Drying Rate of Fabrics: Heated Plate 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 fabrics has gained additional importance. The 2008 AATCC-ASTM International's *Moisture Management Technical Supplement: Applicable to Apparel, Linens, and Soft Goods*, contains three techniques for the measurement of drying times of fabrics. This test method is an additional approach to the drying test methods in the *Technical Supplement*.

1. Purpose and Scope

1.1 This test method determines the drying rate of a fabric, exposed to a prescribed volume of water, while in contact with a heated plate set at 37°C (99°F), the skin surface temperature at which the human body starts to perspire.

1.2 This method is applicable to all types of fabrics, including knits, wovens, and non-wovens, as well as to fabrics taken from end product items.

2. Principle

2.1 This method determines the drying rate of a fabric based on the evaporative rate that occurs when the fabric is placed in contact with a prescribed amount of water at the interface of a heated metal plate, held to a constant temperature.

3. Terminology

3.1 **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 atmospheres in which the test is performed, and the volume challenge of the liquid.

3.2 **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 the amount of water is constant between tests. The testing conditions are controlled by the analyzer and the room.

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

3.4 **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. While the test may be performed at alternative conditions, for comparison of results, the same conditions must be used.

5.2 This test is performed with a set amount of water. While different amounts of water may be used, care should be taken to ensure that the water does not wick to the edge of the test specimen. If water migrates to the edge of the sample, then it is necessary to increase the specimen size or reduce the volume and repeat the test with a new specimen. Further, when comparing results, tests must be conducted with the same amount of water.

5.3 The drying rates of fabrics with a membrane in its structure can be tested using this method as long as the moisture vapor transmission rate of the fabric is greater than 5,000 g/m^2/day (see 14.1 of JIS L 1099, Method B1,) to allow for detection of water evaporation. Multi-layered composite fabrics can also be tested using this method.

5.4 When testing fabric in socks, the socks should be cut open and the inner portion of the sock placed in contact with the heated plate, to simulate contact of fabric with human skin.

6. Apparatus and Materials

6.1 Drying rate test apparatus (see Fig. 1).

6.2 Temperature recorder—with capabilities to take readings every 1 s, data storage, and transmittal to computer data file.

6.3 IR thermocouple probe—temperature range of 15.0-50.0 ± 0.1°C (59.0-122.0 ± 0.18°F).

6.4 Fan box – production of 1.5 ± 0.5 m/s air flow across the width of the hot plate, measured directly behind the IR thermocouple probe.

6.5 Metal plate—30.5 × 30.5 ± 0.5 cm.

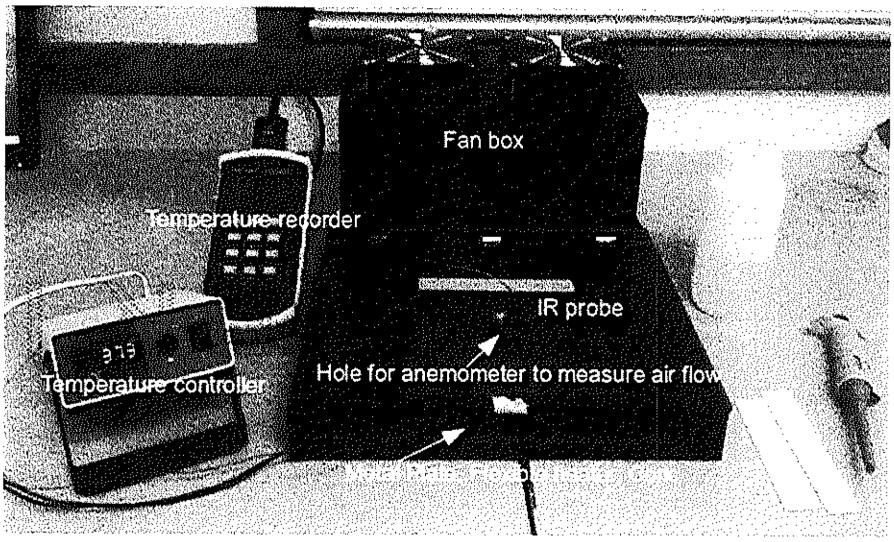

Fig. 1—Test apparatus.

6.6 Flexible heater—30.5 × 30.5 ± 0.5 cm with controller to maintain temperature of 37 ± 1°C (98 ± 2°F).

6.7 Cork board for insulation—30.5 × 30.5 ± 0.5 cm.

6.8 Micropipette, adjustable volume, 0.100-1.000 ± 0.003 mL.

6.9 Anemometer—hot wire-type, capable of measuring air flow from 0.5-2.5 ± 0.1 m/s.

6.10 Magnetic, plastic or metal strip, 15.0 cm long, 4.0 ± 2.0 cm wide, 0.2 ± 0.1 cm thick, can be used to hold the specimen in place.

6.11 Deionized or distilled water.

7. Sampling

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

8. Test Specimens

8.1 From each fabric 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.

8.3 If testing socks or hosiery, slit the specimen lengthwise and test each unique construction area. If the specimen is less than the desired size, then monitor the water migration closely. If water migrates to the edge of the sample, then it is necessary to reduce the volume and repeat the test with a new specimen.

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 Turn on the temperature controller for the flexible heater and fan to let the metal plate temperature stabilize to 37 ± 1°C (99 ± 2°F).

10.2 Use a hot wire anemometer to verify the air flow across the plate is 1.5 ± 0.5 m/s. Measure the air flow directly behind the IR thermocouple probe.

10.3 Place a test specimen on the metal plate for five minutes to allow the specimen to equilibrate to the metal plate temperature with the side of the specimen intended to be next to the skin placed against the metal plate surface. Use a strip to hold the top edge of the specimen, the one closest to the air fan to the metal plate surface.

10.4 Position the IR thermocouple probe in the middle of the specimen 1.0 ± 0.1 cm above the specimen. It is helpful to have a mark on the metal plate which is centered to the field of view of the IR thermocouple probe.

10.5 Start the recorder, lift the free end of the specimen (the opposite side of the magnetic strip) and apply 0.200 ± 0.003 mL of water on the plate below the specimen directly under the IR thermocouple probe. Reposition the specimen so the specimen covers the water drop. The start time is when the specimen comes in contact with the water.

10.6 View the specimen to determine the wicking profile generated by the water. Verify that the water did not wick to the edge of the specimen. If the water does wick to an edge of the sample then use a larger specimen or reduce the volume.

10.7 Collect and record the temperature every second until temperature returns to the initial temperature. Repeat the test on the additional specimens.

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

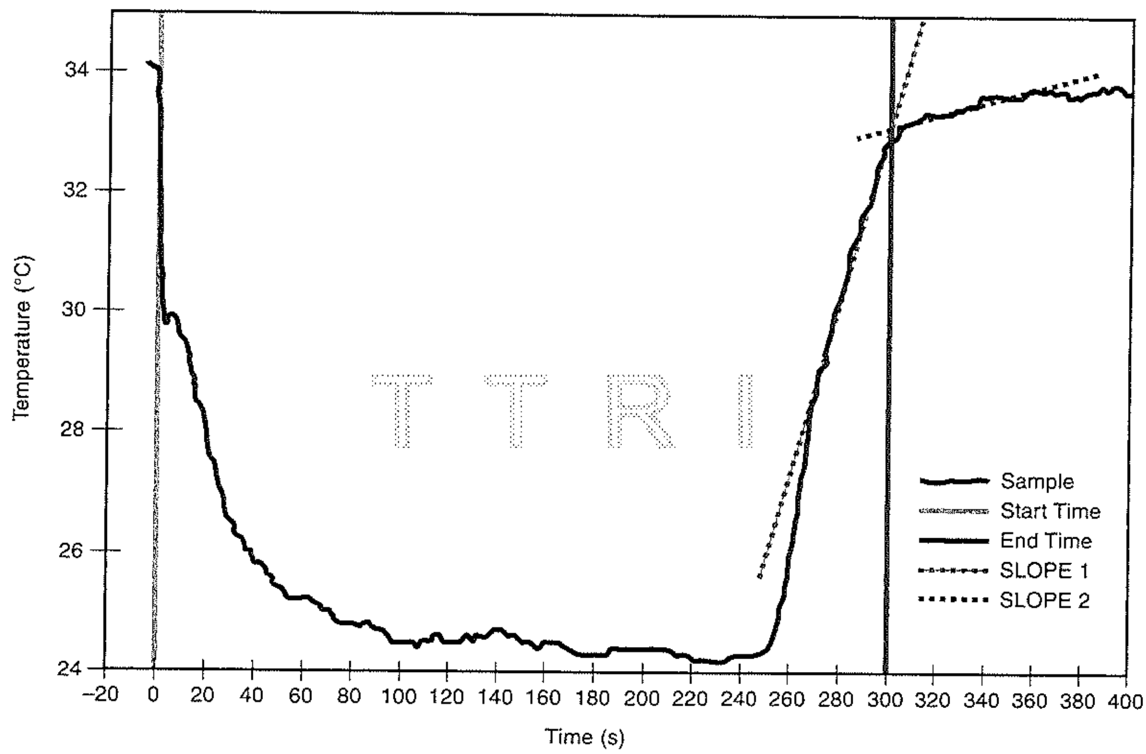

Fig. 2—Plot of temperature versus time to determine dry time.

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 Average the drying time of the three specimens.

11.4 Calculate the drying rate (***R***), using the following equation:

$$R = V / \textit{Drying Time}$$

where:

R = drying rate, in mL/h

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

Drying Time = End time – Start Time, in hours

Example: ***R*** = 0.200 (mL)/0.0836 (h) = 2.39 mL/h

11.5 Average the three values for each sample.

12. Report

12.1 Report the individual and average drying rates for each fabric stating the water volume used. When comparing data, laboratory temperature, laboratory relative humidity, instrument air flow, and the water volume must be the same.

13. Precision and Bias

13.1 *Precision.*

13.1.1 An internal laboratory test was run in 2010 in which five different fabrics were tested in one laboratory over two days using two operators using a 0.200 ± 0.003 mL water challenge. The analysis of variance technique was applied to the data set. The analysis is being retained in the RA63 committee files. The number of tests (n), mean average (Mean), 95% confidence interval (95% CI), standard error (SE), and standard deviation (SD) are shown in Table I.

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 Japanese Industrial Standards (JIS) may be obtained through web site: www.jsa.or.jp.

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—Analysis of Variance

Drying Rate by Fabric (mL/hr @ 0.2 mL challenge)	n	Mean	95% CI	SE	SD
40% polyester, 60% cotton woven (145 g/m²)	12	1.83	± 0.16	0.07	0.25
100% polyester double knit (150 g/m²)	12	1.93	± 0.07	0.03	0.11
100% cotton jersey knit (230 g/m²)	12	0.84	± 0.05	0.02	0.08
100% polyester fleece, (136 g/m²)	12	1.34	± 0.07	0.03	0.11
Sock—38% polyester, 25% cotton, 25% nylon, 12% spandex	12	0.66	± 0.04	0.02	0.07