

Dimensional Changes of Woven or Knitted Wool Textiles: Relaxation, Consolidation and Felting

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1. Purpose and Scope

1.1 This method is an accelerated test for determination of relaxation, consolidation and felting shrinkage of woven and knitted textiles containing 50% or more wool.

1.2 The overall dimensional change in a fabric during home laundering is a significant performance factor to the ultimate consumer of a garment. However, further analysis of the components of dimensional change is invaluable to a fabric manufacturer, since it allows the fabric manufacturer to make appropriate changes in the design and processing of fabrics to reduce their tendency to change dimensionally when washed.

2. Principle

2.1 Relaxation dimensional change is determined by soaking marked and measured specimens in water containing a wetting agent, hydro-extracting, drying and remeasuring.

2.2 Consolidation dimensional change is determined, after testing for relaxation dimensional change, by immersing the measured specimens in a buffer solution, agitating for a short time period, rinsing, hydro-extracting, drying and remeasuring.

2.3 Felting dimensional change is determined, after testing for consolidation dimensional change, by washing the measured specimens in a solution of soap, polyphosphate and borax, or a solution of soap, polyphosphate and sesquicarbonate in a washer, rinsing, hydro-extracting, drying and measuring.

3. Terminology

3.1 **consolidation dimensional change**, n.—the dimensional change that occurs when a fabric is gently agitated in water to overcome all the frictional constraints in it after it has been allowed to relax in water without agitation.

3.2 **dimensional change**, n.—a generic term for changes in length or width of a fabric specimen subjected to speci-

fied conditions. The change is usually expressed as a percentage of the initial dimension of the specimen.

3.3 **felting dimensional change**, n.—the irreversible dimensional change that occurs in a consolidated wool fabric when it is subjected to agitation in laundering.

3.4 **frictional constraint**, n.—in *textile wet processing*, the resistance to fiber movement imposed by fiber to fiber contacts within a fabric.

3.5 **growth**, n.—a dimensional change resulting in an increase in the length or width of a specimen.

3.6 **laundering**, n.—of *textile materials*, a process intended to remove soils and/or stains by treatment (washing) with an aqueous detergent solution and normally including rinsing, extraction and drying.

3.7 **relaxation dimensional change**, n.—the dimensional change that occurs when a fabric is immersed in water without agitation so that the strains and stresses put into fibers, yarns, or fabrics during previous processing stages such as spinning, weaving or knitting and finishing are relieved.

3.8 **shrinkage**, n.—a dimensional change resulting in a decrease in the length or width of a specimen.

3.9 **wool**, n.—used in the generic sense, fiber from the fleece of the sheep or lamb, hair from the Angora or Cashmere goat, rabbit hair and the so-called specialty hair fibers from the camel, alpaca, llama and vicuna.

4. Safety Precautions

NOTE: These safety precautions are for information only. The precautions are ancillary to the testing procedures and are not intended to be all inclusive. It is the user's responsibility to use safe and proper techniques in handling materials in this test method. Manufacturers MUST be consulted for specific details such as material safety data sheets and other manufacturer's recommendations. All OSHA standards and rules must also be consulted and followed.

4.1 Good laboratory practices should be followed. Wear safety glasses in all laboratory areas.

4.2 Manufacturer's safety recommendations should be followed when operating laboratory testing equipment.

5. Apparatus and Materials

5.1 Apparatus.

5.1.1 Automatic washing machines (see 18.1).

5.1.2 Washing machine, cylindrical wash wheel of the reversing type (see 18.2).

5.1.3 Hydro-extractor—Centrifugal extractor of the laundry type with a perforated basket approximately 29.0 cm (11.5 in.) deep $\times$ 51 cm (20 in.) in diameter, with an operating speed of approximately 1700 rpm (see 18.3).

5.1.4 Tray, 76 $\times$ 61 $\times$ 15 cm (30 $\times$ 24 $\times$ 6 in.), or a suitable substitute.

5.1.5 Indelible ink marking pen (see 18.4) for use with suitable rule, tape, marking template or other marking device (see 18.5).

5.1.6 Conditioning/drying racks with pull-out screen or perforated shelves (see 18.6).

5.1.7 Laboratory forced air oven (see 18.7).

5.2 Measuring Devices.

5.2.1 Tape or rule marked in millimeters, tenths of an inch or smaller increment.

5.2.2 Tape or template with rule marked directly in percent dimensional change to 0.5% or smaller increment (see 18.5).

5.2.3 Schiefer sock-measuring machine (see 18.8).

5.2.4 Digital Imaging System (see 18.9).

5.3 Materials.

5.3.1 Sulfated fatty alcohols or wetting agent.

5.3.2 Phosphate buffer (pH 7)—A solution containing 5.9 g (0.21 oz) of sodium dihydrogen orthophosphate (anhydrous) and 8.0 g (0.28 oz) of disodium hydrogen orthophosphate (anhydrous) per 1000 mL (0.26 gal) of water. Distilled water is not essential but water having a hardness greater than 100 ppm (calculated as calcium carbonate) should not be used.

5.3.3 Soap, neutral chip (see 18.10).

5.3.4 Polyphosphate, sodium (see 18.11).

5.3.5 Ballast of 4.3 $\times$ 4.3 cm (11.0 $\times$ 11.0 in.) made of 18.25 tex continuous filament polyester, 2.2 mm (0.09 in.) stitch loop length plain knit (see 18.12). Each piece should weigh approximately 40 g (1.4 oz). The ballast should have rounded corners, have no loose ends, and must not unravel during the test. Alternate size ballast may be necessary to

achieve accurate load weight. Before use, ballast must be adjusted to pH 7 by soaking them in the buffer solution specified in 5.3.2.

5.3.6 Nonionic detergent. A synthetic detergent of the ethylene oxide alkyl phenol condensate type (see 18.13).

6. Test Specimens

6.1 Sampling and Preparation.

6.1.1 The preparation of test specimens will vary depending upon the type of fabric being tested.

6.1.2 Three specimens of each sample to be tested are required to increase the precision of the average.

6.1.3 Where possible, each specimen should contain different groups of lengthwise and widthwise yarns.

6.1.4 Fabrics that are badly distorted in their unlaundered state due to faulty finishing or other causes may give deceptive dimensional change results when laundered by any procedure. Therefore, it is recommended that in such cases the specimens be replaced or, if used, the results of the dimensional change test be considered as indicative only. Fabric condition should be reported.

6.1.5 Prior to marking, pre-condition and condition test specimens as directed in ASTM D 1776, Standard Practice for Conditioning and Testing Textiles. Condition each specimen for at least 4 h in an atmosphere of $21 \pm 1^\circ\text{C}$ ($70 \pm 2^\circ\text{F}$) and $65 \pm 2\%$ RH by laying each test specimen separately on a screen or perforated shelf of a conditioning rack.

6.2 Marking.

6.2.1 Woven and warp knit fabrics: Take each 38×38 cm (15×15 in.) test specimens and mark with three 25 cm (10 in.) pairs of bench marks parallel to the length of the fabric, and three 25 cm (10 in.) pairs of bench marks parallel to the width of the fabric. Each bench mark must be at least 5 cm (2 in.) from all edges of the test specimen. Pairs of bench marks in the same direction must be approximately 12 cm (5 in.) apart. Any alternate size specimen and bench marks used must be indicated in the report. Marks of 46 cm and 18 in. are commonly used to give better precision (see 18.14). Sewing thread can be used to make bench marks.

6.2.2 Flat and circular knit fabrics: Tubular finished knit fabric samples representing goods used in the tubular state; i.e., underwear, sweat shirts, polo shirts, etc., to be tested in the tubular state. Tubular finished knit fabric samples representing goods used in the slit open width state; i.e., dresses, slacks, suits, etc., are to be slit and handled flat. Mark specimens as in 6.2.1. For fabrics which will run or ladder, it is suggested that the edges be sewn with stitch type 505 (see 18.15).

6.3 Original Measurement.

6.3.1 To improve the accuracy and precision of the dimensional change calculations based on the bench marks applied to the fabrics in 6.2, measure and record the distance between each pair of bench marks with suitable tape or rule to the nearest millimeter, 0.1 in. or smaller increment. This is Measurement A.

6.3.2 Hosiery. The specimen is one sock. Make the original footlength measurement on a Schiefer Sock-Measuring Device. Place the conditioned sock over the metal form, align the heel gore by moving the pivoting clamp to the position by the limiting stop and tighten the clamp. Align the toe gore with the center of the toe form and draw the sock back smoothly. Press the pin on the indicator through the sock and the small hole in the top of the toe form and slowly apply the force of the weight to the sock. Using a tension of 2.268 kg (5.0 lb), read the footlength to the nearest 0.1 in. directly from the pin indicator against the scale. This is Measurement A.

7. Test Procedure: Relaxation Dimensional Change

7.1 Wetting Out. Half fill the tray with 0.1% solution of sulfated fatty alcohols (or other wetting agent) in water at $38 \pm 3^\circ\text{C}$ ($100 \pm 5^\circ\text{F}$). Submerge the marked specimens in the tray and allow them to soak for 4 h or overnight. The water temperature may be allowed to come to room temperature during the soaking period.

7.2 Hydro-extraction. With as little distortion as possible, remove the wet specimens from the tray in ball form and hydro-extract for 10 s at full speed.

7.3 Drying. Lay specimens flat, without blocking or distortion, on a drying rack. Allow specimen to dry in still air at room temperature or dry in an oven at $60 \pm 5^\circ\text{C}$ ($140 \pm 9^\circ\text{F}$). Do not press the specimens dry.

7.4 After drying, condition the specimens for at least 4 h by laying each specimen separately on the screen or perforated shelf of a conditioning rack at $21 \pm 1^\circ\text{C}$ ($70 \pm 2^\circ\text{F}$) and $65 \pm 2\%$ RH.

8. Measurement

8.1 Woven and knitted fabrics. After conditioning lay each test specimen without tension on a flat smooth, horizontal surface. Measure and record the distance between each pair of bench marks to the nearest millimeter, 0.1 in. or smaller increment. This is Measurement R. If using a scale marked in percent dimensional change, measure to nearest 0.5% or smaller and record the percent dimensional change directly.

8.2 Socks. Load and record specimen on the Schiefer Sock-Measuring Device as directed in 6.3.2.

9. Calculation

9.1 If measurements were made directly in percent relaxation dimensional change, average the measurements in each direction made for the three specimens. Calculate length and width averages separately to the nearest 0.1%.

9.2 If measurements were made to the nearest millimeter, 0.1 inch or smaller, calculate the percent relaxation dimensional change as follows:

% Relaxation Dimensional Change

$$= (R - A)/A \times 100$$

where:

A = Original dimension

R = Dimension after relaxation

Both original and final measurements are the averages of the measurements in each direction made on the three test specimens. Calculate length and width averages separately to nearest 0.1% (see 18.16).

9.3 A final measurement smaller than the original measurement is a negative dimensional change which is shrinkage. A final measurement larger than the original measurement results in a positive dimensional change which is growth or negative shrinkage.

10. Test Procedure: Consolidation Dimensional Change

10.1 Washing.

10.1.1 After determination of the relaxation dimensional change as described in Sections 7-9, prepare a 25.0 L (6.6 gal) phosphate buffer solution with a pH of 7.0 and containing 0.5% nonionic detergent. Add the solution to the washing machine.

10.1.2 Temperature of the total load at the beginning of the test shall be $40 \pm 3^\circ\text{C}$ ($105 \pm 5^\circ\text{F}$).

10.1.3 Add to the washing machine a load of 1.00 ± 0.02 kg (2.20 ± 0.04 lb) made up of specimens and ballast (see 5.2.5). No more than half of the load should contain specimens. If one specimen weighs more than 500.0 g (1.1 lb), the limitation regarding test load proportion does not apply.

10.1.4 Set the washing machine for a 5 min, delicate wash (see Table II, Test Method 135). Stop the machine after completion of the wash cycle.

10.2 Rinsing.

10.2.1 Remove each test specimen separately by folding the corners of each to the center in such a way that the whole specimen can be supported in the hand.

10.2.2 Rinse each specimen with as little agitation as possible in three successive baths of water at $40 \pm 3^\circ\text{C}$ ($105 \pm 5^\circ\text{F}$). Transfer each specimen from bath to bath giving one gentle squeeze to remove excess water.