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Standard Specification for Artists' Colored Pencils[1]

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1. Scope

1.1 This specification establishes requirements for composition, performance, and labeling of artists' colored pencils.

1.2 This specification covers vehicles and additives. Requirements are included for identification, lightfastness, and consistency.

1.3 Colored pencil specimens are exposed to both natural daylight through window glass and simulated window glass-filtered daylight radiation to determine the lightfastness rating for each pencil.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

D4236 Practice for Labeling Art Materials for Chronic Health Hazards

D4303 Test Methods for Lightfastness of Colorants Used in Artists' Materials

E284 Terminology of Appearance

G24 Practice for Conducting Exposures to Daylight Filtered Through Glass

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

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

3. Terminology

3.1 *Definitions*—Refer to Terminology E284 for appearance terms used in this specification and to Terminology G113 for terms relating to natural and artificial lightfastness tests.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bloom, n*—a cloudy exudation on the surface of colored pencil due to wax migration.

3.2.2 *burnish, v*—to firmly rub the surface of the sample following application of the colored pencil until the binder breaks down and the color is forced into the texture of the substrate to improve coverage.

3.2.3 *colored pencil, n*—a core of extenders, binders, pigments and additives, such as wax/oil and thickeners surrounded by a casing.

3.2.4 *color stick, n*—a core of extenders, binders, pigments and additives, such as wax/oil and thickeners without a casing but sometimes with a paper sleeve.

3.2.5 *substrate, n*—white, uncoated, neutral pH, buffered paper, or board, without optical brighteners, to which color is applied.

3.2.6 *watercolor pencil, n*—a colored pencil with a water-dispersible core.

3.2.7 *water-soluble color stick, n*—a water-dispersible color stick.

4. Significance and Use

4.1 This specification establishes quality requirements and provides a basis for common understanding among producers, distributors, and users.

4.2 It is not intended that all pencils meeting the requirements be identical nor of uniform excellence in all respects. Variations in manufacture, not covered by this specification, may cause some artists to prefer one brand over another, either of which may be acceptable under this specification.

4.3 Variation in test results can result from differences in pigment manufacture from time to time in a company, different varieties of a pigment from company to company, different combinations of pigments and other ingredients, specimen preparation, different instruments and instrumental readings, variations in the surface of the specimen, and the conditions of

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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.

exposure. Allowance for these variations is made by establishing lightfastness categories, each of which covers a defined range of color loss.

4.4 Since a specific colored pencil may be unusually sensitive to some aspect of a particular method of accelerated lightfastness testing and show a change in color that would not occur in a normal home or gallery environment, two types of exposure are required.

4.5 Some variation in test results is to be expected even when the same type of exposure is repeated; therefore, after triplicate specimens are exposed in each type of exposure, any outlier is discarded and the mean of the specimens is calculated for each exposure type to determine the lightfastness category for each. If the two types of exposures place colored pencil in the same lightfastness category, it is the category for that pencil. Instead of testing a third time if the two types of exposures place the colored pencil in different lightfastness categories, producers may elect to use the poorer of the two relevant lightfastness categories.

4.6 Variations in specimen preparation and measurement may result in as much as 4 units of CIE 1976 L*a*b* (CIELAB) color difference ΔE*, calculated using the equation given in Practice D2244, between the measurements of a test specimen before and after exposure; therefore, only color differences greater than 4 ΔE* are considered color loss.

5. Labeling Requirements

5.1 *Provide on the Pencil:*

5.1.1 Company or brand name.

5.1.2 Company assigned identification number for the pencil, or company assigned color name for the pencil, or both; however, pigment names shall not be used as pencil names unless the pencil contains only that pigment, or a variant of that pigment, or that pigment and white; otherwise the word "Hue" must be added to the name.

5.1.3 Country of origin.

5.1.4 The Colour Index Names of the pigments used in the pencil if space permits.

5.1.5 *Lightfastness*—Lightfastness Category indicated by the symbols I, II, III, IV or V. Only colored pencils in Lightfastness Categories I and II conform with this Specification.

5.2 *Provide in Literature Included in Packaging Container and at Points of Purchase:*

5.2.1 Identification of the type of pencil: colored, watercolor, color stick, water-soluble color stick.

5.2.2 Name and address of manufacturer, importer or supplier.

5.2.3 The Colour Index name and Constitution Number of every pigment in each pencil.

5.3 *Toxicity*—All products and labeling must conform to the Federal Hazardous Substances Act and to ASTM Practice D4236.

5.4 *Statement of Conformance*—Provide Statement of Conformance in literature and on packaging container if all pencils in the container are Lightfastness I or II: "Conforms to ASTM Specification D6901," or "Conforms to ASTM D6901." This statement may be combined with other conformance statements, such as, "Conforms to the quality and health requirements of ASTM Specification D6901 and Practice D4236."

6. Quality Assurance for Artists' Colored Pencils

6.1 *Conditions Not Covered in This Specification that Affect Colored Pencils:*

6.1.1 *Substrate*—The effective pH of the paper used will affect the long-term color appearance of the applied color.

6.2 *Additives*—Thickeners, preservatives, surfactants, wax, oil, and humectants may be used to achieve consistency, prevent microbial deterioration, and control application results.

6.3 Pencils shall be capable of being applied in a smooth, uniform coating of color without scratch marks.

6.4 The colored lead shall not crumble or break excessively when used with pressure sufficient to apply the color smoothly.

7. Specimen Preparation and Exposure

7.1 *Materials:*

7.1.1 *Colored Pencils, Watercolor Pencils, Color Sticks or Water-soluble Color Sticks*—Materials to be tested.

7.1.2 *Substrate*—White paper or board. To avoid substrate discoloration during the testing procedures, the substrate shall be 100 % cotton, acid free, buffered, uncoated, and contain no optical brighteners.

7.2 *Preparation of Test Specimens:*

7.2.1 Prepare ten specimens of each pencil or stick to be tested. Cut the paper substrate into a size that fits the holder to be used for exposure. Draw a specimen square 28 by 28 mm (1⅛ by 1⅛ in.) in the center of each paper substrate. Leave enough white substrate around each specimen so that the colored portion will not be damaged by handling or instrument mounting hardware. Using constant pressure, color each specimen substrate evenly and firmly with the colored pencils, watercolor pencils, color sticks, or water-soluble color sticks. Repeat as necessary to completely cover the square drawn on the substrate. In the case of a metallic color, finish with parallel strokes in whichever direction results in an even metallic sheen. Burnish each sample to make coverage as complete and uniform as possible.

NOTE 1—It is difficult to achieve an even coating of the color with complete hiding of the substrate. If the substrate is not completely covered, measurement will vary from spot to spot. If the coating has varying thicknesses, the specimen will fade unevenly. In these cases the complete surface of the substrate in the colored area may have to be measured to get a repeatable and reproducible measurement that represents the average color of the specimen. If a 25 mm (1 in.) diameter instrument measuring port is used, the whole colored surface of the specimen is measured; if a smaller measuring port is used, additional measurements of different portions of the colored surface of the specimen are necessary to accurately represent the color.

7.3 *Color Measurement Prior to Exposure:*

7.3.1 Prior to conducting the measurements described in 7.3.2, gently wipe each specimen with cotton to remove any surface bloom. Repeat this step immediately before specimen exposure.

7.3.2 The color difference among the ten replicate specimens and the uniformity of color on each specimen shall be <4 CIELAB units. Color measurements are made using either a spectrophotometer, spectrocolorimeter, or colorimeter set to use Illuminant D65 and the 1964 10° observer and excluding specular reflection from the measurement. Reproducibility among specimens can be determined using a 25 mm, viewing port on the color measurement device. For color uniformity across the colored area, use a 10 mm or smaller viewing port. If the color difference among specimens or non-uniformity across the specimen exceeds 4 CIELAB units, apply more color to specimens as needed until they meet the uniformity requirement.

7.3.2.1 When using a 25 mm viewing port, make three measurements. After each measurement, lift, partially rotate the specimen, and reposition the viewing port for the next measurement. Find the mean of these measurements in CIELAB units and record it as the value for the unexposed specimen.

7.3.2.2 When using an instrument with a 10 mm or smaller measuring port, make 5 measurements. After each measurement, lift, partially rotate the specimen, and reposition the measuring port for the next measurement. Find the mean of these measurements in CIELAB units and record it as the value for the unexposed specimen.

7.4 *Exposure:*

7.4.1 Three specimens of each color shall be exposed to glass filtered solar radiation using Method A. In addition, three specimens shall be exposed in a xenon-arc device operating with window glass filters using Method B or C. One specimen of each color shall be retained for visual comparison with test specimens following exposure, and three specimens shall be retained for use in a third exposure, if needed.

7.4.2 Store the retained, unexposed specimens in the dark unless the formulation includes oil. Store specimens that contain oil in subdued light, 500 to 750 lx (50 to 75 fc), to prevent yellowing. If specimens must be stored for as long as 100 days, store then in the dark, but remove those containing oil and place in subdued light for at least seven days before measurement or visual evaluation.

7.4.3 *Test Method A—Exposure to Natural Daylight Filtered through Glass:*

7.4.3.1 Follow Practice G24 and expose specimens during the months from September through May in an Arizona test site in a window glass covered Black Box containing a small fan to circulate the air. Conduct the exposure with the Black Box positioned to a 45° angle to the horizontal, facing the equator. Expose the samples to a total global solar (290 to 2500 nm) radiation dose of 1260 MJ/m^2 incident on the glass.

7.4.4 *Test Method B—Exposure to Xenon-Arc Radiation Simulating Daylight Filtered Through Window Glass:*

7.4.4.1 Use a xenon-arc device that conforms to the requirements defined in Practices G151 and G155. Unless otherwise specified, the spectral power distribution of the xenon-arc device shall conform to the requirements in Practices G151 and G155 for xenon arc radiation through a window glass filter.

7.4.4.2 Place specimens in the test device in positions that conform with irradiance uniformity specified in Practice G151, or to assure equal radiant exposure, reposition specimens during exposure.

NOTE 2—Replicate specimens should not be placed near one another during the exposures.

7.4.4.3 When only a few colored pencil specimens are being exposed in a small xenon-arc device, test all triplicates at the same time. However, if there are too many specimens for all triplicates to fit in the device at once, test one or two replicate specimens at a different time.

NOTE 3—To track the rate of color change in specimens as a function of radiant exposure in the xenon-arc device, the radiant exposure of 1260 MJ/m^2 can be divided into three or more phases and the device programmed to stop at he end of each phase so the color can be measured and recorded. The specimens are then returned to the test chamber and exposure is continued until the specified radiant exposure is reached.

7.4.4.4 Unless agreed otherwise, in a xenon-arc device that controls at 340 nm, the irradiance at the control point shall be 0.35 ± 0.02 W/(m^2·nm) at 340 nm and specimens exposed to 100 % light to reach a total radiant exposure of 510 kJ/(m^2·nm) at 340 nm, the calculated equivalent of 1260 MJ/m^2 of full spectrum solar radiation. For a xenon-arc device that controls exposure at 300 to 800 nm, the irradiance at the control point shall be 500 ± 75 /w/m^2 at 300 to 800 nm and specimens exposed 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. For further information see Appendix XI in Test Methods D4303.

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

NOTE 4—Each of the set points and its tolerances specified represent an operational control point for equilibrium conditions at a single location in the cabinet, which may not necessarily represent the uniformity of these conditions throughout the cabinet. The set point is the target condition for the control sensor with the exact number specified programmed by the user. The operational fluctuation given 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. The operational fluctuation specified is the maximum deviation allowable from the set point of the sensor at the control point during equilibrium conditions.

7.4.5 *Test Method C — Exposure Simulating Daylight Filtered Through Window Glass in a Humidity Controlled Xenon-arc Device*—This environment will typically have higher relative humidity than Method B.

7.4.5.1 Follow 7.4.4.

7.4.5.2 Mount specimens in unbacked holders and follow 7.4.4.2. It is recommended that all unused spaces in the specimen exposure area be filled with blank metal panels that are not highly reflective.

7.4.5.3 Follow 7.4.4.3.

7.4.5.4 Follow 7.4.4.4.

7.4.5.5 Set the relative humidity at the control point in the test chamber to 55 % RH and maintained at ± 10 % RH.

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

NOTE 5—It has been found that Alizarin Crimson and other pigments are affected differently when exposed to a light/dark cycle rather than to continuous light. Dark periods are characteristic of daylight and indoor light. Therefore, when mutually agreed on, the following light/dark cycle may be employed as an alternate to 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 7.4.4.4. 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 ± 10 % at the control point, during both the light and dark periods. Any variance from the specified test cycle must be detailed in the Report section.

8. Measurement After Exposure

8.1 Following exposure, but prior to measurement, gently wipe each colored pencil test specimen with cotton to remove any bloom.

8.2 If the colored area of an exposed test specimen appears excessively streaked or spotty, showing areas of white paper, assign that colored pencil to Lightfastness V.

8.3 Shortly after exposure, if a 25 mm measuring port is used, make three measurements of each exposed specimen not already placed in Lightfastness V as described in 7.3.2.1. Use Illuminant D65 and the 1964 10° observer and with specular reflection excluded. Record the measurements of each specimen as the color of the exposed specimen.

8.3.1 If the measurement port is smaller than 25 mm and the pencil has not already been placed in Lightfastness V, make five measurements of each specimen as described in 7.3.2.2. Record the mean of these measurements as the color of the exposed specimen panel.

8.4 For each specimen, 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 D2244 and state the color change in total color difference units, ΔE^*_{ab}.

8.5 Gently remove any bloom from the retained (unexposed) specimen prepared from each colored pencil, measure them 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.

8.6 Unless the color of the retained specimen has changed significantly during storage, visually compare the retained specimen of each pencil with the exposed specimen of that pencil 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 CIELAB color difference units, remeasure both specimens and recalculate the color difference. Make this check also following any subsequent exposures.

8.7 Examine the CIELAB color differences, expressed as ΔE^*_{ab}, for the triplicate exposed in Text Method A and also for the triplicate specimens exposed in either Test Method B or C. Find the mean of the CIELAB color differences of the exposed triplicate specimens, expressed as ΔE^*_{ab}, for Test Method A. This is the test result for that exposure method. Find the mean of the CIELAB color differences of the exposed triplicate specimens, expressed as ΔE^*_{ab} for Test Method B or C. This is the test result for that exposure method. In both Test Method A and Test Method B or C, if the color difference of one of the three specimens is 5 ΔE^*_{ab} or more units larger than the closest of the other two test results, discard that test result as aberrant. If one test result was discarded as aberrant, find the mean of the CIELAB color differences of the remaining two specimens, expressed as ΔE^*_{ab}. This is the test result for that exposure method.

8.7.1 Use the ΔE^*_{ab} from Test Method A and the ΔE^*_{ab} from Test Method B or C to assign lightfastness categories as described in Section 9.

8.7.2 If Test Method A and Test Method B or C place the colored pencil in the same lightfastness category, then the colored pencil is assigned to that lightfastness category and no further action is required.

8.7.3 If Test Method A and Test Method B or C place the colored pencil in different lightfastness categories, or if the two test method results are within ± 0.5 ΔE^*_{ab} of the dividing line between lightfastness categories, conduct a re-test using the test method that yielded a lower lightfastness rating or place the pencil in the poorer of the two relevant lightfastness categories.

8.7.3.1 When a re-test is conducted, expose triplicate specimens as outlined in Section 7.

8.7.3.2 After the re-test exposure is complete, if the color difference of one of the three specimens is 5 ΔE^*_{ab} or more units larger than the closest of the other two specimens, discard that test result as aberrant.

8.7.3.3 Find the mean of the CIELAB color difference expressed as ΔE^*_{ab}, of the exposed triplicate specimens, or duplicate specimens if one has been discarded, for the re-tested Test Method. This is the test result for that Test Method.

8.7.4 Using the ΔE^*_{ab} results of the re-test, assign lightfastness categories as described in Section 9. If the new results of Test Method A and Test Method B or C place the colored pencil into the same lightfastness category, then assign the colored pencil to that lightfastness category. If the results still place the colored pencil into different lightfastness categories, then assign the colored pencil to the poorer of the two relevant lightfastness categories.

9. Interpretation of Results

9.1 When a very light color specimen loses all, or almost all, color during exposure, this loss of color does not result in a large CIELAB color difference between the specimen before and after exposure. Therefore, place all colored pencils whose test specimen bleached, or lost almost all color, into Lightfastness Category V regardless of the size of the CIELAB color difference.

9.2 *Lightfastness I*—Assign colored pencils that exhibit a mean color change of $\Delta E^*_{ab} \leq 4$ to Lightfastness Category I.

9.3 *Lightfastness II*—Assign colored pencils that exhibit a mean color change of $\Delta E^*_{ab} > 4$ and ≤ 8 to Lightfastness Category II.

9.4 For information and to establish nomenclature, the following ratings are listed. Colored pencils with these ratings do not conform to this specification.

9.4.1 *Lightfastness III*—Assign colored pencils that exhibit a mean color change of ΔE^*_{ab} >8 and ≤16.0 to Lightfastness Category III.

9.4.2 *Lightfastness IV*—Assign colored pencils that exhibit a mean color change of ΔE^*_{ab} >16 and ≤24 to Lightfastness Category IV.

9.4.3 *Lightfastness V*—Assign colored pencils that exhibit a mean color change of ΔE^*_{ab} >24 or have lost all but a trace of color to Lightfastness Category V.

10. Report

10.1 It is assumed that this report will be written after a lightfastness test conforming to Specification D6901 has been completed on a group of colored pencils. The following applies to reports for both methods:

10.1.1 Name of company.

10.1.2 ASTM test methods used.

10.1.3 Colored pencil type.

10.1.4 Colour Index Names and Constitution Numbers of every pigment in each pencil for all colored pencils tested.

10.1.5 Date when exposure began.

10.1.6 CIELAB values of L*, a*, and b* for test specimens prior to exposure.

10.1.7 Date when test specimens were removed from exposure, and total exposure time.

10.1.8 CIELAB values of L*, a*, and b* for test specimens following exposure. If it is not possible to measure specimens immediately after removal from exposure, give the date when measured.

10.1.9 Lightfastness category for all test specimens as determined in Section 9.

10.2 The following is specific information required for each of the test methods:

10.2.1 *Test Method A:*

10.2.1.1 Total radiant exposure, in MJ/m^2.

10.2.2 *Test Method B or Test Method C:*

10.2.2.1 Name and model of apparatus used.

10.2.2.2 Exposure cycle used (100 % light or light/dark cycle).

10.2.2.3 Irradiance level and tolerance limits in $W/(m^2 \cdot nm)$ at 340 nm, at the machine control point.

10.2.2.4 Radiant exposure at 340 nm, in $kJ/(m^2 \cdot nm)$.

10.2.2.5 Relative humidity, if measured.

10.2.2.6 Uninsulated black panel temperature. If light and dark periods are employed, then uninsulated black panel temperature must be listed for each period.

10.2.2.7 Chamber air temperature, if measured. If light and dark periods are employed, then the chamber air temperature must be listed for each period.

10.2.2.8 Specimen repositioning schedule, if used.

11. Keywords

11.1 colored pencils; daylight through window glass; lightfastness; quality requirements; test specimens; xenon arc exposures

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 This specification includes a method for placing colored pencils in general lightfastness categories that can be communicated to artists on labels and literature. The test method must not only provide accurate information to artists, but also ensure that different companies testing the same formulation at different times and using different combinations of the xenon arc machines (simulating daylight through window glass) and window glass filtered natural daylight exposure, will place the pencil in the same Lightfastness Category. The following studies have been conducted to select the appropriate test conditions for colored pencils.

X1.1.1 *Round Robin 1*—Two specimens of fifteen colored pencils were exposed in six types of accelerated exposure, three exposures under glass to natural summer daylight, two of these in south Florida and one in Arizona; and three exposures in different xenon arc machines filtered to simulate daylight through window-glass. Four papers used as substrates and a set of eight PPLF Reference Standards were included in the exposures. The Florida and Arizona exposures in Type A cabinets were eliminated due to excess moisture and summer heat, respectively. Type A and Type B cabinets are described in Practice G24. Using the procedure given in Test Methods D4303 80 % of the pencils were placed in the same lightfastness category no matter which combination of the remaining natural and xenon arc exposures were selected; however, many of the pencils fell in the poorer categories, which do not conform with the specification.

X1.1.2 *Round Robin 2*—Five colored pencils were selected that fell on the borderlines between Lightfastness Categories I, II, and III in Round Robin 1. Triplicates of each color and a PPLF Reference Standard 4 were exposed under glass to natural daylight in three Type B cabinets in Florida. Two were winter exposures and one a summer exposure. Triplicates of the same pencils were also exposed in five xenon arc machines with window-glass filters. Two machines could monitor irradiance at 340 nm. The ability to monitor irradiance at 340 nm was established as significant, and moisture in the Florida

boxes remained a concern. The largest variation in test results was due to incomplete hiding of the substrate.

X1.1.3 Triplicate specimens were prepared from four of the above colored pencils on three papers that were found satisfactory as substrates in Round Robin 1. Measurement showed that these specimens were at complete hiding.

X1.1.4 Duplicate specimens of fifty colored pencils known to fall in Lightfastness Categories I, II, or III, were exposed in the fall months of the year to natural daylight in Arizona using Type A and Type B cabinets, and in south Florida using a Type A cabinet. These duplicates were also exposed in two xenon arc machines with window-glass filters. Thirty-eight of the fifty pencils were placed in the same Lightfastness Category by a combination of the Arizona test in the Type B cabinet and either of the xenon arc machine tests; however, one machine could not monitor irradiance at 340 nm. Thirty-four of the fifty pencils were also tested in a second xenon arc machine that monitored radiance at 340 nm. After outliers were discarded and pencils that tested as borderline between Lightfastness Categories were retested, there was only one pencil that was placed in one Category by one combination of Arizona and xenon arc exposure and in another Category by the other Arizona and xenon arc combination. This indicates that this test method may result in 97 % of the pencils being placed in the same Lightfastness Category, even when different xenon arc machines are used, as long as radiant exposure reaches 510 kJ/(m^2·nm) measured at 340 nm. Alternatively, rather than retesting borderline pencils, companies may choose to place these pencils in the poorer of the bordering Categories.