

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.

	Section
Principle.....	2
Terminology.....	3
Safety Precautions	4
Uses and Limitation.....	5
Apparatus and Materials.....	6
Comparison Standards.....	7
Test Specimen Preparation	8
Machine Operating Condition	9, 18, 26
Calibration and Verification ..	10-11, 19-20, 27-28
AATCC Fading Unit	
Measurement.....	12-13, 21, 29-30
Machine Exposure	14-17,
Procedures	22-25, 31-34
Evaluation of Results.....	35-39
Report	40
Precision and Bias	41-42
References.....	43
Notes	44
Appendix.....	A
Appendix.....	B

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 1 mm:

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

3.10 irradiance, n.—radiant power per unit area incident on a receiver, typically reported in watts per square meter (W/m²).

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 recom-

mended units are: Joule (J) for quantity of radiant energy, watt (W) for quantity of radiant power, and meter squared (m²) 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.

3.13 **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/m²).

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 rel-

ative 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/m² (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 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 41).

suitable for multiple exposure levels, such as 10, 20, 40, etc. AFU.

6.7 Black-Panel Thermometer (see 3.3, 44.2).

6.8 Black Standard Thermometer (see 3.4, 44.2).

NOTE: The Black-Panel Thermometer should not be confused with the Black Standard Thermometer. Temperatures as measured by the two different devices generally will not agree at the same test condition. The term *Black Thermometer*, as used in this method, refers to either the Black Panel or Black Standard Thermometers.

6.9 Spectrophotometer or Colorimeter (see 43.2).

6.10 Xenon-Arc Lamp Fading Apparatus optionally equipped with light monitors and control systems (see Appendix A and 44.6).

7. Comparison Standards

7.1 AATCC Blue Wool Lightfastness Standards, as defined in Method 16.3, 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.

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

follows:

8.2.1 Specimen Backing—For all options, if the specimens do not have an integrated backing 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

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 44.7 and 44.8). 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 44.8).

Option 1 Xenon-Arc Lamp, Alternate Light and Dark

Machine Operating Conditions

9. Preparation of Test Apparatus

9.1 Prior to running the test procedure, verify machine operation by using the following test protocol. To enhance the repeatability of test results, install test apparatus in a room where temperature and relative humidity are controlled in accordance with the manufacturer's recommendations.

9.2 Check to see that the machine has been calibrated and maintained within the manufacturer's recommended calibration schedule interval.

9.3 Turn off all rack and specimen spray units, if applicable.

9.4 Set machine operating conditions as follows:

Light source	Xenon
	Alternate light/dark (Light ON/OFF)
Black Standard temperature	70 ± 1°C (158 ± 2°F)
Chamber air temperature	
Light cycle	43 ± 2°C (110 ± 4°F)
Dark cycle	43 ± 2°C (110 ± 4°F)
Relative Humidity %	
Light cycle	35 ± 5
Dark cycle	90 ± 5
Light cycle hours	
Light – ON	3.8
Light – OFF	1.0
Filter type	See A3.3
Irradiance	
W/m ² /nm (at 420 nm)	1.10 ± 0.03
W/m ² at (300–400nm)	48 ± 1
Water requirements (Input)	
Type	Demineralized, distilled or reverse osmosis
Solids ppm	Less than 17, preferably less than 8
pH	7 ± 1
Temperature	Ambient 16 ± 5°C (61 ± 9°F)

(see Appendix A.) Be sure that the temperature chosen is appropriate for the type of Black Thermometer to be used (see 44.2). Fill the specimen rack with framed white card stock and the required black thermometer unit. The white card stock is used to simulate air flow in the test chamber during the test exposure and should not include the actual test specimens. Support the black thermometer unit in the specimen drum or rack in the same manner as the test specimen frames. Operate and control the test apparatus as described above and further defined by the manufacturer. Operate the test apparatus in this mode and adjust the instrumentation to provide the required black panel or black standard temperature, chamber air temperature and relative humidity. When exterior indicators are not available, read the black thermometer unit through the window in the test chamber door.

9.5 Verify using AATCC Blue Wool Lightfastness Standards following the guidelines in 11.1–11.2.2. If the fade of the L2 or L4 standards do not meet these requirements follow the instrument manufacturer's instructions for calibration and repeat the 20 AFU exposure with fresh L2 or L4 standards. If the fade does meet the requirements described in Section 11, remove the white card stock from the specimen rack and proceed.

9.6 For additional information to prepare and operate the test apparatus refer to the manufacturer's instructions and the following:

9.6.1 Test Standard ASTM G151 and G155 (see 43.4 and 43.5).

10. Calibration, Verification and AATCC Fading Unit Measurement

10.1 Instrument Calibration—To ensure standardization and accuracy, the instruments associated with the exposure apparatus (that is, light monitor control system, Black Thermometers, chamber air sensor, humidity control system, UV sensors and radiometers) require periodic calibration. Whenever possible, calibration shall be traceable to national or international standards. Calibration schedule and procedure should be in accordance with manufacturer's instructions.

10.1.1 The accuracy of machine operation must be verified by exposure of an applicable AATCC Blue Wool Lightfastness Standard and assessment of the Standard after every 80-100 AATCC Fading Units. Always expose reference standards near the center position of the specimen rack adjacent to the black-panel temperature sensing unit.

11. Verification by AATCC Blue Wool Lightfastness Standards

11.1 Expose the L4 AATCC Blue Wool Lightfastness Standard at the specified temperature, humidity and operating conditions for 20 ± 2 continuous light-on operating hours. After exposure, assess the exposed standard specimen, either visually or instrumentally. Increase or decrease the wattage of the lamps, the time of exposure, of both, and expose additional standard specimens until the change in color of the exposed standard meets one of the following criteria.

11.1.1 Visual Comparison—equals the change in color exhibited by the L4 Standard of Fade applicable to the Lot designation used.

11.1.2 Instrumental Color Measurement—Lot designations of AATCC Blue Wool Lightfastness Standard L4 equals the CIELAB units of color change specified on the calibration certificate supplied with the standard as determined by AATCC EP6, Evaluation Procedure for Instrumental Color Measurement.

11.2 Alternatively, the L2 AATCC Blue Wool Lightfastness Standard may be exposed at the specified temperature, humidity and selected conditions for 20 ± 2 continuous light-on operating hours. After exposure, assess the exposed standard specimen, either instrumentally or compare to a L2 Standard of Fade for 20 AFU. When required, increase or decrease the wattage of the lamps, or the time of exposure, or both, and expose additional standard specimens until the change in color of the exposed standard meets one of the following criteria.

11.2.1 Visual Comparison—equals the change in color exhibited by the L2 Standard of Fade for 20 AFU applicable to the Lot designation used (see 44.5).

11.2.2 Instrumental Color Measurement—The performance of the Blue Wool lot designations of AATCC Blue Wool Lightfastness Standard L2 and L4 must equal the CIELAB unit of color change specified on the calibration certificate supplied with the standard as determined by AATCC EP6.

12. AATCC Fading Unit Measurement by AATCC Blue Wool Lightfastness Standards

12.1 The use of AATCC Blue Wool Lightfastness Standards and AATCC Fading Units provides a common exposure standard across the various exposure methods: daylight, carbon-arc lamp and xenon-arc lamp. The terms *clock hours* and *machine hours* are not valid reporting methods.

12.2 Table I illustrates the number of AATCC Fading Units to produce a color change equal to Step 4 on the Gray Scale for Color Change (see 43.1) or instrumentally (see 43.3) on each of the AATCC Blue Wool Lightfastness Standards.

12.3 For instrumental color measurement, the colorimetric data are calculated using CIE 1964 10° observer data for Illuminant D₆₅. Express the color difference in CIELAB units as directed in AATCC EP6.

NOTE: For Xenon-Arc, Alternating Light and Dark, Option 1, although calibration is conducted using continuous light-on operating hours, it may take more or less operating hours during the actual test cycle due to the inclusion of the dark periods.

13. AATCC Fading Unit Measurement based on Spectral Irradiation

13.1 The 20 AATCC Fading Units are produced by an exposure interval of 85 kJ/(m²nm) measured at 420 nm when xenon-arc machines are operated at the conditions specified in this test method (see Table I).

Machine Exposure Procedures

14. Machine Exposure, General Conditions

14.1 Specimen Mounting. Mount the test material on the specimen rack. Make sure that all materials are adequately supported. Any displacement of the material toward or away from the source, even by a small distance, may lead to variation in fading between specimens (see 8.2). When alternate light and dark cycles are required, begin exposure at the start of the light cycle.

14.2 In the case of woven, knitted and nonwoven fabrics, unless otherwise specified, ensure that the side normally used as the face is directly exposed to the radiant source.

14.3 Operate the test apparatus on a daily basis until the selected exposure has been completed. Avoid unnecessary delays when interrupting the exposure period to change filters, carbons or lamps, as such delays may contribute to variations in results or lead to errors. When available, monitor exposure test chamber conditions with suitable recorders. If necessary, readjust the controls to maintain the specified test conditions.

15. Machine Exposure to a Specified Amount of Radiant Energy

15.1 One-Step Method—Expose the test specimens and applicable standards for 5, 10, 20 or multiples of 20 AATCC Fading Units until the specimen has been exposed to the desired amount of radiant energy defined in terms of AATCC Fading Units measured by simultaneous exposure of the appropriate Blue Wool Standard(s).

15.2 Two-Step Method—Proceed as directed in 15.1, except double the exposure area of the test specimens. After the specimen has been exposed to the first specified level of radiant energy, remove the specimens from the test chamber and mask (cover) one-half of the exposed area and continue the exposure for an additional 20 or multiples of 20 AATCC Fading Units until the specimen has been exposed to the higher desired amount of radiant energy.

15.3 In those machines equipped with irradiation monitors, the AATCC Fading Units of exposure can be determined and controlled by measuring kJ/(m²nm) at 420 nm (see Table I).

NOTE: The two-step method is preferred for the complete characterization of the lightfastness of a test specimen.

16. Machine Exposure using a Reference Specimen

16.1 Expose the test specimen(s) and reference specimen(s) simultaneously to the required end point in terms of AATCC Fading Units, kilojoules per square meter of irradiance or reference specimen performance (that is, the reference specimen shows a color change equal to Step 4 on the Gray Scale of Color Change).

17. Machine Exposure for Lightfastness Classification

17.1 One-Step Method—Expose test specimen(s) simultaneously with a series of AATCC Blue Wool Lightfastness Standards or determine the number of AATCC Fading Units required to produce a color change in the test specimen equal to Step 4 on the Gray Scale for Color Change (see 44.10).

17.2 Two-Step Method—Proceed as di-

rected in 17.1, except double the exposure area of the test specimens. After the specimen has been exposed to a color change equal to Step 4 on the Gray Scale for Color Change, remove the specimens from the test chamber and mask (cover) one-half of the exposed area and continue the exposure until the test specimen exhibits a color change equal to Step 3 on the Gray Scale for Color Change (see 44.10).

Option 2

Xenon-Arc Lamp, Continuous Light, Black Standard Option

Machine Operating Conditions

18. Preparation of Test Apparatus

18.1 Prior to running the test procedure, verify machine operation by using the following test protocol. To enhance the repeatability of test results, install test apparatus in a room where temperature and relative humidity are controlled in accordance with the manufacturer's recommendations.

18.2 Check to see that the machine has been calibrated and maintained within the manufacturer's recommended calibration schedule interval.

18.3 Turn off all rack and specimen spray units, if applicable.

18.4 Set machine operating conditions as follows:

Light source	Xenon Continuous Light-on
Black Standard temperature	$60 \pm 3^{\circ}\text{C}$ ($140 \pm 8^{\circ}\text{F}$)
Chamber air temperature	$32 \pm 5^{\circ}\text{C}$ ($90 \pm 9^{\circ}\text{F}$)
Relative Humidity %	30 ± 5
Filter type	See A3.3
Irradiance $\text{W/m}^2/\text{nm}$ (at 420nm)	1.25 ± 0.2
Irradiance W/m^2 (300–400nm)	65 ± 1
Water requirements (Input)	
Type	Demineralized, distilled or reverse osmosis
Solids ppm	Less than 17, preferably less than 8
pH	7 ± 1
Temperature	Ambient $16 \pm 5^{\circ}\text{C}$ ($61 \pm 9^{\circ}\text{F}$)

(see Appendix A.) Be sure that the temperature chosen is appropriate for the type of Black Thermometer to be used (see 44.2). Fill the specimen rack with framed white card stock and the required black thermometer unit. The white card stock is used to simulate air flow in the test chamber during the test exposure and should not include the actual test specimens. Support the black thermometer unit in the specimen drum or rack in the same manner as the test specimen frames.

Operate and control the test apparatus as described above and further defined by the manufacturer. Operate the test apparatus in this mode and adjust the instrumentation to provide the required black panel or black standard temperature, chamber air temperature and relative humidity. When exterior indicators are not available, read the black thermometer unit through the window in the test chamber door.

18.5 Verify using AATCC Blue Wool Lightfastness Standards following the guidelines in 20.1–20.2.2. If the fade of the L2 or L4 standards do not meet these requirements follow the instrument manufacturer's instructions for calibration and repeat the 20 AFU exposure with fresh L2 or L4 standards. If the fade does meet the requirements described in Section 20 remove the white card stock from the specimen rack and proceed.

18.6 For additional information to prepare and operate the test apparatus refer to the manufacturer's instructions and the following:

18.6.1 Test Standard ASTM G151 and G155 (see 43.4 and 43.5).

19. Calibration, Verification and AATCC Fading Unit Measurement

19.1 Instrument Calibration—To ensure standardization and accuracy, the instruments associated with the exposure apparatus (that is, light monitor control system, Black Thermometers, chamber air sensor, humidity control system, UV sensors and radiometers) require periodic calibration. Whenever possible, calibration shall be traceable to national or international standards. Calibration schedule and procedure should be in accordance with manufacturer's instructions.

19.1.1 The accuracy of machine operation must be verified by exposure of an applicable AATCC Blue Wool Lightfastness Standard and assessment of the Standard after every 80–100 AATCC Fading Units. Always expose reference standards near the center position of the specimen rack adjacent to the black-panel temperature sensing unit.

20. Verification by AATCC Blue Wool Lightfastness Standards

20.1 Expose the L4 AATCC Blue Wool Lightfastness Standard at the specified temperature, humidity and operating conditions for 20 ± 2 continuous light-on operating hours. After exposure, assess the exposed standard specimen, either visually or instrumentally. Increase or decrease the wattage of the lamps, the time of exposure, of both, and expose additional standard specimens until the change in color of the exposed standard meets one of the following criteria.

20.1.1 Visual Comparison—equals the

change in color exhibited by the L4 Standard of Fade applicable to the Lot designation used.

20.1.2 Instrumental Color Measurement—Lot designations of AATCC Blue Wool Lightfastness Standard L4 equals the CIELAB units of color change specified on the calibration certificate supplied with the standard as determined by AATCC EP6.

20.2 Alternatively, the L2 AATCC Blue Wool Lightfastness Standard may be exposed at the specified temperature, humidity and selected conditions for 20 ± 2 continuous light-on operating hours. After exposure, assess the exposed standard specimen, either instrumentally or compare to a L2 Standard of Fade for 20 AFU. When required, increase or decrease the wattage of the lamps, or the time of exposure, or both, and expose additional standard specimens until the change in color of the exposed standard meets one of the following criteria.

20.2.1 Visual Comparison—equals the change in color exhibited by the L2 Standard of Fade for 20 AFU applicable to the Lot designation used (see 44.5).

20.2.2 Instrumental Color Measurement—The performance of the Blue Wool lot designations of AATCC Blue Wool Lightfastness Standard L2 and L4 must equal the CIELAB unit of color change specified on the calibration certificate supplied with the standard as determined by AATCC EP6.

21. AATCC Fading Unit Measurement by AATCC Blue Wool Lightfastness Standards

21.1 The use of AATCC Blue Wool Lightfastness Standards and AATCC Fading Units provides a common exposure standard across the various exposure methods: daylight, carbon-arc lamp and xenon-arc lamp. The terms *clock hours* and *machine hours* are not valid reporting methods.

21.2 Table I illustrates the number of AATCC Fading Units to produce a color change equal to Step 4 on the Gray Scale for Color Change (see 43.1) or instrumentally (see 43.3) on each of the AATCC Blue Wool Lightfastness Standards.

21.3 For instrumental color measurement, the colorimetric data are calculated using CIE 1964 10° observer data for Illuminant D₆₅. Express the color difference in CIELAB units as directed in AATCC EP6.

NOTE: For Xenon-Arc, Alternating Light and Dark, Option 1, although calibration is conducted using continuous light-on operating hours, it may take more or less operating hours during the actual test cycle due to the inclusion of the dark periods.