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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Methods for Evaluating the Relative Lightfastness and Weatherability of Printed Matter[1]

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1. Scope

1.1 These test methods cover the determination of the relative lightfastness and weatherability of printed matter under the following seven conditions, of which two involve exposure to natural daylight and five involve accelerated procedures in the laboratory:

1.1.1 *Test Method 1*—Daylight behind window glass,

1.1.2 *Test Method 2*—Outdoor weathering,

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

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

1.1.5 *Test Method 5*—Enclosed carbon-arc lamp without water spray,

1.1.6 *Test Method 6*—Enclosed carbon-arc lamps with water spray, and

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

1.2 These test 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 test 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 *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:*

D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials[2]

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[2]

D 2616 Test Method for Evaluation of Visual Color Differences with a Gray Scale[2]

D 4302 Specification for Artists' Oils, Resin Oil, and Alkyd Paints[3]

D 4674 Test Method for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Fluorescent Lighting and Window-Filtered Daylight[4]

D 5067 Specification for Artists' Watercolor Paints[3]

D 5098 Specification for Artists' Acrylic Emulsion Paints[3]

E 284 Terminology of Appearance[2]

E 991 Practice for Color Measurement of Fluorescent Specimens[2]

E 1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry[2]

E 1347 Test Method for Color and Color Difference Measurements of Object-Color Specimens by Tristimulus (Filter) Colorimetry[2]

E 1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry[2]

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials[5]

G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[5]

G 24 Practice for Conducting Exposures to Daylight Filtered Through Glass[5]

G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[5]

G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[5]

2.2 *ANSI Standard:*

PH 2.30 for Graphic Arts and Photography—Color Prints, Transparencies and Photomechanical Reproductions,

[1] These test methods are under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.56 on Printing Inks.

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[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vol 06.02.

[4] *Annual Book of ASTM Standards*, Vol 08.03.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

Viewing Conditions[6]

3. Terminology

3.1 Definitions relating to weathering tests are covered in Terminology G 113. Definitions relating to color attributes and color differences are covered in Practice D 1729 and Test Method D 2244. Other appearance terms used in these test methods are defined in Terminology E 284.

3.2 *Definitions:*

3.2.1 *radiant exposure, H, n*—time integral of the irradiance at a given point over a specified time interval.

3.2.2 *Discussion*—Radiant exposure is usually a spectral quantity, with units of joules per square metre per unit wavelength [$J/m^2 \cdot nm$]. The wavelength region to be covered should be specified.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *ultraviolet radiant exposure*—an integration with respect to time of the ultraviolet irradiance on the exposed face of the specimen. UV irradiance (wavelengths below 400 nm) is believed largely responsible for degradation of organic materials. Units are J/m^2.

4. Summary of Test 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.

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 test 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.

5.2.2 Exploratory studies demonstrated that the fluorescent-lamp apparatus ranked a series of 16 printed specimens in nearly the same order as did fluorescent lighting prevailing in cooperating laboratories.

5.3 To accommodate variations in light intensity among days, seasons, locations, or instruments, duration of exposure is preferably expressed as the cumulative ultraviolet radiant exposure 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 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 on 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 1—Specifications D 4302, D 5067, and D 5098 provide useful guides to the lightfastness of pigments in several types of artists' paints after 1260 MJ/m^2 total radiant exposure (equivalent to about 2 or 3 months' exposure to daylight behind glass). 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 *Test Method 1 Daylight Behind Window Glass*—Outdoor exposure cabinet conforming to Method A of Practice G 24. The cabinet is covered with window glass that transmits typically less than 3.5 % at wavelengths shorter than 310 nm. Accessories include a mutually agreeable radiometer[7] (for example, 295 to 385 nm), and humidity and temperature recorders.

6.1.2 *Test Method 2 Outdoor Weathering*—Outdoor exposure rack conforming to Practice G 7. Accessories are the same as in 6.1.1 with the addition of a wetness meter and rain gage.

6.1.3 *Test Methods 3 and 4 Xenon-Arc*—Xenon-arc lamp apparatus of the water-cooled or air-cooled type conforming to Practice G 26. An alternative air-cooled apparatus is described in Annex A1. According to Practice G 26, the water-cooled apparatus is equipped with a borosilicate/soda lime filter system to simulate natural daylight filtered through window glass for Test Method 3 or with a borosilicate filter system to simulate the spectral-power distribution of unfiltered natural daylight for Test Method 4. Accessories include a narrow-band radiometer[8] (340 ± 1.0 nm) for water-cooled apparatus or a broad-band radiometer (for example, 300 to 400 nm) for air-cooled apparatus, black-panel and air temperature thermometers, humidity recorder, and specimen holders.

[6] Available from American National Standards Institute, 13th Floor, 11 W. 42nd St., New York, NY 10036.

[7] The most popular radiometer in the United States monitors in the wavelength range 295 to 385 nm, which accounts for about 80 % of the solar UV irradiance between 300 and 400 nm. A radiometer that measures a narrow spectral band may also be used.

[8] Modern devices are equipped with a built-in radiometer calibrated for use in the instrument in which it is installed. Proper radiometers for older equipment are available from the manufacturer.

6.1.4 *Test Methods 5 and 6 Enclosed Carbon-Arc*—For Test Method 5, single enclosed carbon-arc apparatus type D, DH, H or HH (the second H indicates humidity control) conforming to Practice G 23. For Test Method 6, twin enclosed carbon-arc Type D or DH conforming to Practice G 23. Accessories include glass globes, carbons, specimen holders, and a black-panel thermometer unit.

6.1.5 *Test Method 7 Fluorescent-Lamp Apparatus*—Exposure cabinet conforming to Test Method D 4674. The cabinet is constructed of UV reflective aluminum with a clear chromatic conversion coating, and the light source is a combination of very high-output cool white fluorescent lamps and soda lime glass-filtered fluorescent UV sunlamps. Accessories include a broad-band detector (250 to 400 nm) and a temperature sensing device.

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 D 2616.

6.2.3 *Color Measuring Instrument*, (for instrumental evaluation), such as a spectrophotometer conforming to Test Method E 1331 or E 1349, or a tristimulus colorimeter conforming to Test Method E 1347, or, if the specimens are fluorescent, to Practice E 991.

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 Practices G 23 or G 26.

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 sunlight or the operating light source of an accelerated 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 test 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.

NOTE 2—**Caution:** 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 D 1729 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 3—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, make certain that the size of each exposed area conforms to 9.4. Place specimens intended for xenon-lamp 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 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:

TEST 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).

NOTE 4—Either site averages about 0.5 MJ/m^2 of total ultraviolet radiation under glass per day.

10.1.2 Mount the 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 G 24.

TEST METHOD 2 OUTDOOR WEATHERING

10.1.4 Commercial sites are the same as in 10.1.1.