Designation: D3424 – 11

Standard Practice for Evaluating the Relative Lightfastness and Weatherability of Printed Matter[1]

This standard is issued under the fixed designation D3424; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard describes procedures for the determination of the relative lightfastness and weatherability of printed matter under the following conditions, which involve exposure to natural daylight or accelerated procedures in the laboratory:

1.1.1 *Method 1*—Daylight behind window glass,

1.1.2 *Method 2*—Outdoor weathering,

1.1.3 *Method 3*—Xenon-arc apparatus with window glass filters to simulate daylight behind window glass,

1.1.4 *Method 4*—Xenon-arc apparatus with water spray and daylight filters to simulate outdoor weathering,

1.1.5 *Method 7*—Fluorescent lamp apparatus to simulate indoor fluorescent lighting in combination with window-filtered daylight.

1.1.6 *Method 8*—Fluorescent lamp apparatus operating with fluorescent cool white lamps to simulate indoor fluorescent lighting.

NOTE 1—Previous versions of this standard included Methods 5 and 6 that are based on enclosed carbon-arc exposures. These methods are described in Appendix X1. The spectral irradiance of the enclosed carbon-arc is a very poor simulation of solar radiation, window glass filtered solar radiation, or the emission of lamps used for interior lighting. In addition, enclosed carbon-arc devices are no longer readily available or commonly used.

1.2 These methods require that a suitable print or other control (reference standard) be run along with the test sample. Color changes due to conditions of exposure may be evaluated by visual examination or instrumental measurement.

1.3 These methods are applicable to prints on any flat substrate including paper, paperboard, metallic foil, metal plate, and plastic film, and are produced by any printing process including letterpress, offset lithography, flexography, gravure, and silk screen.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials

D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

D2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale

D4302 Specification for Artists' Oil, Resin-Oil, and Alkyd Paints

D4674 Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

D5067 Specification for Artists' Watercolor Paints

D5098 Specification for Artists' Acrylic Dispersion Paints

E284 Terminology of Appearance

E991 Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method

E1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry

E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry

E1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry

G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials

G24 Practice for Conducting Exposures to Daylight Filtered Through Glass

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

[1] This practice is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.56 on Printing Inks.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
G153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

2.2 *ANSI Standard:*

PH 2.30 for Graphic Arts and Photography—Color Prints, Transparencies and Photomechanical Reproductions, Viewing Conditions[3]

2.3 *ISO Standard:*

ISO 9370 Plastics — Instrumental determination of radiant exposure in weathering tests—General guidance and basic test method[3]

3. Terminology

3.1 Definitions relating to weathering tests are covered in Terminology G113. Definitions relating to color attributes and color differences are covered in Practices D1729 and D2244. Other appearance terms used in these test methods are defined in Terminology E284.

4. Summary of Exposure Methods

4.1 Printed specimens of the test and control are simultaneously exposed under conditions appropriate to the end-use application, or as agreed upon between the producer and the user.

4.2 The color changes of the exposed prints are periodically evaluated visually or instrumentally versus either an exposed control or an unexposed file specimen.

4.3 The endpoint is reached when it is established that the test print is equal to, better than, or worse than the control after equal exposure periods or based on duration of exposures required to produce a predetermined color change in each.

5. Significance and Use

5.1 Lightfastness or weatherability for specified periods of time is pertinent for certain types of printed matter such as magazine and book covers, posters and billboards, greeting cards and packages. Since the ability of printed matter to withstand color changes is a function of the spectral-power distribution of the light source to which it is exposed, it is important that lightfastness be assessed under conditions appropriate to the end-use application.

5.2 The accelerated procedures covered in these exposure methods provide means for the rapid evaluation of lightfastness or weatherability under laboratory conditions. Test results are useful for specification acceptance between producer and user and for quality control.

5.2.1 The xenon-arc lamp with an appropriate filter system exhibits a spectral-power distribution that corresponds more closely to that of daylight than the carbon-arc. In turn, accelerated tests using xenon-arc apparatus may be expected to correlate better with exposure to natural daylight than do those using carbon-arc apparatus.

5.3 To accommodate variations in light intensity among days, seasons, locations, or instruments, duration of exposure is preferably expressed as the radiant exposure in specific bandpasses rather than time. In either case, the inclusion of an appropriate control serves to minimize effects of variations in test conditions.

5.4 Color changes are not a linear function of duration of exposure. The preferred method of determining lightfastness or weatherability is to expose the prints for a number of intervals and to assess the time or radiant exposure required to obtain a specified color difference.

5.5 For a given printing ink, lightfastness and weatherability or both depend on the type of substrate, the film thickness of the print, and the area printed (solid versus screen). Therefore, it is important that the nature of the test and control specimens correspond to that expected under actual use conditions.

NOTE 2—Specifications D4302, D5067, and D5098 provide useful guides to the lightfastness of pigments in several types of artists' paints after 1260 MJ/m^2 total window glass filtered solar radiant exposure (equivalent to about 2 or 3 months' exposure to window glass filtered solar radiation in accordance with Practice G24 at a tilt angle of 45 degrees). However, because of major differences between printing inks and artists' colors, especially in applied film thickness, it cannot be assumed that the lightfastness categories of printed ink films containing these pigments will be comparable to those indicated in the three specifications.

6. Apparatus

6.1 *Exposure Apparatus:*

6.1.1 *Exposure Method 1 Daylight Behind Window Glass*—Outdoor exposure cabinet conforming to Method A of Practice G24.

6.1.2 *Exposure Method 2 Outdoor Weathering*—Outdoor exposure rack conforming to Practice G7.

6.1.3 Exposure Methods 1 and 2 require a broad band UV radiometer meeting the requirements of ISO 9370.

NOTE 3—In Method 1, the glass typically removes most short wavelength UV radiation up to about 310 nm. Commercial suppliers of exposures conducted according to Method 1 or Method 2 measure a variety of climate parameters including temperature and relative humidity during these exposures, and can provide this data upon request.

6.1.4 *Exposure Method 3 Xenon-Arc with Window Glass Filters*—Xenon-arc apparatus equipped with a window glass filter to simulate solar radiation filtered through window glass as specified in the Apparatus sections of Practices G151 and G155.

6.1.5 *Exposure Method 4 Xenon-arc with Daylight Filters and Water Spray*—Xenon-arc apparatus equipped with a daylight filter and water spray to simulate outdoor weathering as specified in the Apparatus sections of Practices G151 and G155.

6.1.6 *Exposure Method 7 Fluorescent UV/Cool White Lamp Apparatus*—Exposure cabinet conforming to Practice D4674, Method 1. This exposure uses soda lime glass filtered fluorescent UVA340 or UVB lamps in combination with very high output (VHO) cool white fluorescent lamps. Conditions

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

are adjusted to produce a defined condition of UV exposure measured from 250 nm to 400 nm and are conducted to a time agreed upon by interested parties.

6.1.7 *Exposure Method 8 Fluorescent-Lamp Apparatus* conforming to the requirements of Practice G154. Fluorescent cool white lamps to conform to the requirements of Practice D4674, Annex A2.

6.2 *Apparatus for Print Evaluation:*

6.2.1 *Standard Daylight,* (for visual evaluation), preferably a D50 light source conforming to ANSI Standard PH 2.30.

6.2.2 *Gray Scale Chart and Masks,* (optional, for visual evaluation) conforming to Test Method D2616.

6.2.3 *Color Measuring Instrument,* (for instrumental evaluation), such as a spectrophotometer conforming to Test Method E1331 or E1349, or a tristimulus colorimeter conforming to Test Method E1347, or, if the specimens are fluorescent, to Practice E991.

7. Materials

7.1 *Control (Reference Standard),* preferably a printed specimen of known lightfastness or weatherability; alternatively, AATCC Blue Wool Lightfastness Standards in accordance with Practice G151.

7.2 *Mounting Material,* such as light-weight card stock, on which to mount non-rigid specimens (paper, plastic, or foil) during exposure tests.

7.3 *Masking Material,* (optional), such as white card stock, aluminum foil, or other opaque material with a non-UV-reflecting surface.

7.4 *Unprinted Stock,* (optional), identical to that used for the printed specimens.

7.5 *Backing Material,* (for use during instrument measurements on nonopaque specimens), such as several sheets of the unprinted stock, a standard white (card) stock, or a spare calibration standard.

8. Hazards

8.1 **Precaution:** Never look directly at the sun or the operating light source of an accelerated aging apparatus unless wearing UV protective eyewear.

8.2 Newer accelerated apparatus are equipped with safety switches that turn the lamps off prior to gaining access. Users of very old carbon-arc apparatus must be certain to turn the switch off before opening the test chamber door.

8.3 Users of carbon-arc apparatus are cautioned that burning carbon rods become very hot. After the device is turned off, wait at least 15 min for the arcs to cool, and wear canvas or other protective work gloves when changing the rods. Avoid inhaling ash dust.

9. Test Specimens

9.1 These exposure methods do not cover preparation of printed specimens. The test print should match the control print in color, substrate, print area, and ink film thickness.

9.2 It may be useful to include the unprinted substrate and a vehicle print in exposure tests so as to determine the contribution of paper or vehicle yellowing to color changes.

9.3 Unless otherwise agreed upon, at least two specimens are to be exposed at each set of test conditions. The test specimens shall be of uniform color, gloss, and texture; clean and free of fingerprints.

9.3.1 **Warning:** When handling test specimens, be careful not to contaminate the surface by touching with fingers.

9.4 For visual evaluation, the specimen size indicated in Practice D1729 is a minimum of 90 by 165 mm. For instrumental evaluation, the specimen must be large enough to cover the specimen port; a minimum size of 35 mm^2 is satisfactory for many instruments. In the case of samples intended for xenon-lamp or carbon-arc exposure, the specimens should be of sufficient dimensions to be accommodated in the specimen holders.

9.5 Prepare file specimens (unexposed controls) in the following manner:

(*1*) For visually evaluated tests, set aside a replicate print or cut off a segment of suitable size; store in a dark dry place.

(*2*) For instrumentally evaluated tests, make color measurements on the relevant specimen area(s) prior to exposure; see 11.3.1 and 11.3.2.

NOTE 4—The file specimen should not be a masked specimen. Even though shielded from radiation, some materials may undergo color changes due to the heat or moisture present during the test.

9.6 Mount nonrigid specimens onto cardstock. If masking is specified in order to obtain multiple exposures on a single specimen, make certain that the size of each exposed area conforms to 9.4. Place specimens intended for xenon-arc or carbon-arc exposure in specimen holders; provide a sufficient number of blanks so as to fill the specimen rack.

10. Procedures for Light and Weather Exposure

10.1 Expose the test specimens simultaneously with the control in the apparatus and under the conditions agreed upon between the producer and the user. When conditions have not been specified, use the following guidelines:

EXPOSURE METHOD 1 DAYLIGHT BEHIND WINDOW GLASS

10.1.1 Common commercial exposure sites are southern Florida (a high humidity area) and Arizona (a low humidity area). Table 1 shows the average daily solar ultraviolet radiation for exposures conducted in Miami and Phoenix.

NOTE 5—Solar UV radiation data in Table 1 is for 1996 through 2006.

10.1.2 Mount the test and control specimens under glass on open racks at an angle of 45° facing the equator.

10.1.3 Monitor cumulative ultraviolet radiant exposure of the glass-filtered daylight (for example, 295 to 385 nm, little of which will be below 310 nm), relative humidity, and air temperature, in accordance with Practice G24.

TABLE 1 Average Daily Total Solar Ultraviolet Radiation (Mj/m^2, 295-385 nm, for 1996-2006) for Exposures Conducted in Accordance with Practice G24, Method A, with Rack Tilted at 45° to Horizontal

Month	Miami	Phoenix
January	0.47	0.42
February	0.54	0.51
March	0.58	0.62
April	0.59	0.70
May	0.55	0.72
June	0.46	0.70
July	0.50	0.65
August	0.50	0.66
September	0.49	0.66
October	0.53	0.58
November	0.47	0.46
December	0.42	0.40
Average annual	0.47	0.59

EXPOSURE METHOD 2 OUTDOOR WEATHERING

10.1.4 Commercial sites are the same as in 10.1.1. Table 2 shows average total ultraviolet radiation per day for exposures conducted in Miami or Phoenix at an angle of 45° to the horizontal.

NOTE 6—Data for solar UV radiation data in Table 2 is for 1985 through 2006.

10.1.5 Mount the test and control specimens on a rack faced with unpainted plywood at an angle of 45° facing the equator.

10.1.6 Monitor ultraviolet radiation exposure (for example, 295 to 385 nm), relative humidity, air temperature, and total rain fall in accordance with Practice G7.

EXPOSURE METHOD 3 XENON-ARC APPARATUS WITH WINDOW GLASS FILTERS TO SIMULATE DAYLIGHT BEHIND WINDOW GLASS

10.1.7 Set up the xenon-arc apparatus with the Window glass filter system and operate in accordance with Practices G151 and G155.

10.1.8 Unless otherwise specified, use the following exposure conditions.

10.1.8.1 Expose the specimens to 100 % light.

10.1.8.2 Set the irradiance level to 1.2 watts per square metre per unit wavelength W/(m^2·nm) for control at 420 nm. To achieve sample irradiance equivalent to the latter when the irradiance is controlled at either 340 nm, 300-400 nm, or 300-800 nm, consult the manufacturer of the equipment for the irradiance settings in these spectral regions. During equilibrium conditions, the maximum allowable fluctuation of the irradiance meter from the set point is ±0.02 W/(m^2·nm) when irradiance is controlled at 420 nm or 340 nm, ±3 W/m^2 when irradiance is controlled at 300-400 nm or ±25 W/m^2 when 300-800 nm irradiance control is used.

TABLE 2 Average Daily Total Solar Ultraviolet Radiation (Mj/m^2, 295-385 nm) for Exposures Conducted in Miami or Phoenix at 45° to Horizontal

Month	Miami	Phoenix
January	0.72	0.61
February	0.84	0.76
March	0.92	0.93
April	0.95	1.06
May	0.89	1.09
June	0.76	1.10
July	0.77	1.05
August	0.77	1.06
September	0.78	1.04
October	0.80	0.89
November	0.70	0.70
December	0.63	0.58
Average annual	0.80	0.91

10.1.8.3 Program the device to produce an uninsulated black panel temperature of 63°C. Unless otherwise specified, in devices capable of controlling relative humidity, program the device to produce a relative humidity of 40 %. During equilibrium conditions, the allowable fluctuation of the meter indicating uninsulated black panel temperature shall be a maximum of ±2.5°C, and when relative humidity is controlled, the allowable fluctuation of the meter indicating relative humidity shall be a maximum of ±10 %.

10.1.8.4 If the meter indicating the uninsulated black panel temperature or relative humidity (if controlled) drifts out of the ranges given above, stop the test and make any necessary repairs or adjustments.

10.1.9 Fill the rack with mounted test and control specimens making sure that the specimens face the lamp. In devices with rotating specimen racks, fill empty spaces, if any, with blanks.

10.1.10 Monitor the cumulative radiant exposure in either the narrow or broad band regions.

10.1.11 Reposition the specimens after specified intervals in accordance with the Procedure sections of Practices G151 and G155.

EXPOSURE METHOD 4 XENON-ARC APPARATUS WITH WATER SPRAY AND DAYLIGHT FILTERS TO SIMULATE OUTDOOR WEATHERING

10.1.12 Operate the xenon-arc with the Daylight filter system in accordance with Practices G151 and G155.

10.1.13 Unless otherwise specified, use the following exposure conditions.

10.1.13.1 Expose the specimens to 100 % light.

10.1.13.2 Set the irradiance level to 0.35 watts per square meter per unit wavelength W/(m^2·nm) at 340 nm. To achieve sample irradiance equivalent to the latter when the irradiance is controlled at either 300-400 nm, or 300-800 nm, consult the manufacturer of the equipment for the irradiance settings in these spectral regions. During equilibrium conditions, the maximum allowable fluctuation of the irradiance meter from the set point is ±0.02 W/(m^2·nm) when irradiance is controlled at 340 nm, ±3 W/m^2 when irradiance is controlled at 300-400 nm or ±25 W/m^2 when 300-800 nm irradiance control is used.

10.1.13.3 Program the device to produce an uninsulated black panel temperature of 63°C. Unless otherwise specified, in devices capable of controlling relative humidity, program the device to produce a relative humidity of 40 %. During equilibrium conditions, the allowable fluctuation of the meter indicating uninsulated black panel temperature shall be a maximum of ±2.5°C, and when relative humidity is controlled, the allowable fluctuation of the meter indicating relative humidity shall be a maximum of ±10 %.

10.1.13.4 Same as 10.1.8.4.

10.1.13.5 Use the exposure cycle consisting of 102 minutes light only followed by 18 minutes of light with water sprayed on the front surface.

10.1.13.6 Same as 10.1.9.

10.1.13.7 Same as 10.1.10.

10.1.13.8 Same as 10.1.11.

EXPOSURE METHOD 7 FLUORESCENT UV/COOL WHITE LAMP APPARATUS

10.1.14 Load the specimen trays and perform other steps in accordance with the Method I of Practice D4674.

10.1.15 Reposition the specimens in accordance with Test Method D4674 at time intervals equal to 25 ± 5 % of the total test time.

EXPOSURE METHOD 8 FLUORESCENT COOL WHITE LAMPS

10.1.16 Use apparatus conforming to the requirements of Practice G154 and equipped with F40T12 cool white lamps. Place specimens in the device, and fill all spaces not used by test specimens with blank metal panels. Operate the device with lamps on continuously and with the black panel temperature controlled at 50°C. During equilibrium conditions, the maximum allowable fluctuation of the meter indicating the black panel temperature shall be ±3°C. Reposition specimens according to one of the procedures described in Practice G154. If the indicated black panel temperature falls outside of the range defined above, stop the test and make any necessary repairs or adjustments before continuing.

NOTE 7—Method 8 is the same as Method III in Practice D4674.

11. Evaluations

11.1 *Exposed Samples Evaluation:*

11.1.1 After one or more mutually agreeable intervals, remove the test specimens from the exposure apparatus, make visual (see 11.2) or instrumental evaluations (see 11.3), and, if further exposure is required, return the specimen to the apparatus in a rotated order, when specified. The exposure intervals may be as follows:

11.1.1.1 Specific duration(s) of time,

11.1.1.2 Specific duration(s) of ultraviolet radiant exposure (if measured), or

11.1.1.3 A number of intervals (time or ultraviolet radiant exposure) spanning that required to determine whether the test sample is equal to, better than, or worse than the control after equal exposure periods or based on duration of exposures required to produce a predetermined color change in each.

11.2 *Visual Evaluation:*

11.2.1 In order to facilitate direct comparisons, it may be necessary to trim off the unprinted paper border and the unexposed part of the print, if any, on the longer side of the exposed specimens.

11.2.2 Using standard daylight, preferably the D50 light source specified in ANSI pH 2.30, examine the specimens in accordance with Practice D1729. Compare the exposed specimens with the exposed control and (if specified) the unexposed file specimen. If the gray scale is used, follow the procedure in Test Method D2616.

11.2.3 Where there is a perceptible color difference, note the nature of the changes in accordance with Practice D1729, for example, turns lighter, darker, greener, redder, bluer, or yellower.

11.3 *Instrumental Evaluation:*

11.3.1 Set the spectrophotometer or colorimeter for the largest area of view or illumination that can accommodate the respective specimens, and standardize according to Test Methods E1331, E1347, or E1349. If the test substrate is not completely opaque, provide a background as suggested in 7.5.

11.3.2 Make measurements as prescribed in Test Methods E1331, E1347, or E1349 using either the CIE 1964 (10°) Supplementary Standard Observer and Standard Illuminant D_{65} or the CIE 1931 (2°) Standard Observed and Standard Illuminant C, as long as the same basis is consistently used. If hemispherical geometry is used, the specular component may be either included or excluded as long as the same condition is consistently used. Make the measurements on each test and control specimen prior to exposure (see 9.5), and after each exposure. Make a minimum of three measurements per specimen, moving or rotating the specimen between measurements.

11.3.3 Using the CIE 1976 L* a* b* equation described in Practice D2244, calculate ΔL*, Δa*, Δ b*, and ΔE^*_{ab} between each exposed specimen and its file specimen (unexposed counterpart).

11.3.4 (Optional) Plot ΔE^*_{ab} or other specified color difference parameter versus time or cumulative ultraviolet radiant exposure. Determine by interpolation the duration required to obtain a specified level of color difference. This approach permits the rate of color changes to be determined and lightfastness or weatherability to be more accurately determined than with tests based on a single duration.

11.4 If appropriate or required, evaluate the specimens for changes in other appearance properties such as cracking, crazing, blistering, delamination, etc., or physical properties such as surface gloss, interlayer adhesion, chemical or molecular weight changes, etc.

12. Report

12.1 The report shall contain the following information for both the test material and the control:

12.1.1 Specimen identification, including the method of printing, print area (solid or halftone), and substrate,

12.1.2 Exposure apparatus and conditions as indicated in the appropriate referenced document. If a radiometer is used, include the wavelengths of light that were monitored,

12.1.3 Procedure for evaluating color changes (either visual or instrumental), and

12.1.4 Whether the test sample was equal to, better than, or worse than the control.

NOTE 8—In the case of instrumental measurements, a single ΔE^*_{ab} cannot be used to specify acceptable color differences irrespective of color. While many colors are visibly different at a ΔE^*_{ab} of 1.0 or less, oranges may require a ΔE^*_{ab} of at least 4.0 and yellows 5.0.

12.1.5 Results from any other appearance or physical property measurements conducted, including a reference to the

standards describing the property measurements, or a brief description of the measurement procedures used.

13. Precision and Bias

13.1 *Precision*—Precision data for the exposure methods described in this standard are not available. Practice G151 describes how to use data obtained by these exposures when precision data are not available.

13.2 *Bias*—No information can be presented on the bias of the color changes determined in this practice because no material having an accepted reference value is available.

14. Keywords

14.1 accelerated exposure; carbon-arc apparatus; color difference measurements; daylight behind window glass; fluorescent lamp apparatus; gray scale; lightfastness; outdoor exposure; printed matter; printing inks; weatherfastness; xenon-arc apparatus

APPENDIX

(Nonmandatory Information)

X1. ENCLOSED CARTON-ARC EXPOSURES

X1.1 Previous versions of this standard included two artificial accelerated exposures using enclosed carbon-arc. The spectral emission of the enclosed carbon-arc is not a good simulation of solar radiation, solar radiation filtered by window glass, or cool white fluorescent lamps commonly used for interior lighting. This is shown in Fig. X1.1.

X1.2 The exposure cycles using the enclosed-carbon-arc included in previous versions are described in X1.3.

X1.3 METHOD 5 ENCLOSED CARBON-ARC WITHOUT WATER SPRAY

X1.3.1 Set up the carbon-arc apparatus to operate in accordance with the Apparatus sections of Practices G151 and G153.

X1.3.2 Unless otherwise specified, use the following exposure cycle:

X1.3.2.1 Expose samples to 100 % light.

X1.3.2.2 Program the device to produce an uninsulated black panel temperature of 63°C. In devices capable of controlling relative humidity, program the device to produce a relative humidity of 40 %. During equilibrium conditions, the allowable fluctuation of the meter indicating uninsulated black panel temperature shall be a maximum of ±3°C. and when

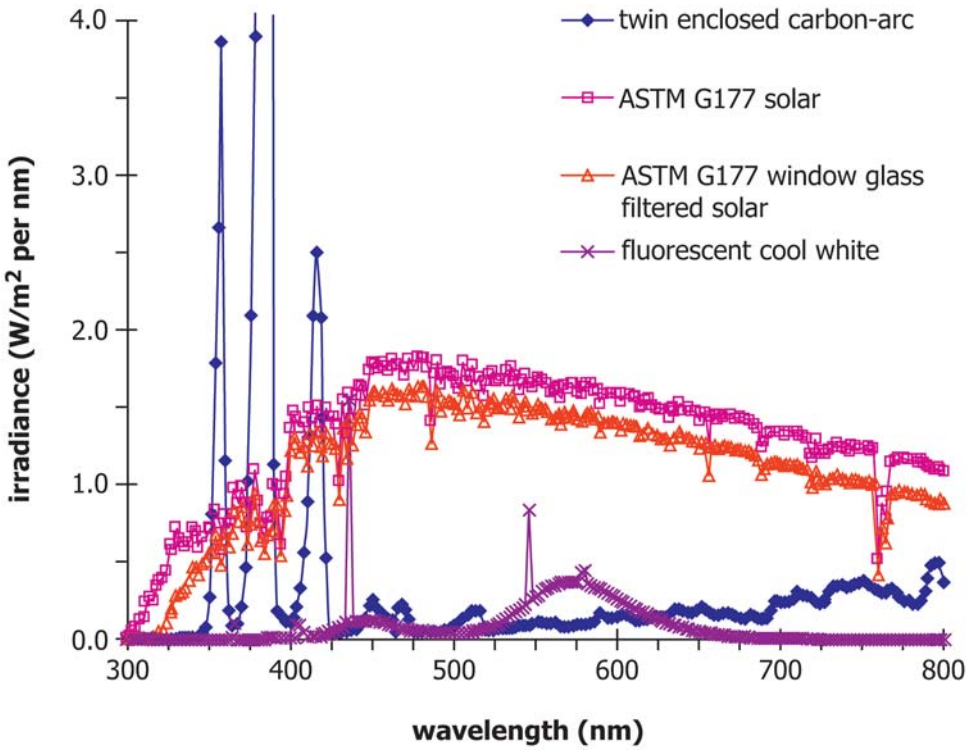

FIG. X1.1 Spectral Irradiance of Enclosed Carbon-arc Compared to Solar Radiation, Window Glass Filtered Solar Radiation, and Fluorescent Cool White Lamps

relative humidity is controlled, the allowable fluctuation of the meter indicating relative humidity shall be a maximum of ±10 %.

X1.3.2.3 Fill the rack with mounted test and control specimens making sure that the specimens face the lamp. Fill empty spaces, if any, with blanks.

X1.3.2.4 Insert new carbons and clean the globe after each 20 to 22 h of operation. See specific hazards in 8.2 and 8.3. Reposition the specimens daily in accordance with the Procedure sections of Practices G151 and G153.

X1.3.3 An interlaboratory test of Test Method 5 (enclosed carbon-arc lamp without water spray) was conducted in which eight laboratories tested the relative lightfastness of two pairs of colors (Yellow 12 versus Yellow 13, and Red 53 versus Red 57:1). Each color was printed by the sheet-fed offset process as a solid and a 40 % halftone onto a coated paper and an uncoated paper. The Yellow 13 prints were more lightfast than the corresponding Yellow 12 prints, and the Red 57:1 prints, which darkened, were more lightfast than the Red 53 prints. Furthermore, the uncoated paper prints were more stable than the corresponding coated paper prints, and the solids more stable than the halftones.

NOTE X1.1—Ranking results with different types of light sources may vary.

X1.4 METHOD 6 ENCLOSED CARBON-ARC WITH WATER SPRAY

X1.4.1 Set up the carbon-arc apparatus to operate in accordance with the Apparatus sections of Practices G151 and G153.

X1.4.2 Unless otherwise specified, use the following exposure cycle:

X1.4.2.1 Expose specimens to a cycle of 102 min. of light alternating with 18 min. of light and water spray.

X1.4.2.2 Program the uninsulated black-panel temperature to 63°C (145°F). In apparatus with humidity control, set the relative humidity to 40 %. At equilibrium conditions, the maximum allowable fluctuation of the meter indicating black-panel temperature is ±3°C, and the maximum allowable fluctuation of the meter indicating relative humidity is ±10 %.

X1.4.3 Same as 1.2 and 1.3.