Test Method for Colorfastness to Light: Xenon-Arc

1. Purpose and Scope

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

1—Xenon-Arc Lamp, Alternate Light and Dark
2—Xenon-Arc Lamp, Continuous Light, Black Standard Option
3—Xenon-Arc Lamp, Continuous Light, Black Panel Option

1.2 The use of these test options does not imply, expressly or otherwise, an accelerated test for a specific application. The relationship between any lightfastness test and the actual exposure in use must be determined and agreed upon by the contractual parties.

1.3 This test method contains the following sections that assist in the use and implementation of the various options for determining lightfastness of textile materials.

2. Principle

2.1 Specimens of the textile material to be tested and the agreed upon comparison standard(s) are exposed simultaneously to a light source 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, or by instrumental color measurement. 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 44.1).

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 **black-panel thermometer,** n.—a temperature measuring device, the sensing unit of which is coated with black paint designed to absorb most of the radiant energy encountered in lightfastness testing (see 44.2).

3.3.1 This device provides an estimation of the maximum temperature a specimen may attain during exposure to artificial light. Any deviation from the geometry of this device described in 44.2 may have an influence on the measured temperature.

3.4 **black standard thermometer,** n.—a temperature measuring device, the sensing unit of which is coated with black material designed to absorb most of the radiant energy encountered in lightfastness testing and is thermally insulated by means of a plastic plate (see 44.2).

3.4.1 This device provides an estimation of the maximum temperature a specimen may attain during exposure to artificial light. Any deviation from the geometry of the device described in 44.2 may have an influence on the measured temperature. The temperature measured by the black standard thermometer will not be the same as that measured by the black-panel thermometer; therefore, they cannot be used interchangeably.

3.5 **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.

3.6 **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.

3.7 **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.

3.8 **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.

3.9 **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 1mm:

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

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

3.11 **"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.

3.12 **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/cm^2; 1 cal/cm^2 = 4.184 J/cm^2 or 41840 J/m^2.

3.13 **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.

3.14 **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.

3.15 **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.

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

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

3.20 **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

3.21 **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).

3.22 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 Do not operate the test equipment until the manufacturer's instructions have been read and understood. It is the operator's responsibility to conform to the manufacturer's directions for safe operation.

4.2 The test equipment contains high intensity light sources. Do not look directly at the light source. The door to the test chamber must be kept closed when the equipment is in operation.

4.3 Before servicing light sources, allow 30 min for cool-down after lamp operation is terminated.

4.4 When servicing the test equipment, shut off both the off switch and the main power disconnect switch. When equipped, ensure that the main power indicator light on the machine goes out.

4.5 Good laboratory practices should be followed. Wear safety glasses in all laboratory areas.

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.

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.

6. Apparatus and Materials (see 44.3)

6.1 AATCC Blue Wool Lightfastness Standards L2 through L9 (see 44.1, 44.4 and 44.5).

6.2 L4 AATCC Blue Wool Standard of Fade for 20 AATCC Fading Units (AFU) (see 44.5).

6.3 L2 AATCC Blue Wool (alternate) Standard of Fade for 20 AATCC Fading Units (AFU) (see 11.2, 44.5).

6.4 Gray Scale for Color Change (AATCC EP1) (see 44.5).

6.5 Card stock: 163 g/m^2 (90 lb) one ply, White Bristol Index.

6.6 Test masks made of material approaching zero light transmittance, and

Table I—AATCC Fading Unit and Light Exposure Equivalents for AATCC Blue Wool Lightfastness Standards (see Section 41)[a]

AATCC Blue Wool Lightfastness Standard	AATCC Fading Units	Xenon Only kJ/(m^2nm) @ 420 nm	Xenon Only kJ/(m^2nm) 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 41).