Wrinkle Recovery of Woven Fabrics: Recovery Angle

Developed in 1951 by AATCC Committee RR6; jurisdiction transferred in 1995 to AATCC Committee RA61; revised 1952, 1953, 1956, 1959, 1998 (with title change); reaffirmed 1968, 1972, 1975, 1978, 1984, 1990, 2003; editorially revised 1986, 1991, 1995; reaffirmed and editorially revised 1996; Option 1, Partly equivalent to ISO 2313.

1. Purpose and Scope

1.1 This test method is used to determine the wrinkle recovery of woven fabrics. It is applicable to fabrics made from any fiber, or combination of fibers.

2. Principle

2.1 A test specimen is folded and compressed under controlled conditions of time and force to create a folded wrinkle. The test specimen is then suspended in a test instrument for a controlled recovery period, after which the recovery angle is recorded.

3. Terminology

3.1 **wrinkle recovery,** n.—that property of a fabric which enables it to recover from folding deformations.

4. Safety Precautions

NOTE: These safety precautions are for information purposes 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.

5. Uses and Limitations

5.1 Two options for performing wrinkle recovery angle testing are included in this test method. The Option 1 procedure is applicable to equipment commercially available and similar to devices used in ISO 2313: Determination of the Recovery from Creasing of a Horizontally Folded Specimen by Measuring the Angle of Recovery (see 13.1). The Option 2 procedure is for those laboratories that still have the older recovery devices which are no longer available from their original source.

5.2 This method has been used as a research tool and for production quality control (see 13.2).

5.3 Parameters to be controlled in the test are: relative humidity, temperature, applied pressure, time under pressure, and recovery time. This method specifies arbitrary selected values for the latter three factors, based on a compromise between conditions likely to be encountered in service, and the expeditious conduct of the test. Two conditions of temperature and relative humidity are specified as being representative of normal experience. For specialized purposes, it may be advisable to use other combinations of temperature and humidity.

5.4 Specimens from limp or heavy weight fabrics may twist or curl making angle readings difficult to determine (see 13.3).

6. Apparatus

6.1 Wrinkle Recovery Tester and accessories, Option 1 (see Fig. 1, 13.4 and 13.5).

6.1.1 Loading device with two flat plates (see Fig. 2).

6.1.2 Wrinkle Recovery Circular Scale divided into degrees over the range 10–180° (see Fig. 3).

Fig. 1—Option 1—Wrinkle Recovery Angle Tester and accessories.

6.1.3 Paper or aluminum foil not exceeding 0.04 mm thick.

6.2 Wrinkle Recovery Tester and accessories, Option 2 (see Fig. 4).

6.2.1 Disk and protractor with clamp mounted to the disk (see Fig. 4).

6.2.2 Specimen holder with two superimposed stainless steel leaves, 0.16 ± 0.01 mm thick, fastened together at one end. The top leaf is shorter than the bottom leaf.

6.2.3 Plastic press, consisting of two superimposed leaves 95 × 20 mm fastened together at one end. A 23 × 20 mm plastic section is attached to the outer surface of the free end of one leaf, flush with the outer edges that form a platform for a weight.

6.3 Tweezers with a jaw width of 25 mm and a line marked on both external faces 5 mm from the end and parallel to the jaw width (see Fig. 5). Another pair of tweezers, preferably plastic, is needed to handle specimens.

6.4 Clock or timer accurate to ± 1 s.

6.5 Template, 40 × 15 mm.

6.6 Weight, 500 ± 5 g.

6.7 Conditioning chamber suitable for the manipulation of the test specimen and the test apparatus that can produce atmospheres other than the standard atmosphere for testing textiles.

7. Test Specimens

7.1 Identify the face and back of the fabric sample. Avoid taking specimens from creased, wrinkled, or distorted sections of the sample.

7.2 Cut 12 specimens 40 × 15 mm, six with their long dimension parallel to the warp direction of the fabric and six with their long dimension parallel to the filling direction.

7.2.1 Cut warp specimens from sample locations with different warp yarns. Cut filling specimens from sample locations with different filling yarns (see Fig. 6). Unless otherwise specified, take specimens no nearer the selvage or edge of the fabric than one tenth the width of the fabric.

7.3 Mark the fabric face of each specimen.

7.4 Avoid handling or distorting the specimens. The use of a template or die for cutting the specimens and tweezers for handling them is recommended.

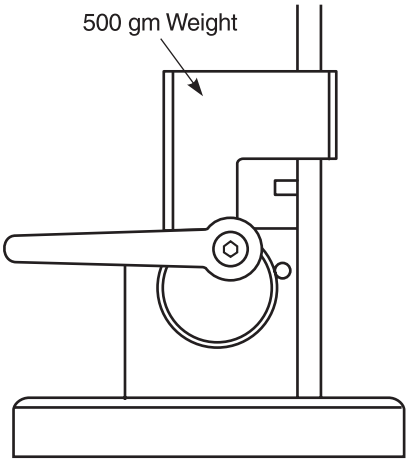

Fig. 2—Option 1—Loading device.

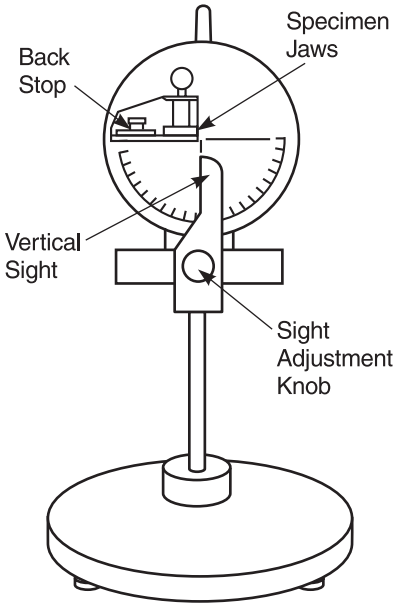

Fig. 3—Option 1—Wrinkle Recovery Angle Tester.

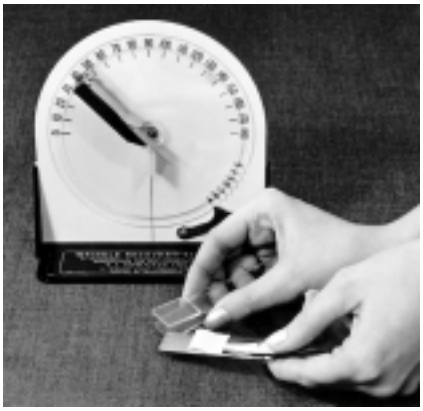

Fig. 4—Option 2—Wrinkle Recovery Tester and accessories

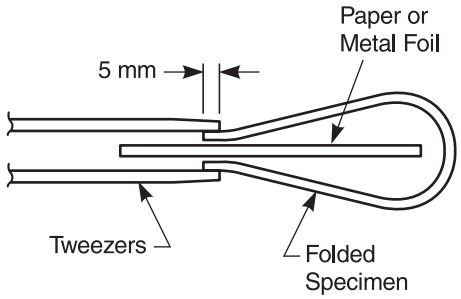

Fig. 5—Option 1—Folding of specimen.

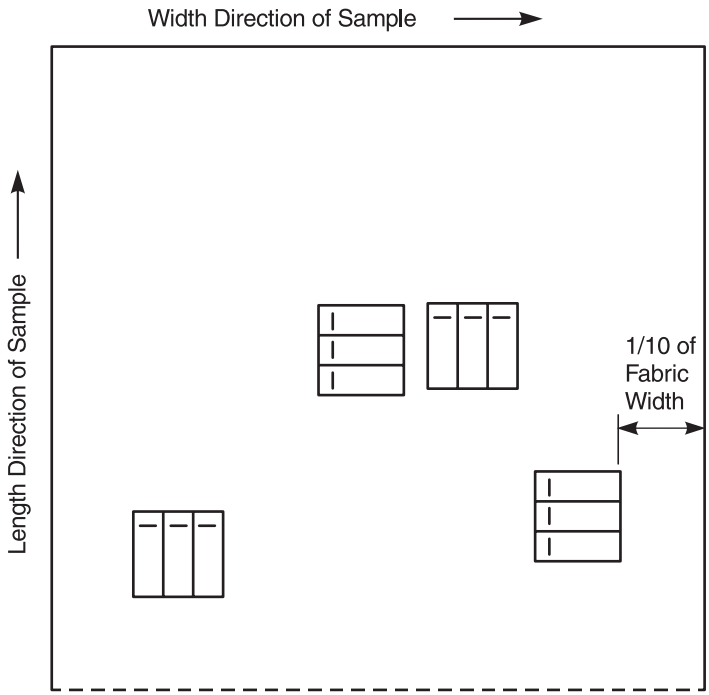

Fig. 6— Specimen sampling layout.

8. Conditioning

8.1 Lay specimens flat to condition at 65 ± 2% RH, 21 ± 1°C (70 ± 2°F) for at least 24 h prior to testing. Shorter conditioning periods which still allow attainment of equilibrium moisture content are acceptable.

8.2 If other atmospheres are used, they should be reported with the test results (see 11.3). For example, high humidity determinations may be made after conditioning samples at 35 ± 1°C (95 ± 2°F), 90 ± 2% RH for 24 h prior to testing.

9. Procedure

9.1 Option 1.

9.1.1 Three sets of loading devices, crease recovery scales and weights can be used to test three specimens sequentially, one after another every 60 s.

9.1.2 Fold a face-to-face specimen end-to-end and hold it in this position with tweezers, gripping no more than 5 mm from the ends. In instances where the surfaces of the specimens show a tendency to stick together, place a piece of paper or aluminum foil, 18 × 14 mm, between the ends of the specimen (see Fig. 5). Avoid touching the specimen with anything other than the tweezers.

9.1.3 Place the folded specimen between the two leaves of the loading device and immediately apply the weight. Start a timing device. Wait 60 ± 2 s to repeat steps 9.1.2 and 9.1.3 for the next specimen. Wait another 60 ± 2 s to start the third specimen's load timing.

9.1.4 After 5 min ± 5 s, quickly but smoothly, remove the weight from the first specimen so that the specimen press does not spring open.

9.1.5 Using tweezers, transfer the folded specimen to the instrument's circular scale specimen holder. If paper or foil was used, remove it at this time. In-

sert one end of the specimen between the clamp on the specimen holder, leaving the other end to hang freely. Avoid disturbing the folded formation by placing the specimen no farther into the clamp than the back stop. Start timing the recovery period. Wait 60 ± 2 s, sequentially, to load the second and third specimens in holders.

9.1.6 While the specimen is in the holder, adjust the instrument to keep the free hanging end of the specimen in alignment with the vertical mark. Frequent adjustment during the 5 min time period is necessary to avoid gravitational effects.

9.1.7 Read and record the recovery angle from the circular scale 5 min ± 5 s after inserting a specimen into a clamp. If the free end of the specimen twists, sight a vertical plane through its center and align it with the vertical mark on the circular scale. Read and record the recovery angle for each specimen after 5 min ± 5 s after inserting it into a clamp.

9.1.8 Repeat all steps for three specimens in the opposite direction and for specimens to be folded face-to-back in both fabric directions.

9.2 Option 2.

9.2.1 Using tweezers, place a specimen between the leaves of the metal holder with one end aligned under the 18 mm mark. With the tweezers, lift the free end of the specimen up and over to the 18 mm mark taking care to loop back rather than flatten the specimen. Hold the edge of the specimen firmly in place with a thumbnail.

9.2.2 Still holding the specimen end with a thumbnail, open the jaws of a plastic press with the other hand. Insert the holder with the specimen between the long and short jaws, releasing the thumbnail when bringing the end edge of the long jaw into contact with the specimen. The 18 mm mark on the metal holder, the unfolded end of the specimen, and the end edge of the plastic press are to be aligned before releasing the specimen. A fold should be formed 1.5 mm from the end of the short metal leaf. The plastic press should be in firm contact with the folded specimen but should not be squeezed.

9.2.3 Invert the press-holder combination on a flat surface with the small platform up. Gently apply a weight to the platform. Start a timing device. Repeat steps 9.2.1 through 9.2.3 for a second specimen after 60 ± 2 s has lapsed. After 60 ± 2 additional s, repeat all steps for the third specimen.

9.2.4 After 5 min ± 5 s, remove the weight. Pick up the press-holder combination by the plastic press and insert the exposed end of the specimen holder in the clip mount on the face of the recorder device. Open the jaws and remove the press rapidly taking care to avoid rolling the exposed end of the specimen or pulling it out of the holder.

9.2.4.1 Align the holder with the front edge of the clip mount shelf. The specimen fold should line up with the spot at the center of the recorder disk leaving the free hanging leg of the specimen aligned with the vertical guide line on the scale. Take special care to not touch, blow on or jam the specimen against the face of the recorder. Perform all operations as rapidly as possible. Repeat steps 9.2.4 and 9.2.4.1 for the second specimen, starting 60 ± 2 s after the weight is removed from the first specimen. Repeat all steps for the third specimen, 60 ± 2 s after the weight was removed from the second specimen.

9.2.4.2 To eliminate gravitational effects, keep the free hanging leg of the specimen aligned with the recorder's vertical guide line during the 5 min ± 5 s recovery period. Adjust every 15 ± 1 s for the first minute, and once a minute thereafter during the remaining recovery period. Make the final adjustment 15 ± 1 s before the 5 min ± 5 s recovery period ends. A procedure to run continuous specimen testing is given in 13.6.

9.2.5 Read and record the recovery angle from the scale 5 min ± 5 s after inserting a specimen into the clip mount on the recorder. If the free end of a specimen twists, sight a vertical plane through its center and align it with the vertical mark on the recorder scale. Read and record the recovery angle for each specimen after it has been inserted in the clip mount for 5 min ± 5 s.

9.2.6 Repeat all steps for three specimens in the opposite direction and for specimens folded face-to-back in both fabric directions.

10. Calculation

10.1 Calculate the average recovery in degrees for each group of three specimens; warp folded face-to-face; warp folded back-to-back; filling folded face-to-face; and filling folded back-to-back.

10.2 If the difference between face-to-face and back-to-back averages is not greater than 15°, average all warp readings and all filling readings separately. If the difference between face-to-face and back-to-back averages is greater than 15°, report the four averages separately.

11. Report

11.1 State that the tests were performed as directed in AATCC Method 66, Option 1 or Option 2.

11.2 Report the average warp and filling (or when necessary warp-face, warp-back, filling-face and filling-back) recovery angles.

11.3 If other testing atmospheres are used, report the conditions under which the test was performed with the average values.

12. Precision and Bias

12.1 *Precision.*

12.1.1 In 1996, a single laboratory study was run comparing Option 1 to Option 2. Five face-to-face determinations were made for warp and filling specimens for six fabrics. The study showed either option to give similar and satisfactory test results.

12.1.2 Using this study as a basis, a provisional *within-laboratory* precision statement is included for guidance of users of the test method. The range of variance values for the data set was 1 to 58 (degree squared) for warp specimens and 1 to 21 for filling specimens. Users of the method should use standard statistical techniques in making any comparisons of either *within-laboratory* or *between-laboratory* averages.

12.1.3 Provisional *within-laboratory* precision (see Table I).

12.1.4 An ISO interlaboratory was performed in 1988 (see 13.7).

12.2 *Bias.*

12.2.1 Wrinkle recovery angle can be defined only in terms of a test method. There is no independent referee method for determining the true value of this property. This method has no known bias.

13. Notes

13.1 ISO 2313: Determination of the Recovery from Creasing of a Horizontally Folded Specimen by Measuring the Angle Recovery, may be obtained from ANSI, 11 West 42nd St., New York NY 10036; tel: 212/302-1286; fax: 212/398-0023, or ISO.

13.2 AATCC Method 66 interlaboratory test results using the original crease recovery angle devices showed significant differences in *between-laboratory* precision, but good *within-laboratory* precision. The method,

Table I—Precision Factors (95%)

	Option 1		Option 2	
	Warp	Filling	Warp	Filling
Avg of Error Variance	6.08	6.27	17.85	4.80
Standard Deviation	2.47	2.50	4.22	2.19
Critical Differences @ 3/Det/Avg	5.6	5.7	9.6	5.0
Critical Differences @ 6 Det/Avg	3.2	3.2	5.4	2.8

however, cannot be recommended for acceptance testing.

13.3 Most specimens will have a straight, free hanging leg. When the free hanging specimen leg is not straight, alignment problems may cause angle reading difficulty. If a specimen's free leg twists, align the center of the bottom edge of the specimen with the vertical guide line on the tester. If a specimen curls, align the section of the free hanging leg closest to the crease angle with the vertical guide line on the tester.

13.4 Available from Advanced Testing Instruments Corp., 316D Business Pkwy, Greer SC 29651-7119; tel: 864/989-0566; fax: 864/989-0567; e-mail: aticorporation@cs.com. The James H. Heal instrument is called a Crease Recovery Angle Tester but is referred to in TM 66 as the Wrinkle Recovery Tester.

13.5 The instrument manufacturer supplies the apparatus with weights and specimens templates for ISO 2313. Available from ANSI, 11 West 42nd St., New York NY 10036; tel: 212/302-1286; fax: 212/398-0023.

13.6 Practical Procedure for Option 2 Multiple Specimen Testing. This procedure requires six testers, six weights, 12 plastic presses, 18 specimen holders and one timer. The test run consists of running six specimens concurrently on cycles staggered at 7 min intervals.

13.6.1 After six specimens have been mounted in the press-holder combinations, the first cycle is started by placing weights on all six presses within 5 s. The weights are removed 5 min later in the same order, so that the folding time is the same for all specimens. The specimens are then placed in the clips on recorders as rapidly as possible. The specimens are to be adjusted and read in the same order so that the recovery time will be 5 min for each specimen. One minute after starting to remove the weights and inserting holders into recorders, place weights on the next set of holder press combinations. Start timing with the weight load application. This procedure requires a continuously running clock or timer.

13.6.1.1 Differential times among specimens occur between the folding and the recovery period when specimens are in the plastic presses without load. The differential was found not to have appreciable effect on test results, in that, the specimens held in holders without load are not free to recover.

13.6.2 Each set of six specimens follows the preceding one by 7 min, the creasing period being started (load application) at 0, 7, 14, etc. min. Continuous operation by this technique will yield 51 readings per h.

13.7 In the spring of 1988, 11 laboratories agreed to participate in an interlaboratory trial to determine the reproducibility of this method. Data was received from nine of the laboratories located in Belgium, South Africa, Sweden, the United Kingdom and five laboratories in the United States.

The *within-laboratory* variability demonstrated in this study is negligible and, while there is more variability between laboratories, that variability is within statistical control. From the data presented, it can be concluded that this test method does provide a test procedure which will allow laboratories to compare the wrinkle behavior of fabrics in a reproducible manner.

The full study containing all raw data is available from the secretariat of ISO/TC 38/SC2 (ANSI) upon request.