond strength for that side as “foam tear.”

16.8 In the event it is impossible to separate manually the foam from either the face or the backing fabric as instructed in 16.1 and 16.4 without rupturing the foam, report the bond strength for the side or sides where this occurs as “foam tear.”

17. Report

17.1 State that the tests were made as directed in ASTM Test Methods D 2724. Describe the material or product sampled and the method of sampling used.

17.2 Report the following information:

17.2.1 The individual length and width dimensional changes to the nearest 0.5 % for each test specimen as well as the average length and width shrinkage for both test specimens and identify these results with the procedures used.

17.2.2 The absence or presence of any delamination in the drycleaned or laundered and dried specimens before pressing or ironing. Use the term “acceptable bond” for fabrics that have not delaminated and “unacceptable bond” for fabrics that have delaminated. In the case of three-layer laminated fabrics, report whether the delamination has occurred on the face or backing fabric or both. Rate the lot as “unacceptable” if either fabric has delaminated.

17.2.3 Any alteration in appearance or esthetic properties of the drycleaned or laundered and dried specimens when compared with the residual portion of the original sample. For example, report whether the specimens, identified by the drycleaning or laundering and drying procedures used, show:

17.2.3.1 Puckering,

17.2.3.2 Crack marks,

17.2.3.3 Bubbling or blisters,

17.2.3.4 Face fabric pilling,

17.2.3.5 Loss or gain of stiffness,

17.2.3.6 Color change, and

17.2.3.7 Wrinkles.

17.2.4 If strength of bond tests were run, report the following information along with the solvent used for wet specimens:

17.2.4.1 Whether the tests were run on the fabric as bonded or laminated, or after the three drycleaning cycles, or after the five laundering cycles.

17.2.4.2 Whether the tests were run on dry or wet specimens as described in Section 14.

17.2.4.3 Whether constant rate of transverse or constant rate of extension type tensile testing machine was used.

NOTE 9—While this method provides for three drycleaning cycles, five laundering and drying cycles, or both, the number of cycles can be decreased or increased for special purposes but in this case the report should state what cycles were used.

18. Precision and Bias

18.1 *Interlaboratory Test Data*[11]—An interlaboratory test, in which nine different bonded and laminated fabrics were used, was run during 1969. Five laboratories participated and recorded the average wet bond strength (sometimes called wet peel bond strength) for 76-mm (3-in.) wide specimens after drycleaning, hand washing, and machine washing the specified number of times. No data is reported for machine wash-tumble dry wet-bond strength because some of the fabrics delaminated before the five wash cycles were completed and some exhibited "foam tear." Of the participating laboratories, four used the constant rate of extension type tensile testing machine, and one used the constant rate of traverse type machine. The calculated components of variance expressed as standard deviations and the degrees of freedom on which they are based, are listed in Table 4.

18.2 *Precision*—Based upon the components of variance stated in 18.1, the average test results should be considered significantly different at the 95 % level if the difference equals or exceeds the differences listed in Table 5.

TABLE 4 Components of Variance, Wet Bond Strength

	Single-Operator Component, oz/in.	DF	Between-Laboratory Component, oz/in.	DF
Drycleaning	0.54	30	0.00	4
Hand wash-line dry	0.23	15	0.48	4

TABLE 5 Critical Differences, Wet Bond Strength

	Number of Observations in Each Average	Critical Differences oz/1 in. Wide Test Specimen	
		Single-Operator Precision	Between-Laboratory Precision
Drycleaning	2	1.1	1.1
	3	0.9	0.9
	4	0.8	0.8
Hand wash-line dry	2	0.6	2.0
	3	0.5	1.9
	4	0.4	1.9

NOTE 10—The critical differences listed in Table 5 were calculated using the values of *t* that correspond to the degrees of freedom listed in Table 4.

18.3 *Bias*—The procedure in Test Methods D 2724 for measuring strength of bond has no bias because the value of this property can be defined only in terms of a test method.

NOTE 11—The nature of the bonding and laminating processes which involve the adhesion of two or three components with adhesive systems that apply the adhesive in discrete quantities in a discontinuous form on the textile surface, produces bonded and laminated fabrics that are nonuniform in their bond strength characteristics. Considerable variations in bond strength are commonly found at various points across the width of the fabric and from one end to the other in a single piece. Because of this, it is often desirable to report the bond strength value of the test specimen with the lowest bond strength in addition to reporting the average as specified in 15.7.

19. Indexing Terms

19.1 This standard is indexed under the following terms: apparel, bonded fabric, and delamination strength.