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Standard Test Methods for Lightfastness of Colorants Used in Artists' Materials[1]

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1. Scope

1.1 Four test methods to accelerate the effects of long term indoor illumination on artists' materials are described below. One of the natural daylight methods and one of the xenon-arc methods are used to categorize the lightfastness of colorants.

1.1.1 *Test Method A*—Exposure in southern Florida to natural daylight filtered through window glass.

1.1.2 *Test Method B*—Exposure in Arizona to natural daylight filtered through window glass.

1.1.3 *Test Method C*—Exposure in a non-humidity controlled xenon-arc device simulating daylight filtered through window glass.

1.1.4 *Test Method D*—Exposure in a humidity controlled xenon-arc device simulating daylight filtered through window glass.

1.2 These test methods are used to approximate the color change that can be expected over time in colorants used in artists' materials exposed indoors to daylight through window glass.

NOTE 1—The color changes that result from accelerated exposure may not duplicate the results of normal indoor exposure in a home, art gallery, or museum. The relative resistance to change, however, can be established so colored materials can be assigned to categories of relative lightfastness.

NOTE 2—Users who wish to test colored materials under fluorescent illumination should consult Practice D 4674.

1.3 Lightfastness categories are established to which colorants are assigned based on the color difference between specimens before and after exposure.

1.4 Color difference units are calculated by the CIE 1976 L*a*b* color difference equation.

1.5 These test methods apply to colored artists' materials.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 *This standard does not purport to address 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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

D 4302 Specification for Artists' Oil, Resin-Oil, and Alkyd Paints

D 4674 Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

D 5067 Specification for Artists' Watercolor Paints

D 5098 Specification for Artists' Acrylic Dispersion Paints

D 5724 Specification for Gouache Paints

D 6901 Specification for Artists' Colored Pencils

E 284 Terminology of Appearance

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry

E 1348 Test Method for Transmittance and Color by Spectrophotometry Using Hemispherical Geometry

E 1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry

G 24 Practice for Conducting Exposures to Daylight Filtered Through Glass

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

G 141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

3. Terminology

3.1 *Definitions*—Appearance terms used in these test methods are defined in Terminology E 284. Terms relating to natural and artificial lightfastness tests are defined in Terminology G 113.

3.1.1 *glass*, *n*—as used in these test methods, glass refers to single-strength window glass.

[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 D01.57 on Artist Paints and Related Materials.

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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.

4. Summary of Test Methods

4.1 Color measurements are made on duplicate specimens that have been prepared as directed in the specification for that material. Examples of specifications are: D 4302, D 5067, D 5098, D 5724, and D 6901. Each contains colorants in a different vehicle. The measurements are recorded for comparison with readings made after the specimens have been exposed.

4.2 Lightfastness is determined by exposing the specimens to daylight filtered through glass outdoors either in southern Florida or in Arizona and also to xenon arc radiation through a window glass filter.

4.3 The colorants are classified by the amount of color change calculated as ΔE* units in accordance with Practice D 2244.

4.4 Variations in test results can be due to differences in specimen preparation, surface irregularities, color measurements and conditions of exposure. Allowance for these variations is made by assigning a wide range of color change n each of the five lightfastness categories. Colorants are placed in one of these categories based on the mean of the ΔE* values obtained from two or more types of exposure. Only colorants that place in the first two categories conform to the requirements of this standard.

5. Significance and Use

5.1 The retention of chromatic properties by a colorant over a long period of years is essential in a work of art. Accelerated exposure simulates color changes that may reasonably be expected. The producer and the user of artists' materials, therefore, can be apprised of suitable colorants.

5.2 Variations in results may be expected between the test methods. Also, some variation may be expected when the same test is repeated. Variations in Methods A and B are due to differences in outdoor conditions that are not accounted for in testing to equivalent radiant exposures. Information on sources of variability and strategies for addressing variability in laboratory accelerated exposure tests is found in Guide G 141.

5.3 This standard does not cover factors other than lightfastness that can affect the permanence of art materials.

6. Apparatus

6.1 *Outdoor Exposure Facilities* as described in Practice G 24, using an exposure angle of 45°, facing the equator.

6.2 *Xenon-Arc Lightfastness Apparatus* as described in Practice G 155.

6.3 *Spectrophotometer*, abridged spectrophotometer or colorimeter capable of excluding specular reflectance in its measurement.

7. Procedure

7.1 Prepare seven specimens of the art materials to be tested, following the directions given in the appropriate specification. If there is no specification for the art material, seven specimens must be prepared that are as similar, uniform, and opaque as possible.

7.1.1 Two specimens of each color shall be exposed in each of two test methods, either A or B and either C or D. One specimen of each color shall be retained for a visual comparison with the test specimens following exposure, and two specimens shall be retained for use in a third exposure if needed.

7.1.2 The retained, unexposed specimens are stored in the dark unless the formulation contains oil. Store specimens that contain oil in a light level of 500 to 700 lux (50 to 75 fc) to prevent yellowing. If specimens must be stored for as long as 100 days, store all specimens in the dark, but remove those containing oil and place in the light level specified above to prevent yellowing for at least 7 days before measurement or visual evaluation.

7.1.3 Cut the specimen to a size that will fit the holder to be used for exposure and the port of the color measuring instrument.

7.1.4 Determine if test specimens are opaque. Colors mixed with white, as described in the specifications for artists' paints, are opaque. Other materials must be applied over both a black substrate and a white substrate to determine opacity. Any measured color difference between the color over black and over white indicates a lack of opacity.

7.1.4.1 A measurement representative of the whole specimen must be obtained if the specimen is not opaque. To get a representative measure of the color, both before and after exposure. either (1) use a large measuring port of 25 mm (1 in.) diameter, or (2) using a small port, obtain the mean of a number of measurements of various areas of the specimens, and compare it with the mean of a second set of measurements of different areas. If the means agree, use that value as the representative color. Otherwise, repeat the procedure until agreement is obtained.

7.2 Immediately before exposure, measure all test specimens using a spectrophotometer or spectrocolorimeter (see Test Method E 1348 or E 1349) or colorimeter (see Test Method E 1347) using Illuminant D65 and the 1964 10° Observer and excluding specular reflection from the measurement. Record the CIELAB measurement data.

7.2.1 Measure specimen panels with any brush marks in the same direction and measure the same area of the panel before and after each exposure interval. If the design of the instrument allows, three readings at different locations on the panel should be made and the mean calculated. If feasible, mark on the back of the specimen the spot(s) measured, and remeasure these same spots following exposure.

7.3 Expose duplicate specimens in each of two test methods, outdoor Test Method A or B and xenon arc Test Method C or D, as described below:

7.3.1 *Test Method A—Exposure in Southern Florida Below 27° Latitude to Natural Daylight Filtered Through Window Glass*—Test Method A can be used for under glass outdoor exposure if the material is an oil paint or acrylic dispersion paint on an aluminum substrate.

7.3.1.1 Mount duplicate specimens of each color on an open sided rack under glass and expose in southern Florida at a 45 degree angle to the horizontal facing south during October through May to a total global solar (290 to 2500 nm) radiation dose of 1260 MJ/m^2 incident on the glass, in accordance with Practice G 24.

7.3.2 *Test Method B—Exposure in Arizona to Natural Daylight Filtered Through Window Glass*—Use Test Method B if the test specimens are prepared on a paper substrate or the vehicle is affected by the combination of high moisture content and temperature fluctuations that are characteristic of south Florida. Examples are watercolor and gouache paints, colored pencils, colored water-thinned inks, and pastels.

7.3.2.1 Mount duplicate specimens in an enclosed black box with a small fan to circulate the air and expose in Arizona at a 45 degree angle to the horizontal facing south during October through May to a total global solar (290 to 2500 nm) radiation dose of 1260 MJ/m^2 incident on the glass, in accordance with Practice G 24

7.3.3 *Test Method C—Exposure Simulating Daylight Filtered Through Window Glass in a Xenon Arc Device That Does Not Control the Relative Humidity*—This method will generally have a low relative humidity.

7.3.3.1 Use a xenon-arc device that conforms to the requirements defined in Practices G 151 and G 155. Unless otherwise specified, the spectral power distribution of the xenon-arc shall conform to the requirements in Practice G 155 for xenon arc radiation through a window glass filter.

(a) Place specimens in the test device in positions that conform with specifications in Practice G 151 or use the procedures described in this practice that either ensure equal radiant exposure on all specimens or compensate for irradiance differences within the exposure chamber. To assure equal radiant exposure it may be necessary to reposition specimens during exposure.

7.3.3.2 Unless agreed otherwise, set the irradiance at the control point to 0.35 ± 0.02 at 340 nm and expose specimens to 100 % light to reach a total radiant exposure of 510 kJ/(m^2·nm) at 340 nm, the equivalent to 1260 MJ/m^2 of total solar radiation. For a xenon-arc device that controls exposure at 300 to 800 nm, set the irradiance at the control point to 500 W/m^2 and expose to 100 % light to reach a total radiant exposure of 739 MJ/m^2 at 300 to 800 nm. For xenon arc devices that control exposures in a different spectral region, consult the manufacturer of the device for the irradiance and radiant exposure required to produce equivalent test results.

7.3.3.3 The uninsulated black panel temperature shall be 63 ± 2°C. For the equivalent insulated black panel temperature, consult the manufacturer of the device.

NOTE 3—The set points specified for irradiance, temperature and humidity are the target conditions for the sensor programmed by the user at the control point. Therefore, when a standard calls for a particular set point, the user programs that exact number. The operational fluctuation specified with the set point does not imply that the user is allowed to program a set point higher or lower than the exact set point specified. Operational fluctuation is determined by the machine variable and is the maximum deviation allowable from the set point of the sensor at the control point during equilibrium conditions.

NOTE 4—To track the rate of color change in the xenon arc exposure, the total exposure time can be divided into three or more phases and the device programmed to stop at the end of each phase so the specimens can be measured and recorded. Then specimens are returned to the test chamber and exposure continues until the total required amount of irradiation is reached.

7.3.4 *Test Method D—Exposure Simulating Daylight Filtered Through Window Glass in a Humidity Controlled Xenon-Arc Device*—This environment will typically have higher relative humidity than Test Method C:

7.3.4.1 Follow 7.3.3.1.

7.3.4.2 Mount specimens in unbacked holders and follow step (a) in 7.3.3.1. It is recommended that all unused spaces in the specimen exposure area be filled with blank metal panels that are not highly reflective.

7.3.4.3 Follow 7.3.3.2.

7.3.4.4 Follow 7.3.3.3.

7.3.4.5 Set the relative humidity at the control point in the test chamber to 55 ± 5 % RH.

7.3.4.6 In machines that allow control of chamber air temperature, it shall be set at 43 ± 2°C.

NOTE 5—Duplicate specimens should not be placed near one another during the exposures.

NOTE 6—It has been found that Alizarin Crimson and other colorants are affected differently when exposed to a light/dark cycle rather than to continuous light. Dark periods are characteristic of exposure to daylight as well as to indoor lighting. Therefore, when mutually agreed upon, the following alternative light and dark cycle may be employed as an alternate constant light: 3.8 h light followed by 1 h dark. During the light period, the conditions of irradiance, temperature and humidity are as given in 7.3.3 or 7.3.4. During the dark period, the uninsulated black panel temperature shall be set at 35 ± 2°C at the control point. In machines that allow control of air chamber temperature, it shall also be set at 35 ± 2°C at the control point. In machines that allow control of relative humidity, it shall be set at 55 ± 5° RH at the control point, during both light and dark periods. Any variance from the specified test cycle must be detailed in the Report section.

7.4 Following exposure, if the surface of an exposed test specimen appears excessively streaked or spotty, showing areas of white substrate, assign that colorant to Lightfastness V.

7.5 Shortly after exposure, measure the exposed specimens not already placed in Lightfastness V, using Illuminant D65 and the 1964 10° Observer and with specular reflection excluded. Record the measurement.

7.6 Calculate the color difference between the recorded measurement of the specimen before exposure and the recorded measurement of the specimen after exposure in accordance with Practice D 2244 and state the color change in total color difference units ΔE^*_{ab}.

7.7 Measure the retained (unexposed) specimen of each color and compare the measurement with the pre-exposure measurement of that specimen to verify that the retained specimen has not changed color significantly during storage.

7.7.1 Unless the color of the retained specimen has changed significantly during storage, visually compare the retained specimen of each material with the exposed specimen of that material to verify that the measured color difference agrees with the perceived color difference. If the visual color difference is inconsistent with the color difference expressed in ΔE^*_{ab} units, remeasure both specimens and recalculate the color difference. Make this check following any subsequent exposures.

7.8 Find the mean of the CIELAB color differences calculated in 7.6 for the two specimens exposed outdoors by Test Method A or B. Find the mean of the color differences calculated in 7.6 for the two specimens exposed in a xenon-arc device by Test Method C or D.