



## Standard Test Method for Bow and Skew in Woven and Knitted Fabrics<sup>1</sup>

This standard is issued under the fixed designation D 3882; 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 bow and skew of filling yarns in woven fabrics and the courses in knitted fabrics.

1.2 This test method can also be used to measure the bow and skew of printed geometric designs such as plaids.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this test method.

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.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 123 Terminology Relating to Textiles<sup>2</sup>
- D 1776 Practice for Conditioning Textiles for Testing<sup>2</sup>
- D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data<sup>2</sup>
- D 2906 Practice for Statements on Precision and Bias for Textiles<sup>2</sup>
- D 3774 Test Method for Width of Woven Fabric<sup>3</sup>
- D 3990 Terminology Relating to Fabric Defects<sup>3</sup>

#### 2.2 AATCC Test Method:

- AATCC 179 Skewness Change in Fabric and Garment Twist Resulting from Automatic Home Laundering<sup>4</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *bow, n*—a fabric condition resulting when filling yarns or knitting courses are displaced from a line perpendicular to

the selvages and form one or more arcs across the width of the fabric. (See also *double bow*.)

3.1.2 *double bow, n*—two fabric bows, arcing in the same direction, as in a flattened *M* or *W* depending on the viewing angle. (See also *double bow*.) (Compare *double reverse bow*.)

3.1.2.1 *Discussion*—In tubular knits, there may be differential bowing between the top and bottom of the tube.

3.1.3 *double hooked bow, n*—one hooked bow at each side of the fabric that arc in opposite directions. (See also *hooked bow*.)

3.1.4 *double reverse bow, n*—two fabric bows arcing in opposite directions. (See also *bow double bow*.) (Compare .)

3.1.5 *hooked bow, n*—a fabric condition in which the filling yarns or knitted courses are in the proper position for most of the fabric width but are pulled out of alignment at one side of the fabric. (See also *double hooked bow*.)

3.1.6 *knitted fabric, n*—a structure produced by interlooping one or more ends of yarn or comparable materials.

3.1.7 *skew, n*—a fabric condition resulting when filling yarns or knitted courses are angularly displaced from a line perpendicular to the edge or side of the fabric.

3.1.7.1 *Discussion*—Knitted courses or filling yarns usually appear as straight line at right angles to the edge or side of the fabric. When tubular knitted fabric is finished, differential skew may occur on the top and bottom part of the tube.

3.1.8 *standard atmosphere for testing textiles, n*—laboratory conditions for testing fibers, yarns, and fabrics in which air temperature and relative humidity are maintained at specific levels with established tolerances.

3.1.8.1 *Discussion*—Textile materials are used in a number of specific end-use applications that frequently require different testing temperatures and relative humidities. Specific conditioning and testing of textiles for end-product requirements can be carried out using Table 1 in Practice D 1776.

3.1.9 For definitions of fabric defect terms, refer to Terminology D 3990. For definitions of other textile terms used in this test method, refer to Terminology D 123.

### 4. Summary of Test Method

4.1 *Bow*—A straightedge is placed across the fabric between two points at which a marked filling yarn, knitting course, designated printed line, or designated design meets the two selvages or edges. The greatest distance between the straightedge and the marked filling line, knitting course, designated printed line, or designated design is measured

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 07.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 07.02.

<sup>4</sup> Available from American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

**TABLE 1 Critical Differences, 95 % Probability Level, for Bow and Skew for the Conditions Noted**

| Property | Number of Observations in Each Average | Critical Differences for the Conditions Noted <sup>A</sup> , % |                               |                                |
|----------|----------------------------------------|----------------------------------------------------------------|-------------------------------|--------------------------------|
|          |                                        | Repeatability                                                  |                               | Reproducibility                |
|          |                                        | (Single-Operator) Precision                                    | (Within-Laboratory) Precision | (Between-Laboratory) Precision |
| Bow      | 1                                      | 0.80                                                           | 0.80                          | 0.80                           |
|          | 3                                      | 0.46                                                           | 0.46                          | 0.46                           |
|          | 6                                      | 0.33                                                           | 0.33                          | 0.33                           |
|          | 12                                     | 0.23                                                           | 0.23                          | 0.23                           |
|          | 24                                     | 0.16                                                           | 0.16                          | 0.16                           |
| Skew     | 1                                      | 2.99                                                           | 2.99                          | 3.18                           |
|          | 3                                      | 1.73                                                           | 1.73                          | 2.04                           |
|          | 6                                      | 1.22                                                           | 1.22                          | 1.63                           |
|          | 12                                     | 0.86                                                           | 0.86                          | 1.38                           |
|          | 24                                     | 0.61                                                           | 0.61                          | 1.24                           |

<sup>A</sup>The critical differences for Table 1 were calculated using  $t = 1.960$ , which is based on infinite degrees of freedom.

parallel to the selvage.

4.2 *Skew*—The straight-line distortion of a marked filling yarn, knitting course, designated printed line, or designated design is measured from its normal perpendicular to the selvage or edge.

## 5. Significance and Use

5.1 This test method is considered satisfactory for acceptance testing of commercial shipments.

5.1.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, the test samples to be used are as homogeneous as possible, are drawn from the material from which the disparate test results were obtained, and are randomly assigned in equal numbers to each laboratory for testing. Other fabrics with established test values may be used for this purpose. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 Individual rolls are normally accepted or rejected on the basis of the maximum amount of bow or skew in a specific roll of fabric. The average bow or skew in a roll or lot or the range of bow or skew in a roll may be determined but are not normally used in the trade for acceptance or rejection.

5.3 Bow or skew can be induced during fabric manufacturing, dyeing, tentering, finishing, or other operations where a potential exists for uneven distribution of tensions across the fabric width. Bow and skew are more visually displeasing in colored, patterned fabrics such as plaids and horizontal stripes rather than in solid colors because the contrast makes the distortion more prominent. These defects may cause sewing problems in such fabrics and draping problems in finished products. In some cases, a specified amount of skew is needed, for example, to prevent trouser leg twisting. Matching plaids from distorted patterns may create serious problems for the garment manufacturer or home sewer. Wavy or sharp breaks in

the bow line are more detrimental to the appearance of small parts of a garment (such as collars, pockets, and so forth) than a gradual slope from a straight line.

## 6. Apparatus

6.1 *Measuring Stick or Steel Tape*, graduated in 1-mm ( $\frac{1}{16}$ -in.) divisions and longer than the width of the fabric that is to be measured.

6.2 *Rigid Straightedge*, longer than the width of the fabric that is to be measured.

6.3 *Flat Surface*, of sufficient length to unroll or unfold the fabric (see 6.4).

6.4 *Fabric Inspection Table* (Optional), to unroll and roll fabric rolls or unfold and fold fabric bolts with sufficient lighting that provides transmitted light from underneath the fabric to make the defect more clearly visible.

## 7. Sampling and Test Specimens

7.1 *Primary Sampling Unit*—Consider rolls or bolts of fabric or fabric components of fabricated systems to be the primary sampling unit, as applicable.

7.2 *Laboratory Sampling Unit*—As a laboratory sampling unit take the entire roll or bolt after removing a first 1-mm (1-yd) length. For fabric components of fabricated systems, use the entire system.

7.3 *Test Specimens*—As test specimens, select 3 test areas from each laboratory sampling unit. Exclude the first and last fifth of the roll or bolt or piece length. Select test areas at random but no closer to one another than one fifth of the roll or bolt or piece length.

## 8. Conditioning

8.1 Condition the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles in accordance with Practice D 1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

8.1.1 When full rolls or bolts of fabric cannot be properly conditioned in a reasonable time with available facilities, perform the test without conditioning and report the actual condition prevailing at the time of the test. Such results may not correspond with the results obtained when testing conditioned specimens at the standard atmosphere for testing textiles.

## 9. Procedure

9.1 Test the test specimens in the standard atmosphere for testing textiles in accordance with Section 8.

9.2 Handle the test specimens carefully to avoid altering the natural state of the material.

9.3 Lay the fabric on a smooth, horizontal surface without tension in any direction or use the optional fabric inspection table.

9.4 *Bow*:

9.4.1 Measure the bow in three places spaced as widely as possible along the length of the fabric or along a minimum of 1 m (1 yd). If possible, make no measurement closer to the ends of the roll or piece of fabric than 1 m.

9.4.2 If evident, follow a distinctive color yarn or pattern line across the width of the fabric. Otherwise, trace one filling

yarn, knitting course, or printed line across the full width of the fabric using a soft pencil or suitable marker.

9.4.3 Place a rigid straightedge across the fabric connecting the points at which the distinctive color yarn or pattern line, or marked yarn meets the two selvages or edges.

9.4.4 Measure the distance along the straightedge between the two selvages or edges to the nearest 1 mm ( $\frac{1}{16}$  in.) and record as the baseline distance (BL).

9.4.4.1 For certain end uses where several narrow panels are sewn in a garment, it will be necessary to measure the bow across a narrower distance than the total width of the fabric, for example, a width of 38 cm (15 in.). This distance is used as the fabric width when calculating the bow.

9.4.5 Measure the greatest distance parallel to the selvages or edges between the straightedge and the distinctive color yarn or pattern line, or marked yarn to the nearest 1 mm ( $\frac{1}{16}$  in.) and record as the bow distance (*D*) including the type. (See Fig. 1).

9.4.5.1 If double bow is evident, measure and record both distances.

NOTE 1—Fig. 1 represents typical examples of bows in a fabric that do not have any skew. Many variations in the shape or deepest portion of the arc can occur in actual fabrics. No provision is made to measure bow in the presence of skew.

#### 9.5 Skew:

9.5.1 Measure the skew in three places spaced as widely as possible along the length of the fabric or along a minimum of 1 m (1 yd). If possible, make no measurement closer to the ends of the roll or piece of fabric than 1 m.

9.5.2 If evident, follow a distinctive color yarn or pattern line across the width of the fabric. Otherwise, trace one filling yarn, knitting course, or printed line across the full width of the fabric using a soft pencil or suitable marker (Line AC if right-hand skew, Line AD if left-hand skew).

9.5.3 Place a rigid straightedge across the fabric width perpendicular to the selvage or edge such that it coincides with the lower point on the fabric at which the distinctive color yarn or pattern line, or marked yarn meets one of the selvages or edges (Line BC).

9.5.4 Measure the distance along the straightedge between the two selvages or edges (Line BC) to the nearest 1 mm ( $\frac{1}{16}$  in.) and record as the fabric width (*W*). (See Fig. 2.)

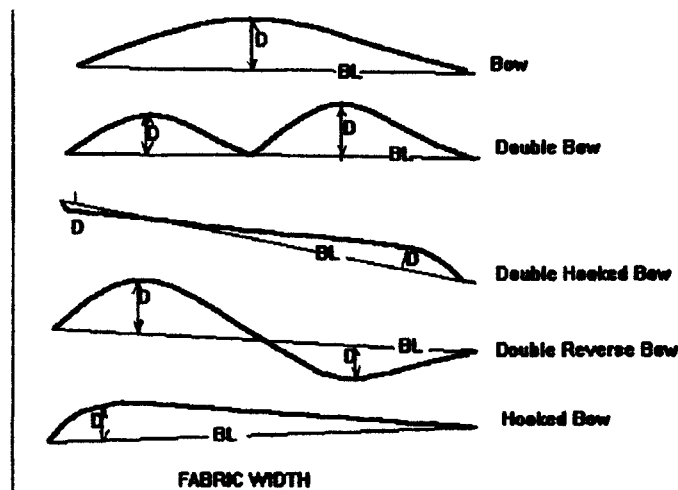


FIG. 1 Typical Bow Conditions

9.5.5 Measure the distance parallel to the selvages or edges between the straightedge and the distinctive color yarn or pattern line, or marked yarn to the nearest 1 mm ( $\frac{1}{16}$  in.) (Line AD, or BD) and record including the skew direction, right-hand “Z,” left hand “S,” and whether evident on the face or back of the fabric. (See Fig. 2.)

NOTE 2—Fig. 2 represents a schematic drawing of typical skew; variations may occur in actual fabric. Examination of Fig. 2 will show that the skew in a fabric will be consistently categorized as left-hand (or right-hand) regardless whether the fabric is being fed from the top or bottom roll of the viewing frame or whether the direction of skew is measured from the right or left selvage or side, provided either the face or back of the fabric is being viewed.

## 10. Calculation

10.1 *Bow, Individual Measurements*—Calculate the maximum bow of individual specimens to the nearest 0.1 % using Eq 1.

$$\text{Bow, \%} = 100(D/BL) \quad (1)$$

where:

*D* = maximum bow distance, mm (in.), (from 9.4.5), and

*BL* = baseline distance, mm (in.), (from 9.4.4).

10.1.1 If double bow is present, calculate the larger of the two bows.

10.2 *Skew, Individual Measurements*—Calculate the skew of individual specimens to the nearest 0.1 % using Eq 2 or Eq 3, as applicable.

$$\text{Skew, \% right-hand} = 100(AB)/BC \quad (2)$$

$$\text{Skew, \% left-hand} = 100(BD)/BC \quad (3)$$

where:

*AB* = skew distance, right hand, mm (in.), (from 9.5.5),

*BD* = skew distance, left hand, mm (in.), (from 9.5.5), and

*BC* = width of fabric, mm (in.), (from 9.5.4).

## 11. Report

11.1 Report that the skew or bow were determined as directed in Test Method D 3882. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information for each laboratory sampling unit:

11.2.1 *Bow*:

11.2.1.1 Individual bow in units of measurements and percent,

11.2.1.2 Maximum bow in units of measurements and percent,

11.2.1.3 Fabric width, and

11.2.1.4 Type of bow observed, for example, double bow, double reverse bow, double hooked bow, hooked bow, or other variation.

11.2.2 *Skew*:

11.2.2.1 Individual skew in units of measurements and percent,

11.2.2.2 Maximum skew in units of measurements and percent,

11.2.2.3 Fabric width,

11.2.2.4 Direction of skew, right-hand “Z,” left-hand “S,” and

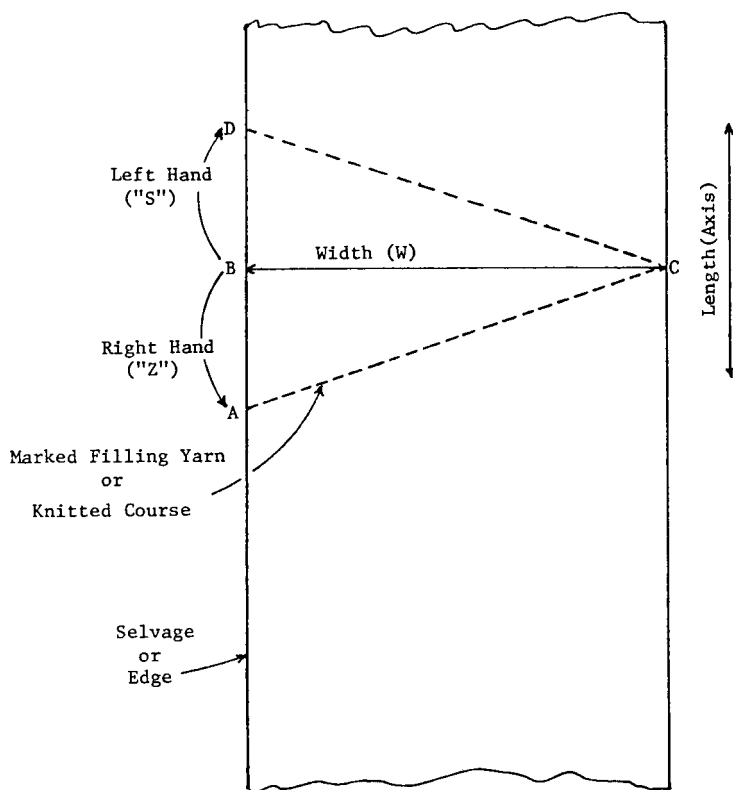


FIG. 2 Typical Skew Conditions

11.2.2.5 Side of fabric where skew was observed, face or back.

## 12. Precision and Bias

12.1 *Summary*—In comparing two averages of three determinations when using the procedures in this test method, the differences should not exceed the single-operator precision values shown in Table 1 for the respective number of tests in 95 out of 100 cases when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of material. Larger differences are likely to occur under all other circumstances.

12.2 *Interlaboratory Test Data*<sup>5</sup>—An interlaboratory test was run in 1981 in which randomly drawn specimens of three materials were tested in each of three laboratories for fabric bow and in each of four laboratories for fabric skew. Two operators in each laboratory each tested two specimens of each material for bow and skew using Test Method D 3882. The precision statement is based upon a testing plan described in Practices D 2904 and D 2906. The three fabrics were: (1) 65 % polyester/35 % cotton plaid approximately 3.9 oz/yd<sup>2</sup> (2) 50 % polyester/50 % cotton fancy weave of 3.8 oz/yd<sup>2</sup>, and (3) 100 % cotton denim of approximately 15.2 oz/yd<sup>2</sup>. Fabric bow ranged from 1.7 to 2.6 % for Fabric A, 0.6 to 2.3 % for Fabric B, and 0.9 to 1.2 % for Fabric C. Skew ranged from 3.6 to 8.2 % for Fabric A, 8.2 to 12.3 % for Fabric B, and 5.4 to 7.4 %

for Fabric C. The components of variance for bow and skew expressed as standard deviations were calculated to be the values listed in Table 2.

12.3 *Precision*—For the components of variance reported in Table 1, two averages of observed values 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 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 on specimens taken from a lot of material of the type being evaluated so as to be as nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories.

NOTE 4—Since the interlaboratory test included only three laboratories for bow and four laboratories for skew, estimates of between laboratory precision may be either underestimated or overestimated to a considerable extent and should be used with special caution.

12.4 *Bias*—The procedure of this test method produces a

TABLE 2 Components of Variance Expressed as Standard Deviations<sup>A</sup>

| Properties | Components of Variance Expressed as Standard Deviations <sup>A</sup> , % |                                  |                                   |
|------------|--------------------------------------------------------------------------|----------------------------------|-----------------------------------|
|            | Repeatability                                                            |                                  | Reproducibility                   |
|            | (Single-Operator)<br>Component                                           | (Within-Laboratory)<br>Component | (Between-Laboratory)<br>Component |
| Bow        | 0.289                                                                    | 0.000                            | 0.000                             |
| Skew       | 1.079                                                                    | 0.000                            | 0.390                             |

<sup>A</sup>The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the squares of those units of measure.

<sup>5</sup> Supporting data are available from ASTM Headquarters. Request RR: D-13-1070.

test value that can be defined only in terms of a test method. There is no independent, referee method by which bias may be determined. This test method has no known bias.

### **13. Keywords**

13.1 bow; knitted fabric; skew; woven fabric

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