Drying Rate of Textiles at their Absorbent Capacity: Air Flow Method

Developed in 2012 by AATCC Committee RA63; reaffirmed 2013.

Foreword

As moisture management products have entered the marketplace, measurement of the drying characteristics of textiles has gained additional importance. The 2008 AATCC-ASTM International *Moisture Management Technical Supplement: Applicable to Apparel, Linens, and Soft Goods* contains three techniques for the measurement of drying times of textiles. This test method is an additional approach to the drying test methods outlined in the *Technical Supplement.*

1. Purpose and Scope

1.1 This test method determines the drying rate of textiles at their absorbent capacity.

1.2 This method is not for testing the drying rate for textiles taken from socks or hosiery.

2. Principle

2.1 This method determines the drying rate of textiles based on the evaporation rate that occurs at their approximate absorbent capacity.

3. Terminology

3.1 **absorbent capacity,** n.—the maximum amount of liquid a material can hold; dependent on the specific test method used.

3.2 **drying rate,** n.—the change in volume per unit time a liquid evaporates from a textile.

NOTE: Drying rate is dependent upon textile construction, fiber content, apparel construction, finishes, the atmosphere in which the test is performed, and the volume challenge of the liquid.

3.3 **drying time,** n.—the time it takes for a specified amount of liquid to evaporate from a textile under controlled testing conditions.

NOTE: In this test method a series of different amounts of water are used to challenge the specimen. The testing conditions are controlled by the analyzer and room conditions.

3.4 **end time,** n.—the time at which the temperature goes through an inflection between the steepest slope and the flat sections of the temperature versus time plot (see Fig. 2 and 11.2).

3.5 **start time,** n.—the time at which the water challenge is added to the specimen.

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 materials 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 The manufacturer's safety recommendations should be followed when operating laboratory testing equipment.

5. Uses and Limitations

5.1 This test is performed under controlled laboratory temperature and relative humidity conditions.

5.2 In order to provide consistent results, consistent air flow is needed. The apparatus used in this method uses 2.5 ± 0.5 m/s air flow through a 13 ± 0.1 cm diameter opening with no specimen present. The results will vary if other rates of air flow are used. While the test may be performed at alternative conditions, for comparison of results, the same conditions must be used.

5.3 This method is limited to textiles—tested on the non-face side—that exhibit a maximum absorbency time of 30 ± 2 s as measured by AATCC TM 79, Absorbency of Textiles (see 14.1). It is not applicable to textiles that exhibit absorbency of more than 30 ± 2 s.

6. Apparatus and Materials

6.1 Temperature recorder, with capabilities to take readings every 1 s, data storage and transmittal to computer data file (see Fig. 1).

6.2 Infrared thermocouple probe—temperature range of 15.0-50.0 ± 0.1°C (59.0-122.0 ± 0.18°F) (see Fig. 1).

6.3 Fan box (16.5 ± 0.1 × 16.5 ± 0.1 × 27.5 ± 0.1 cm) which generates 2.5 ± 0.5 m/s of air flow through a 13.0 ± 0.1 cm diameter opening (see Fig. 1).

6.4 Pipette gravimetric feed (0.010 to 1.000 ± 0.003 mL) (see Fig. 1).

6.5 Paper towels, 5 × 14 cm, a color that will exhibit a color change when wet (light blue preferred) (see Fig. 1).

6.6 Anemometer—hot wire-type, capable of measuring air flow from 0.1 to 5.0 ± 0.1 m/s (see Fig. 1).

6.7 Embroidery hoop (see 14.1).

6.8 Deionized or distilled water.

7. Sampling

7.1 Take rolls representative of a lot sample. If testing a textile from end items, take three items from each lot.

8. Test Specimens

8.1 From each textile sample, cut three specimens (15.0 × 15.0 ± 0.5 cm) from right, center, and left locations across the sample width for each test.

8.2 If testing garments or end-products, take specimens from different sections of the garment; i.e., sleeve, back and front.

9. Conditioning

9.1 Prior to testing, condition test specimens as directed in ASTM D1776, Standard Practice for Conditioning and Testing Textiles (see 14.2). Condition the specimens for at least 4 h in an atmosphere of 21 ± 1°C (70 ± 2°F), 65 ± 2% RH, by laying each specimen separately on a screen or perforated shelf of a conditioning rack.

9.2 Perform all tests in the standard atmosphere for testing.

10. Procedure

10.1 Mount the specimen on the hoop (see 6.7) using a minimal amount of tension to prevent stretching of the specimen. The specimen should not sag in the middle of the hoop. Mount the textile face down.

10.2 Using AATCC TM 79 (see 14.1), place a drop of water on the specimen and determine the absorbency. If the absorbency is less than 30 ± 2 s then proceed with the test. If greater than 30 ± 2 s, then stop test. Textiles with an absorbency time greater than 30 ± 2 s cannot be tested with this method. Allow the specimen to dry for 5 min with the fan turned on, then turn the fan off.

10.3 Insert the water detecting tray with a blue paper towel into the fan assembly.

10.4 Turn on the fan.

10.5 After 5 min measure the tem-

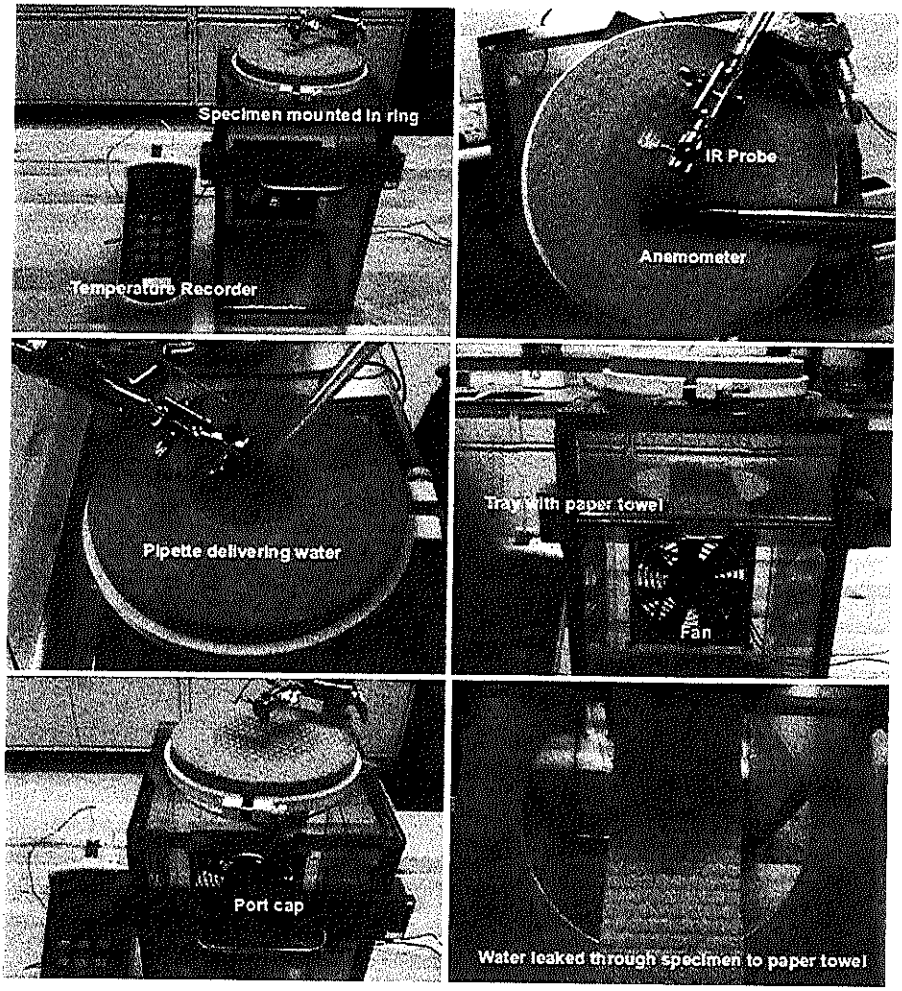

Fig. 1—Different views of the apparatus used to perform test.

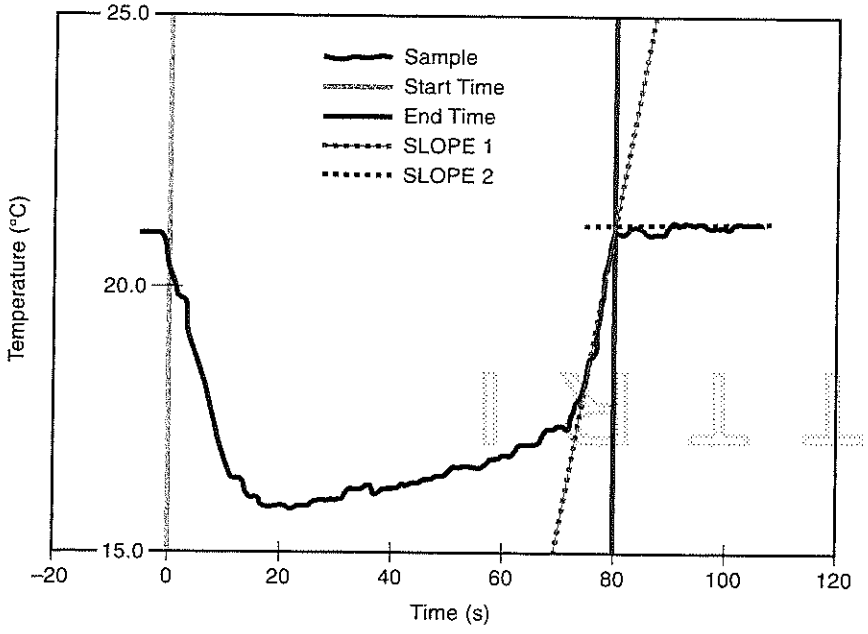

Fig. 2—Plot of temperature versus time.

perature of the textile. This temperature is the dry, equilibrated temperature of the textile.

10.6 Dispense 0.100 ± 0.003 mL of water onto the top of the specimen. Observe if any water passed through the specimen onto the paper towel.

10.7 If the paper towel is wet, allow the specimen to dry. Replace the wet paper towel in the tray with a new paper towel. Reduce the volume in the pipette by 10%, and repeat 10.6. If water did not leak, let the sample dry, then increase the volume by 0.100 mL and test again. Repeat until the absorbent capacity can be estimated (as defined in 10.8).

NOTE: The delivery rate of the water is important. To keep a constant delivery rate a gravimetric feed pipette is used to deliver the water. Deliver the water by touching the pipette to the textile.

10.8 The maximum volume of water that is absorbed by the textile without passing through and wetting the paper towel is equivalent to the absorbent capacity (V_m) for this method.

10.9 Position the IR thermocouple probe in the middle of the specimen 1 cm above the surface.

10.10 Remove the water detection tray. Close port to the shelf.

10.11 Let the specimen dry by waiting for the temperature to return to the value determined in 10.5.

10.12 Place the anemometer probe above and near the center of the specimen. Record air speed through the specimen.

10.13 Select the maximum amount of water to be at least 10% less than V_m. Select four additional volumes of water at approximately 10%, 25%, 50%, and 75% of the maximum amount. For example, a textile with a V_m = 0.470 mL the volumes would be 0.050, 0.100, 0.200, 0.300, and 0.400 ± 0.001 mL.

10.14 Start the testing process by recording temperature data and delivering the first of a series of increasing volumes of water on the specimen in the area of the IR thermocouple probe view.

10.15 Record data every second until the temperature returns to the starting temperature.

10.16 Repeat 10.11-10.15 for each of the other four selected volumes of water.

11. Calculation and Evaluation

11.1 View the data on the recorder or plot the temperature versus time data using a spreadsheet program for each of the three specimens.

11.2 Determine the start and end times on the graph. The start time is when the water is added to the specimen (Time 0 in Fig. 2). The end time is the time at the intersection of the section with the steepest slope and the flat section of the

temperature plot. To determine this intersection time value two linear fits are required. Generate a linear fit for the steepest section of the plot by choosing seven data points within the steepest portion of the plot (Slope 1 in Fig. 2). Generate a linear fit for the flat section of temperature plot by choosing 25 data points after the inflection in the temperature plot (Slope 2 in Fig. 2). The end time is the intersection of the two linear lines. The drying time is the difference of the end time and start time.

11.3 Calculate the drying rate (***R***), using formula 1:

$$R = V/Drying\ Time \quad (1)$$

where:

R = drying rate, in mL/h

V = volume of water used in the test, in mL

Drying Time = End time – Start Time, convert seconds to hours

Example: ***R*** = 0.100 (mL)/0.022 (h) = 4.5 mL/h

11.4 Plot R_i(mL/h) versus V_i(mL) (see Fig. 3) where ***i*** represents each volume challenge.

11.5 Fit the plot of ***R*** versus ***V*** to Equation 2 using a non-linear least squares fitting algorithm:

$$R = a[1\text{-}\exp(-bV)] \quad (2)$$

where:

R = Drying Rate, in mL/h

V = volume of water used, in mL

a and ***b*** = fitting constants

11.6 The fit yields constants ***a*** and ***b***. The fit for Fig. 3 is ***a*** = 11.9 mL/h and ***b*** = 4.7 mL^{-1}.

11.7 The drying rate at the absorbent capacity (R_{max}) is ***a***. In Fig. 3 R_{max} is 12 mL/h.

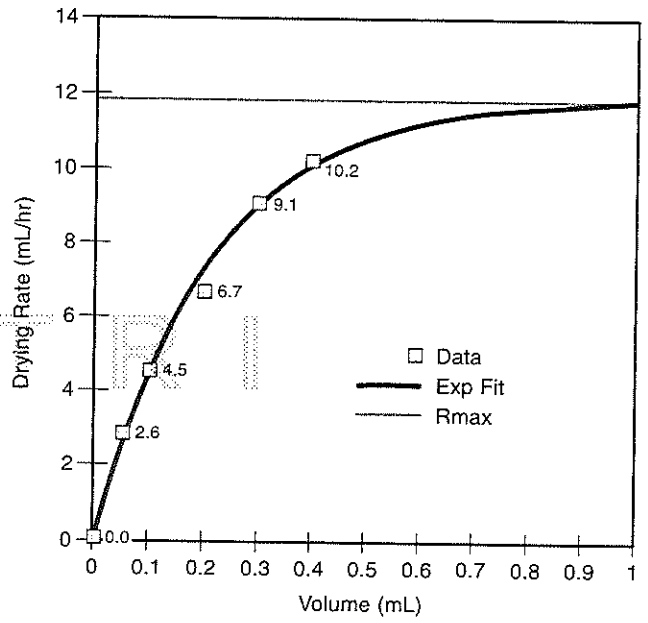

Fig. 3—Plot of drying rate versus challenge volume.

12. Report

12.1 Report the drying rate at each volume and the absorbent capacity for each textile. Determine an average and standard deviation for R_{max} for each textile along with the linear flow rate of air through the textile.

13. Precision and Bias

13.1 *Precision.*

13.1.1 A one-lab precision study was run in 2011 in which four different textiles were tested over two days using two operators. ASTM E691-99, Standard Practice for Conditioning an Interlaboratory Study to Determine the Precision of a Test Method, (see 14.2) was followed for the design and analysis of the data. The data and analysis are being retained in the RA63 committee files. Table 1 contains the textiles tested, the average of averages (x), the standard deviation of averages (s_x), the repeat-ability standard deviation (s_r), and the 95% confidence repeatability limit (r).

13.1.2 *Between laboratory* precision has not been established for this test method. Until such precision information is available, users of the method should use standard statistical techniques in making any comparison of test results for *between-laboratory* averages.

13.2 Bias. The drying rate can be defined only in terms of a test method. There is no independent method for determining the true value. As a means of estimating this property, the method has no known bias.

14. Notes

14.1 Available from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: +1.919.549.8141; fax: +1.919.549.8933; e-mail: orders@aatcc.org; web site: www.aatcc.org.

14.2 Available from ASTM International, 100 Barr Harbor Dr., W. Conshohocken PA 19428; tel: +1.610.832.9500; fax: +1.610.832.9555; web site: www.astm.org.

Table I—Precision

Sample	Drying Rate Airflow (mL/h) $\bar{x}$	$s_{\bar{x}}$	s_r	r
Woven, 40% polyester, 60% cotton 145 g/m²	4.8	0.35	0.43	1.39
Knit, 100% polyester, 150 g/m²	20.4	0.52	0.83	2.38
Knit, 70% cotton, 30% polyester, 175 g/m²	9.7	0.21	0.32	0.95
Fleece, 100% polyester, 136 g/m²	5.9	0.30	0.28	1.06