Test Method for Weather Resistance of Textiles: Exposure to Daylight and Weather

Developed in 1996 by AATCC Committee RA64 to supersede 111A-1990, 111B-1990, 111C-1990 and 111D-1990 originally developed in 1964 and last revised/reaffirmed in 1990; jurisdiction transferred in 2007 to Committee RA50; revised 2003 (with title change), 2015; editorially revised 2007, 2008, 2016, 2019; reaffirmed and editorially revised 2009.

1. Purpose and Scope

1.1 This test method provides a means for determining the weather resistance of textile materials.

1.2 The test options described below are applicable to fibers, yarns and fabrics and products made therefrom, including coated fabrics, whether natural, colored, finished or unfinished. Test options included are:

Option A—Direct Exposure to Natural Light and Weather

Option B—Behind Glass Exposure to Natural Light and Weather without Direct Wetting

1.3 Outdoor testing as described under this method must be performed to verify accelerated laboratory testing. It is up to interested parties to determine frequency and scope of outdoor testing. Refer to AATCC TM169, Test Method for Weather Resistance of Textiles: Xenon Lamp Exposures, and AATCC TM186, Test Method for Weather Resistance: UV Light and Moisture Exposure, for information on the limitations of accelerated laboratory testing.

1.4 This test method contains the following sections that assist in the use and implementation of the various options for determining the weather resistance of textiles.

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2. Principle

2.1 Test specimens and the agreed upon comparison standard(s) are exposed simultaneously to natural weathering, either Directly or Behind Window Glass, either to a specified degree of degradation such as color change, strength loss, etc., or alternately to a specific amount of radiant energy. Exposures can be timed by calendar days, months, or years as well. However, this method can result in more variation when comparing test exposures for equal duration at different time periods. The weather resistance of the material is determined by the exposed portion of the test specimens to an unexposed counterpart, using one or more of the procedures recommended in this test method.

3. Terminology

3.1 **AATCC Blue Wool Lightfastness Standard,** n.—one of a group of dyed wool fabrics distributed by AATCC for use in determining the amount of light exposure of specimens during lightfastness testing.

3.2 **black panel thermometer,** n.—a temperature measuring device, the sensing unit of which is coated with black designed to absorb most of the radiant energy encountered in lightfastness testing.

3.3 **breaking strength,** n.—the maximum force applied to a specimen in a tensile test carried to rupture.

3.4 **broad bandpass radiometer,** n.—a relative term applied to radiometers that have a bandpass width of more than 20 nm at 50% of maximum transmittance and can be used to measure irradiance at wavelengths such as 300-400 nm or 300-800 nm.

3.5 **bursting strength,** n.—the force or pressure required to rupture a textile by distending it with a force applied at right angles to the plane of the fabric, under specified conditions.

3.6 **center wavelength,** n.—the specified wavelength midway between the half power points, for example, 340 nm ± 2 nm.

3.7 **color change,** n.—*as used in colorfastness testing*, a change in color of any kind whether in lightness, hue or chroma or any combination of these, discernible by comparing the test specimen with a corresponding untested specimen.

3.8 **half-power bandpass,** n.—the interval between wavelengths at which transmittance is 50% of peak transmittance in a bandpass filter.

NOTE: The interval should not exceed 20 nm for a narrow bandpass filter.

3.9 **irradiance,** n.—radiant power per unit area as a function of wavelength expressed as watts per square meter, W/m^2.

3.10 **irradiation,** n.—the time integral of irradiance expressed in joules per square meter (J/m^2).

3.11 **laboratory sample,** n.—a portion of material taken to represent the lot sample, or the original material, and used in the laboratory as a source of test specimens.

3.12 **narrow bandpass radiometer,** n.—a relative term applied to radiometers that have a bandpass width of 20 nm or less at 50% of maximum transmittance and can be used to measure irradiance at wavelengths such as 340 or 420, ± 0.5 nm.

3.13 **pyranometer,** n.—a radiometer used to measure the global solar irradiance or if inclined, hemispherical solar irradiance.

3.14 **radiant energy,** n.—energy traveling through space in the of photons or electromagnetic waves of various lengths.

3.15 **radiant exposure,** n.—time integral of irradiance.

3.16 **radiant flux density,** n.—rate of flow of radiant energy past the specimen.

3.17 **radiant power,** n. energy per unit time, emitted, transferred or received as radiation.

3.18 **radiometer,** n.—an instrument used to measure radiant energy.

3.19 **reference fabric,** n.—one or more blue wool lightfastness standards selected for exposure as a check on a test apparatus and operating conditions.

3.20 **specimen,** n.—a specific portion of a material or a laboratory sample upon which a test is performed or which is selected for that purpose.

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3.21 **spectral energy distribution,** n.—the variation of energy due to the source over the wavelength span of the emitted radiation.

3.22 **spectral transmittance,** n.—the percent of incident radiant energy passing through a given material and not absorbed in the process, as a function of wavelength.

3.23 **standard atmosphere for testing textiles,** n.—air maintained at 21 ± 2°C (70 ± 4°F) and 65 ± 5% relative humidity.

3.24 **standard atmosphere for storing textiles,** n.—laboratory conditions maintained as required in ASTM D1776.

3.25 **tearing strength,** n.—the average force required to continue a tear previously started in a fabric.

3.26 **ultraviolet radiation,** n.—radiant energy for which the wavelengths of the monochromatic components are smaller than those for visible radiation and more than about 100 nm.

NOTE: The limits of the spectral range of ultraviolet radiation are not well defined and may vary according to the user. Committee E-2.1.2 of the CIE distinguishes in the spectral range between 400 and 100 nm:

UV-A	315-400 nm
UV-B	280-315 nm
UV-C	100-280 nm

3.27 **visible radiation,** n.—any radiant energy capable of causing a visual sensation.

NOTE: The limits of the spectral range visible radiation are not well defined and may vary according to the user. The lower limit is generally taken between 380 and 400 nm and the upper limit between 760 and 780 nm (1 nanometer, 1 nm = 10^{-9} m).

3.28 **weather,** n.—climatic conditions at a given geographic location, including such factors as sunlight, rain, humidity and temperature.

3.29 **weather resistance,** n.—ability of a material to resist degradation of its properties when exposed to climatic conditions.

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 on 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 Daylight exposure of the skin and eyes for prolonged periods may be hazardous; therefore, caution should be employed to protect these areas. Do not look directly at the sun under any circumstances.

5. Uses and Limitations

5.1 The use of these options does not imply, expressly or otherwise, an accelerated test for a specific application. The degree of correlation between any weather resistance test and the actual exposure in use must be determined mathematically and agreed upon by the contractual parties.

A. Uses

5.2 Option A is intended for use in evaluating the resistance to degradation of a textile and related material, including coated fabrics, when subjected to natural weathering including wetting, and radiant energy factors, and are further intended to check the level of durability represented in a material specification. Option B is intended for use in evaluating the resistance to degradation due to weathering and sunlight exposure under the milder conditions of a protected atmosphere, such as found in indoor environments, where wetting is not a factor and also milder due to reduction in short wavelength UV radiation by the glass.

5.3 The test option selected should reflect expected end-use conditions associated with the material to be tested.

5.4 When using this test method, use a standard of comparison. This comparison material should have a known history in terms of a change in property value after a specific exposure.

B. Limitations

5.5 Not all materials are affected equally by the same light source and environment. Results obtained by the use of any one test option may not be representative of those of any other test option or any end-use application unless a mathematical correlation for a given material or a given application has been established between contractual parties.

5.6 In interpreting the results of these test options, consider that resistance to degradation under simulated actual sunlight exposure is dependent upon such factors as:

5.6.1 The inherent properties of the material, its physical state, mass and compactness.

5.6.2 Spectral energy distribution and density of the radiant flux (from the sun).

5.6.3 The temperature and relative humidity of the air around the textile specimen during exposure.

5.6.4 The effect of leaching or degradation of additive products, including fiber stabilizers, by rain.

5.6.5 Atmospheric contaminants.

5.7.6 The action of additive finishes and colorants including spectral absorption characteristics.

5.6.7 Where applicable, the action of residual laundry or drycleaning chemicals.

5.7 The relative rates of degradation of different textile materials do not necessarily change to the same degree as those factors themselves change. Consequently, the relative durability of textile and related materials under the varying conditions of use cannot be predicted with certainty with any one test. Therefore, it is common practice to investigate the durability of materials by exposure to the variety of conditions under which they can be used to arrive at a full understanding of the performance that can be expected from them.

5.8 Variations in results may be expected when operating conditions are varied within the accepted limits of this method, or tests are conducted in different geographical locations. Therefore, no reference shall be made to results from the use of this method unless accompanied by a report detailing the specific operating conditions and locations in conformance with Section 12.

6. Apparatus and Materials (see 15.1)

6.1 Daylight Exposure Rack that allows wetting by rainfall (see 15.6 and ASTM G7).

6.2 Behind Glass Daylight Exposure Cabinet that is glass covered and does not allow wetting by natural rainfall (see Appendix A and ASTM G24, Type A).

6.3 Black Panel Thermometer.

6.4 Pyranometer.

6.5 UV Radiometer.

6.6 RH Sensor.

6.7 Blue Wool Standards (see AATCC TM16.1, Test Method for Colorfastness to Light: Outdoor, and 14.2.1).

7. Maintenance and Verification

7.1 Maintain in accordance with the manufacturer's instructions. For the Behind Glass Daylight Exposure Cabinet, wash both the exterior surface and the interior surface of the glass cover monthly (or more frequently, if required) to remove dust particles and other undesirable material.

8. Test Specimen Preparation

8.1 Prepare specimens for the specified test procedures of at least the size given in Table I. When applicable, cut specimens with the longer direction parallel to the warp or filling direction as required in a material specification or contract order (see 15.4).

8.1.1 Prepare specimens as required to meet the needs of the applicable test method given in Table I (see 15.2, 15.3, and 15.4).

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Table I—Specimen Size and Preparation

Property	Test Method	Specimen Size
Breaking Strength:		
Strip Test	ASTM D5035	5 × 20 cm (2 × 8 in.)
Grab Test	ASTM D5034	13 × 28 cm (5 × 7 in.)
Single Strand	ASTM D2256	15 cm (6 in.)
Bursting Strength:		
Woven Fabric	ASTM D3786	15 × 15 cm (6 × 6 in.)
Nonwoven Fabric	ASTM D3786	15 × 15 cm (6 × 6 in.)
Knit Fabric	ASTM D3787	15 × 15 cm (6 × 6 in.)
Tear Strength:		
Elmendorf	ASTM D1424	10 × 13 cm (4 × 5 in.)
Trapezoid	ASTM D5587	10 × 18 cm (4 × 7 in.)
Colorfastness to Light: Outdoor	AATCC TM16.1	3 × 6 cm (1.25 × 2.4 in.)

8.1.2 These dimensions are given as a general guide and in most cases will be adequate to perform the required evaluation. Certain materials may exhibit a dimensional change with respect to the exposure. The test equipment manufacturer, physical test apparatus and number of specimens required will affect the needed specimen size. In any event, the test procedures given in Table I should be reviewed to ensure sufficient specimens are exposed for individual needs.

8.1.3 Unless otherwise specified, test specimens shall be a maximum thickness of 25 mm (1 in.). For specimens over 25 mm (1 in.) thick, formed or configured specimens, and large components, specific instructions must be agreed upon between the purchaser and the supplier.

8.1.4 When required to prevent raveling, the specimens may be edged using a flexible epoxy resin or similar material, or by sewing, pinking or fusing.

8.1.5 Labeling each specimen is preferred to provide a record of the changes encountered at different radiant exposure levels. Retain an unexposed specimen for comparison to the exposed specimen.

8.2 Mounting

8.2.1 For ***Options A and B***. To more closely simulate specific end-use conditions, the cabinet backing materials shown below have been found to be acceptable:

Cabinet Backing Materials

End-Use	Cabinet Backing	Approximate Temperatures
Automotive	Solid (Plywood)	82°C (180°F)
Household (Drapery, etc.)	Expanded Metal	63°C (145°F)
Clothing and Sensitive Materials	None (Open)	43°C (110°F)
Fabric Roof Structures	None (Open)	43°C (110°F)

8.2.2 **Fabrics.** Secure the specimens to the frames to hold them smoothly without curling of the edges. Fabrics may be stitched to gauze backing. For colorfastness determinations, mount the specimens in frames as directed in AATCC TM16.1.

8.2.3 **Yarns**. Wind yarns on frames. Only that portion of the yarns directly facing the radiant energy is tested for breaking strength. Single strand or multiple strand testing is performed. When multiple strand testing may be performed, the yarns are wound on the frame closely packed to 2.5 cm (1.0 in.) width. The control specimens must contain the same number of strands as the specimen subjected to exposure. After the exposure has been completed and before the yarns are removed from the frame for testing, those yarns facing the light source are bound together using 2.0 cm (0.75 in.) wide masking or other suitable tape to maintain the closely packed arrangements on the exposure frame.

9. Conditioning

9.1 When the exposure cycle is completed, remove the test and control specimens from the exposure rack and transfer them to a standard atmosphere [air maintained at 21 ± 2°C (70 ± 4°F) and 65 ± 5% relative humidity] for testing textiles for conditioning.

9.2 If the specimens are wet upon removal from the racks, dry them at ambient laboratory conditions or at a temperature not exceeding 71°C (160°F) before placing them in the conditioning atmosphere. The unexposed reference standard (comparison standard) and the retained unexposed original should be treated under exactly that same conditions of drying and conditioning as the test specimens.

9.3 Bring all specimens, control and test, to moisture equilibrium in the standard atmosphere for testing textiles. Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weightings made at intervals of not less than 2 h does not exceed 0.2% of the mass of the specimen. In general practice, the industry approaches equilibrium from the "as received" side.

9.3.1 It is recognized that, in practice, textile materials are frequently not weighed to determine when moisture equilibrium has been reached. While such a procedure cannot be accepted in cases of dispute, it may be sufficient in routine testing to expose the material to the standard atmosphere for testing for a reasonable period of time before the specimens are tested. Twenty-four hours has been found acceptable in most cases; however, certain fibers may exhibit slow moisture equalization rates from the "as received" "wet side." When this is known, a preconditioning cycle, as described in ASTM D1776, Standard Practice for Conditioning and Testing Textiles (see 14.1.12) may be agreed upon between contractual parties.

9.4 For each test to be made on the test material and control, exposed and unexposed, prepare test specimens by marking and raveling or cutting the central portion of each exposed specimen to the dimensions specified in the respective test methods given in Table I. The marking and raveling or cutting of the test specimens is preferred after the exposure but may be done before exposure. Control specimens not exposed are similarly prepared. For samples exposed with wetting, control specimens are wet-out and allowed to dry without tension before testing. All specimens, control and test, are conditioned simultaneously to the standard atmosphere for testing textiles for a minimum of 24 h and preferably longer, depending upon the material, and tested at the same time.

10. Procedure

10.1 Mount on the exposure rack the appropriate number of replicates (see Section 8) of the specimens as required to average out variability and to ensure accuracy of results and the necessary number of replicates of the standard, when such are available. The specimens shall be so positioned as to avoid shadowing of the specimens at the sides of the cabinet.

10.2 Expose the specimens to sunlight and the general elements of weather for a prescribed period of time during which period the radiant energy may be recorded, or when a prescribed amount of radiant exposure has been attained as determined by an applicable specification (see 15.7, 15.8 and 15.9) using a pyranometer and UV radiometer.

10.2.1 ***For Option A***, Direct Exposure to Daylight and Weathering, use Direct Exposure Rack described in Section A2 of Appendix A.

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