Designation: D 3424 – 01

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 apparatus with window glass filters to simulate daylight behind window glass,

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

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

1.1.6 *Test Method 6*—Enclosed carbon-arc apparatus 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 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]

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources[5]

G 153 Practice for Operating Enclosed Carbon Arc Light

[1] These test methods are 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] *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 14.04.

Apparatus for Exposure of Nonmetallic Materials[5]
G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials[5]
2.2 *ANSI Standard:*
PH 2.30 for Graphic Arts and Photography—Color Prints, Transparencies and Photomechanical Reproductions, 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·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.

NOTE 2—All equipment must be calibrated in accordance with the manufacturer's instructions.

6.1.3 *Test Method 3 Xenon-Arc with Window Glass Filters*—Xenon-arc apparatus equipped with a window glass filter system to simulate natural daylight filtered through window glass as specified in the Apparatus sections of Practices G 151 and G 155.

6.1.4 *Test Method 4 Xenon-arc with Daylight Filters and Water Spray*—Xenon-arc apparatus equipped with a daylight

[6] Available from American National Standards Institute, 25 West 43rd St., 4th Floor, 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.