

Test Method for Colorfastness to Light: Outdoor

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1. Purpose and Scope

1.1 This test method provides the general principles and procedures for determining the colorfastness to light of textile materials outdoors under glass. The test options described are applicable to textile materials of all kinds and for colorants, finishes and treatments applied to textile materials.

1.2 This test method contains the following sections.

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2. Principle

2.1 Specimens of the textile material to be tested and the agreed upon comparison standard(s) are exposed simultaneously to a daylight behind window glass under specified conditions. The colorfastness to light of the specimen is evaluated by comparison of the color change of the exposed portion to the masked control portion of the test specimen or unexposed original material using the Gray Scale for Color Change (AATCC EP1), or by Instrumental Color Measurement (AATCC EP6). Lightfastness classification is accomplished by evaluation versus a simultaneously exposed series of AATCC Blue Wool Lightfastness Standards.

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 (see 20.1).

3.2 **AATCC Fading Unit (AFU)**, n.—a specific amount of exposure made under the conditions specified in various test methods where one AFU is one-twentieth (1/20) of the light-on exposure required to produce a color change equal to Step 4 on the Gray Scale for Color Change or 1.7 ± 0.3 CIELAB units of color difference on AATCC Blue Wool Lightfastness Standard L4.

3.3 **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.

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

3.5 **colorfastness**, n.—the resistance of a material to change in any of its color characteristics, to transfer of its colorant(s) to adjacent materials, or both as a result of exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material.

3.6 **colorfastness to light**, n.—the resistance of a material to a change in its color characteristics as a result of exposure of the material to sunlight or an artificial light source.

3.7 **infrared radiation**, n.—radiant energy for which the wavelengths of the monochromatic components are greater than those for visible radiation and less than about 1 mm.

NOTE: The limits of the spectral range of infrared 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 780 nm and 1 mm:

IR-A	780-1400 nm
IR-B	1.4-3.0 μ m
IR-C	3 μ m to 1 mm

3.8 **irradiance**, n.—radiant power per unit area incident on a receiver, typically reported in watts per square meter (W/m^2).

3.9 **“L” designation**, n.—the sequence number given each AATCC Blue Wool Lightfastness Standard according to the number of AATCC Fading Units required to produce a color change equal to Step 4 on the Gray Scale for Color Change.

NOTE: See Table I for the numerical relationship between “L” designations of the standards and their colorfastness to light in AFUs. The colorfastness to light of a fabric specimen can be determined by comparing its color change after light exposure with that of the most similar AATCC Blue Wool Lightfastness Standard as shown in Table II.

3.10 **langley**, n.—a unit of total solar radiation equivalent to one gram calorie per square centimeter of irradiated surface.

NOTE: The internationally recommended units are: Joule (J) for quantity of radiant energy, watt (W) for quantity of radiant power, and meter squared (m^2) for area. The following factors are to be used: 1 langley = 1 cal/cm²; 1 cal/cm² = 4.184 J/cm² or 41840 J/m².

3.11 **lightfastness**, n.—the property of a material, usually an assigned number, depicting a ranked change in its color characteristics as a result of exposure of the material to sunlight or an artificial light source.

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 **photochromism**, n.—a qualitative designation for a reversible change in color of any kind (whether a change in hue or chroma) which is immediately noticeable upon termination of light exposures when the exposed area of a specimen is compared to the unexposed area.

NOTE: The reversal of the color change or instability of the hue or chroma upon standing in the dark distinguishes photochromism from fading.

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

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

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

3.17 **total irradiance**, n.—radiant power integrated over all wavelengths at a point in time expressed in watts per square meter (W/m^2).

3.18 **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

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

NOTE: The limits of the spectral range of 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).

3.20 For definitions of other terms relative to lightfastness used in this test method, refer to AATCC M11.

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 and therefore caution should be employed to protect these areas.

4.2 Good laboratory practices should be followed.

5. Uses and Limitation

5.1 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 and/or a given application has been established. Enclosed Carbon-Arc, Xenon-Arc and Daylight have been extensively used in the trade for acceptance testing of textile materials. There may be a distinct difference in spectral power distribution, air temperature and humidity sensor locations, and test chamber size between test equipment supplied by different manufacturers that can result in differences in reported test results. Consequently, data

obtained from equipment supplied by the different manufacturers, different test chamber size, or different light source and filter combinations cannot be used interchangeably, unless a mathematical correlation has been established. No correlations among differently constructed test apparatus are known to AATCC Committee RA50.

5.2 Results from Xenon-Arc, for all materials should be in good agreement with the results obtained in Daylight Behind Glass (see Table I). Since the spectral distribution of Xenon-Arc, Alternate Light and Dark, equipped with the specified filter glass is very close to that of average or typical daylight behind window glass, it is expected that results should be in good agreement with the results obtained in Daylight, Daylight Behind Glass. The two carbon-arc options, Continuous and Alternating Light and Dark, under the conditions specified, will produce results which correlate with those obtained in the Daylight Behind Glass Method unless the material being tested is adversely affected by the differences in spectral characteristics of Enclosed Carbon-Arc and natural light.

5.3 When using this test method, the test method option selected should incorporate light, humidity, and heat effects based upon historical data and experience. The test method option selected should also reflect expected end-use conditions associated with the material to be tested.

5.4 When using this test method, use a standard of comparison which has a known change in lightfastness after a specific exposure for comparison to the material to be tested. AATCC Blue Wool Lightfastness Standards have been used extensively for this purpose.

Table I—AATCC Fading Unit and Light Exposure Equivalents for AATCC Blue Wool Lightfastness Standards (see Section 17)^a

AATCC Blue Wool Lightfastness Standard	AATCC Fading Units	Xenon Only kJ/(m ² nm) @ 420 nm	Xenon Only kJ/(m ² nm) 300-400 nm
L2	5	21	864
L3	10	43	1728
L4	20	85 ^b	3456
L5	40	170	6912
L6	80	340 ^b	13824
L7	160	680	27648
L8	320	1360	55296
L9	640	2720	110592

^a For color change of Step 4 on the Gray Scale for Color Change.

^b Verified by experiment using Daylight Behind Glass and Xenon-Arc, Continuous Light. All other values are calculated (see Section 17).

6. Apparatus and Materials (see 20.2)

6.1 AATCC Blue Wool Lightfastness Standards L2 through L9 (see 20.1 and 20.3).

6.2 Gray Scale for Color Change (AATCC EP1) (see 20.3).

6.3 Card stock: 163 g/m² (90 lb) one ply, White Bristol Index.

6.4 Test masks made of material approaching zero light transmittance, and suitable for multiple exposure levels, such as 10, 20, 40, etc. AFU.

6.5 Spectrophotometer or Colorimeter (see 19.2).

6.6 Daylight Exposure Cabinet (see 20.4, 20.7 and Appendix A).

7. Comparison Standards

7.1 AATCC Blue Wool Lightfastness Standards, as defined in AATCC TM16.1, are preferred for all options. However, the rate of fade of any AATCC Blue Wool Lightfastness Standard by one test option may not agree with that of other test options.

7.2 The reference standard can be any suitable textile material where a history of the rate of color change is known. Reference standards for comparison must be determined and agreed upon by the contractual parties. Standards must be exposed simultaneously with the test specimen. The use of the standard assists in determining time-to-time equipment and test procedure variations. If test results of the exposed standards differ by more than 10% from the known standard data, thoroughly review the test equipment operating conditions, and correct any malfunctions or defective parts. Then, repeat the test.

8. Test Specimen Preparation

8.1 Number of Specimens—For acceptance testing, use at least three replicate specimens of both the material to be tested and the standard for comparison to ensure accuracy unless otherwise agreed upon between the purchaser and the supplier.

NOTE: It is recognized that in practice one test and one control specimen are used for test purposes. While such a procedure cannot be accepted in cases of dispute, it may be sufficient in routine testing.

8.2 Specimen Cutting and Mounting—Identify each specimen using a label resistant to the environment encountered during the test. Mount in frames such that the surface of the test specimen and the reference specimen are the same distance from the light source. Use covers that avoid specimen surface compression, particularly when testing pile fabrics. The test specimen and the reference standards shall be of equal size and shape. Cut and prepare test specimens for exposure as

**Table II—Classification by AATCC Blue Wool Lightfastness Standards^a
Test Specimen Color Change**

Less Than Standard	Equal To But Not Greater Than Standard	More Than Standard	Lightfastness Class	AATCC Fading Units (AFU)
—	—	L2	L1	5
—	L2	L3	L2	10
L2	—	L3	L2-3	20
—	L3	L4	L3	40
L3	—	L4	L3-4	80
—	L4	L5	L4	160
L4	—	L5	L4-5	320
—	L5	L6	L5	640
L5	—	L6	L5-6	
—	L6	L7	L6	
L6	—	L7	L6-7	
—	L7	L8	L7	
L7	—	L8	L7-8	
—	L8	L9	L8	
L8	—	L9	L8-9	
—	L9	—	L9	

^a The following are examples for using Table II to assign lightfastness classifications:

The test specimen is exposed simultaneously with standards L4, L5, and L6. After exposure and conditioning, the color change exhibited by the test specimen is less than that exhibited by the standards L4 and L5 but greater than that exhibited by the standard L6. The test specimen would be assigned a Lightfastness Classification of L5-6, or use the following example.

The test specimen is examined after each exposure increment until it exhibits a color change equal to Step 4 on the Gray Scale for Color Change. If this occurs after 40 AFU and before 80 AFU exposure, the test specimen would be assigned a Lightfastness Classification of L5-6.

follows:

8.2.1 Specimen Backing—For all options, mount the specimens and standards on white card stock. The card stock shall be white, non-reflecting cardboard. Consult the *AATCC Buyer's Guide* (www.aatcc.org/bg) for information. When mounted test specimens are masked, use test masks approaching zero light transmittance. Put the mounted, or mounted and masked, test specimens in frames with backing as directed in an applicable specification: such as open-backed, solid metal, or solid backing (white cardboard).

8.2.2 Fabric—Cut swatches of fabric with the long direction parallel to the machine (warp) direction, at least 70.0 × 120.0 mm (2.75 × 4.7 in.) with the exposed area measuring not less than 30.0 × 30.0 mm (1.2 × 1.2 in.). Secure the backed specimens in the frames supplied with the test apparatus. Ensure that front and back covers of the holders make good contact with the specimens and give a sharp line of demarcation between the exposed and unexposed areas without compressing the specimen unnecessarily (see 20.5). When required to prevent raveling, the specimens may be edged by sewing, pinking or fusing.

8.2.3 Yarns—Wind or fasten yarns on frames of white card stock to a length of approximately 150.0 mm (6.0 in.). Only that portion of the yarns directly facing the radiant energy is evaluated for color change. Wind the yarn on the frame

closely packed to at least 25.0 mm (1.0 in.) width. The control specimen must contain the same number of strands as the specimen subjected to exposure. After the exposure has been completed, bind together those yarns facing the light source using 20.0 mm (0.75 in.) masking or other suitable tape to keep the yarns closely packed on the exposure frame for evaluation (see 20.6).

9. General Conditions

9.1 Mount the AATCC Blue Wool Lightfastness Standard(s) and the test specimen(s) on cardboard with an opaque cover (mask) covering one-half of the standard.

9.2 Expose standards and test specimen(s) simultaneously to the same test conditions behind glass (see 20.8 and Appendix A). Ensure that the face of the exposed standard(s) and test specimen(s) are at least 75.0 mm (3.0 in.) below the inside surface of the plate glass cover and are positioned at least 150.0 mm (6.0 in.) in from the edges of the glass frame. The back of the exposure cabinet may be varied as follows to achieve the desired exposure conditions:

Backing	Exposure Condition
Open/Expanded Metal	Low Temperature
Solid	High Temperature
Standard(s) and specimen(s) remain exposed 24 h a day and are removed only for inspection.	

9.3 Monitor temperature and relative humidity in the vicinity of the test cabinets (see 20.10).

10. Daylight Behind Glass Exposure to a Specified Amount of Radiant Energy

10.1 Use of AATCC Blue Wool Lightfastness Standards—Mount reference and test specimen(s) to be exposed as directed in 9.1 and expose simultaneously to the same test conditions behind glass as directed in 9.2. Monitor the effect of light by frequently removing the standard(s) from the test frame and evaluating the color change. Continue the exposure until the standard exhibits a difference in color between the exposed and masked portion as described in Section 14. When the test of the specimens is to be terminated after exposure to a specified number of AATCC Fading Units, choose the appropriate standard to achieve the end point. The standards may be used as a set, L2 through L9, or in replicate sets exposed consecutively to total a given end point; that is, singularly expose two L2 standards to reach 10 fading units, or expose one L3 standard to reach 10 fading units.

10.1.1 Remove the specimens from exposure when the desired AATCC Fading Units have been achieved and evaluate as specified in Evaluation of Results. For multiple step exposure, that is, 5 fading units and 20 fading units, a single specimen may be exposed and portions covered (masked) at intervals measured by the standard. The result will be a specimen having an original masked, unexposed section and various sections which have been exposed and subsequently masked. Each section of the specimen, representing a stated exposure interval, can be evaluated versus masked control or an unexposed original portion of the specimen.

10.2 Use of Irradiation Monitors—Mount reference and test specimen(s) to be exposed as directed in 9.1 and expose them simultaneously to the same test conditions behind glass as directed in 9.2.

NOTE: The exposure of the AATCC Blue Wool Lightfastness Standards with their known performance can be helpful in determining whether any unusual conditions were present during the test duration (see 20.8).

10.2.1 Record any one, or a combination of global, broad bandpass, or narrow bandpass irradiation with a radiometer, exposed under the same conditions as the specimens.

10.2.2 Remove the reference and test specimens from exposure when the desired radiant energy, as measured by the radiometer, has been achieved. For multiple step exposure, a single specimen may be exposed and portions covered (masked) at intervals of measured radiant