Designation: D7251 – 11

An American National Standard

Standard Specification for Color and Appearance Retention of Variegated Color Plastic Siding Products[1]

This standard is issued under the fixed designation D7251; 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 specification establishes requirements and test methods for the color and appearance retention of variegated color plastic siding products.

1.2 Color retention testing provides a method for estimating the acceptability of color change in a siding product over a period of years of service.

1.3 Characterization of color and appearance for variegated colors is complicated by the presence of multiple colors in a random pattern. The procedure is based on using a template to reference six spots for color measurement.

1.4 Methods of indicating compliance with this specification are provided.

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.*

NOTE 1—There is no known ISO equivalent to this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

D1435 Practice for Outdoor Weathering of Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

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

E805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

3. Terminology

3.1 *Definitions*—Definitions are in accordance with terminologies in Terminologies D883 and D1600 unless otherwise noted.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *color region*—parameters that define the color space for a siding sample, measured with Hunter Units, sphere geometry (di:8), Illuminant C, 2° Observer, specular component included.

3.2.1.1 *Discussion*—The color values used to classify colors by region were established by measuring the Hunter L, a, b color values from the sample population, calculating the average for Hunter L, a, b, and then choosing the integer from the corresponding L, a, b average values (that is, by truncating any fractional result) to be used to classify colors by region. Thus, average values greater than zero are truncated down to the next lowest integer, and average values less than zero are truncated up to the next highest integer. All values greater than -1 and less than +1 truncate to 0.

3.2.2 *color retention standards*—predictive color regions described by a three dimensional model which constitute acceptable color retention levels resulting from weathering of a specific product type and color.

3.2.2.1 *Discussion*—Color retention standards are defined by equations that describe the three dimensional ellipsoid value.

3.2.3 *ellipsoid value*—a mathematical calculation derived by inserting the measured ΔL, Δa, and Δb values of a weathered specimen into an ellipsoid equation.

3.2.4 *temperate northern climate—in weathering testing*, a North American metropolitan area testing site located within 73 to 100°W longitude and 37 to 45°N latitude.

3.2.5 *variegated plastic siding*—siding having discrete markings of different colors.

4. Classification

4.1 *Definitions*—Definitions are in accordance with terminology in Terminologies D883 and D1600 unless otherwise noted.

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.24 on Plastic Building Products.

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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**

4.2 *Color Regions*—The color region for a color is determined by measuring the Hunter L, a, b color values at six locations on each specimen in a sample population and calculating the average Hunter L, a, b color value. Use the integer value (by truncating any fractional result) of the average to determine the color region for the color using the following region boundaries.

4.2.1 *Region 1*—Brown

L = 20 to 49
a = –1 to 5
b = 2 to 11

L = 25 to 49
a = –8 to 5
b = 12 to 25

4.2.2 *Region 2*—Medium Blue

L = 45 to 64
a = –26 to 1
b = –25 to –2

4.2.3 *Region 3*—Light Blue

L = 65 to 93
a = –12 to 1
b = –25 to –2

4.2.4 *Region 4*—Green

L = 50 to 84
a = –12 to –1
b = –1 to 10

L = 50 to 64
a = –25 to –3
b = 11 to 30

L = 50 to 64
a = –25 to –13
b = –1 to 10

L = 65 to 93
a = –25 to –13
b = 25 to 30

L = 85 to 93
a = –12 to –3
b = –1 to 3

4.2.5 *Region 5*—Medium Beige

L = 50 to 74
a = 0 to 1
b = 4 to 12

L = 50 to 64
a = –2 to 1
b = 11 to 15

L = 65 to 74
a = –12 to –1
b = 11 to 12

4.2.6 *Region 6*—Light Beige

L = 75 to 84
a = 0 to 1
b = 4 to 12

L = 85 to 93
a = –12 to 1
b = 4 to 12

L = 75 to 84
a = –12 to –1
b = 11 to 12

4.2.7 *Region 7*—Gold

L = 65 to 93
a = 0 to 4
b = 13 to 30

L = 65 to 93
a = 5 to 25
b = 16 to 30

4.2.8 *Region 8*—Yellow

L = 65 to 93
a = –12 to –1
b = 13 to 30

4.2.9 *Region 9*—White

L = 85 to 100
a = –2 to 1
b = –1 to 3

All L = 94 to 100

4.2.10 *Region 10*—Light Gray

L = 65 to 84
a = 0 to 1
b = –1 to 3

4.2.11 *Region 11*—Mauve

L = 65 to 93
a = 2 to 25
b = 2 to 12

L = 65 to 93
a = 5 to 25
b = 13 to 15

L = 50 to 64
a = 2 to 25
b = 2 to 30

L = 50 to 64
a = –2 to 1
b = 16 to 30

4.2.12 *Region 12*—Medium Gray

L = 50 to 64
a = 0 to 1
b = –1 to 3

4.2.13 *Region 13*—Dark Gray

L = 25 to 49
a = –1 to 5
b = –1 to 1

4.2.14 *Region 14*—Dark Blue

L = 25 to 44
a = –25 to 3
b = –25 to –2

4.2.15 *Region 15*—Dark Green

L = 25 to 49
a = –20 to –2
b = –1 to 11

4.2.16 *Region 16*—Dark Red

L = 25 to 49
a = 6 to 30
b = –1 to 25

4.2.17 *Region 17*—Purple

L = 25 to 44
a = 4 to 30
b = –25 to –2

L = 45 to 49
a = 2 to 30
b = –25 to –2

L = 50 to 93
a = 2 to 25
b = –25 to 1

4.3 *Ellipsoid Value Equations*—Use the following equations to determine the ellipsoid value representing the change in color due to weathering. Use the equation that corresponds to the color region determined for the specimen's initial color (prior to weathering) in 4.2.

4.3.1 *Region 1*—Brown

$$\frac{(\Delta L - 1.6)^2}{(5.2)^2} + \frac{(\Delta a + 1.0)^2}{(3.0)^2} + \frac{(\Delta b - 0.5)^2}{(2.5)^2} = \text{Ellipsoid Value}$$

4.3.2 *Region 2*—Medium Blue

$$\frac{(\Delta L + 1.0)^2}{(6.0)^2} + \frac{(\Delta a + 0.6)^2}{(2.9)^2} + \frac{(\Delta b - 0.8)^2}{(5.4)^2} = \text{Ellipsoid Value}$$

4.3.3 *Region 3*—Light Blue

$$\frac{(\Delta L + 0.3)^2}{(6.4)^2} + \frac{(\Delta a + 0.1)^2}{(2.7)^2} + \frac{(\Delta b - 0.8)^2}{(4.3)^2} = \text{Ellipsoid Value}$$

4.3.4 *Region 4*—Green

$$\frac{(\Delta L - 0.2)^2}{(5.9)^2} + \frac{(\Delta a - 0.8)^2}{(4.8)^2} + \frac{(\Delta b - 0.2)^2}{(5.6)^2} = \text{Ellipsoid Value}$$

4.3.5 *Region 5*—Medium Beige

$$\frac{(\Delta L + 0.1)^2}{(6.1)^2} + \frac{(\Delta a - 0.0)^2}{(2.8)^2} + \frac{(\Delta b - 0.4)^2}{(3.9)^2} = \text{Ellipsoid Value}$$

4.3.6 *Region 6*—Light Beige

$$\frac{(\Delta L - 0.0)^2}{(5.0)^2} + \frac{(\Delta a - 0.2)^2}{(2.6)^2} + \frac{(\Delta b - 0.3)^2}{(5.4)^2} = \text{Ellipsoid Value}$$

4.3.7 *Region 7*—Gold

$$\frac{(\Delta L + 0.6)^2}{(6.6)^2} + \frac{(\Delta a + 0.3)^2}{(3.4)^2} + \frac{(\Delta b + 0.4)^2}{(4.7)^2} = \text{Ellipsoid Value}$$

4.3.8 *Region 8*—Yellow

$$\frac{(\Delta L + 0.3)^2}{(5.5)^2} + \frac{(\Delta a - 1.0)^2}{(3.3)^2} + \frac{(\Delta b + 0.1)^2}{(5.5)^2} = \text{Ellipsoid Value}$$

4.3.9 *Region 9*—White

$$\frac{(\Delta L - 0.6)^2}{(8.2)^2} + \frac{(\Delta a + 0.0)^2}{(3.3)^2} + \frac{(\Delta b - 1.9)^2}{(5.3)^2} = \text{Ellipsoid Value}$$

4.3.10 *Region 10*—Light Gray

$$\frac{(\Delta L + 1.8)^2}{(7.0)^2} + \frac{(\Delta a - 0.2)^2}{(2.1)^2} + \frac{(\Delta b - 1.3)^2}{(4.0)^2} = \text{Ellipsoid Value}$$

4.3.11 *Region 11*—Mauve

$$\frac{(\Delta L - 0.4)^2}{(6.5)^2} + \frac{(\Delta a - 0.8)^2}{(4.0)^2} + \frac{(\Delta b - 1.1)^2}{(4.5)^2} = \text{Ellipsoid Value}$$

4.3.12 *Region 12*—Medium Gray

$$\frac{(\Delta L + 1.0)^2}{(6.6)^2} + \frac{(\Delta a + 0.3)^2}{(2.5)^2} + \frac{(\Delta b - 1.2)^2}{(3.7)^2} = \text{Ellipsoid Value}$$

4.3.13 *Region 13*—Dark Gray

$$\frac{(\Delta L - 0.1)^2}{(5.1)^2} + \frac{(\Delta a + 0.8)^2}{(3.4)^2} + \frac{(\Delta b + 0.1)^2}{(3.0)^2} = \text{Ellipsoid Value}$$

4.3.14 *Region 14*—Dark Blue

$$\frac{(\Delta L - 0.3)^2}{(5.2)^2} + \frac{(\Delta a - 1.0)^2}{(3.6)^2} + \frac{(\Delta b + 1.3)^2}{(4.5)^2} = \text{Ellipsoid Value}$$

4.3.15 *Region 15*—Dark Green

$$\frac{(\Delta L - 0.0)^2}{(5.0)^2} + \frac{(\Delta a + 0.4)^2}{(3.0)^2} + \frac{(\Delta b + 0.2)^2}{(3.8)^2} = \text{Ellipsoid Value}$$

4.3.16 *Region 16*—Dark Red

$$\frac{(\Delta L - 0.4)^2}{(5.4)^2} + \frac{(\Delta a - 0.8)^2}{(4.0)^2} + \frac{(\Delta b - 0.2)^2}{(3.0)^2} = \text{Ellipsoid Value}$$

4.3.17 *Region 16*—Purple

$$\frac{(\Delta L - 0.0)^2}{(6.0)^2} + \frac{(\Delta a - 0.0)^2}{(5.0)^2} + \frac{(\Delta b - 0.0)^2}{(5.2)^2} = \text{Ellipsoid Value}$$

5. Procedure for Measuring Color Retention

5.1 *Test Site Setup and Exposure Duration Test Times:*

5.1.1 Samples shall be exposed at three test sites: Temperate Northern represented by a site located in Louisville, KY or Cleveland, OH; hot, humid represented by a site located in Miami, FL, and hot, dry represented by a site located in Phoenix, Arizona. Additional test sites are permitted as agreed upon by the buyer and the seller.

5.1.2 All exposures shall be conducted at an angle of 45° facing South and backed using unpainted plywood in accordance with Practices D1435 and G147.

5.1.3 Remove test specimens for color measurement at 24-month exposure. In some cases, 24 months are not sufficient to distinguish material durability differences and longer exposure periods are necessary. Additional exposure times are permitted as agreed upon by the buyer and the seller.

5.2 *Sampling and Specimen Preparation:*

5.2.1 Samples shall be representative of the product to be evaluated.

NOTE 2—Samples prepared in the laboratory in the same manner as commercial samples are an acceptable alternate to a commercial part. If the commercial product is extruded, the laboratory specimen must be extruded; if the commercial product is injection molded, the laboratory specimen must be injection molded, and so forth.

5.2.2 Select a minimum of four specimens per sample per test site to allow for three test specimens and one file specimen for each sample evaluated.

5.2.3 The file specimen will be used for a visual assessment of variegation/contrast change. The test specimens will be measured for color and weathered.

5.2.4 Specimens shall be a flat section and a minimum of 3 by 10 in. (76 by 254 mm). The variegated pattern shall be parallel to the long edge of the specimen.

5.2.5 Use the Variegated Color Measurement Template to identify the 6 spots on each test specimen for color retention testing. The center points of these six spots are specified in Fig. 1. The diameter of the six spots is specified as 0.50 in. (12.2 mm) minimum. Those shown in the diagram are for illustration only.

5.2.6 The exact locations of these test spots must be determined and recorded for each test specimen to allow measurement of color change following exposure testing.

5.2.7 The locations and spot sizes identified in 5.2.5 for each test specimen shall not change once the exposure test is started.

5.2.8 Mark each specimen permanently to ensure retention of identity during and after exposure testing.

NOTE 3—Use of a vibratool leaves a permanent mark that satisfies this criteria.

5.3 *Data Record:*

5.3.1 Measured specimen color values shall be reported to one decimal place.

5.3.2 Calculation of color units shall be reported to one decimal place.

5.4 *Practice:*

5.4.1 Obtain test and file specimens in accordance with 5.2.

5.4.2 Measure the original tristimulus X, Y, and Z values for the six spots identified in 5.2.5 for each test specimen. Color is measured using sphere geometry (di:8), illuminant C, 2° observer, specular component included in accordance with Practice E805. The minimum aperture size for color measurement 0.50 in. (12.2 mm).

5.4.3 Calculate the Hunter L, a, and b units in accordance with the equations in the section on "Hunter L, a, and b Color Space and Color-Difference Equation" in Test Method D2244 using the average of the six measurements and record in a permanent record.

5.4.4 The measured average color of each test specimen is the specimen's initial color and is used to determine color change after specified periods of exposure testing.

5.4.5 Repeat steps 5.4.2 through 5.4.4 for each test specimen.

5.4.6 Calculate the average color in Hunter L, a, b for the three test specimens to determine their color region as defined in 4.2.

5.4.6.1 Calculate the overall average color of the three test specimens for each test site from step 5.4.5.

5.4.6.2 A single color region must be determined and used at all test sites. If the color regions determined for each test site are not the same, re-measure the test specimens for the non-conforming test site. If the three test sites still do not agree,

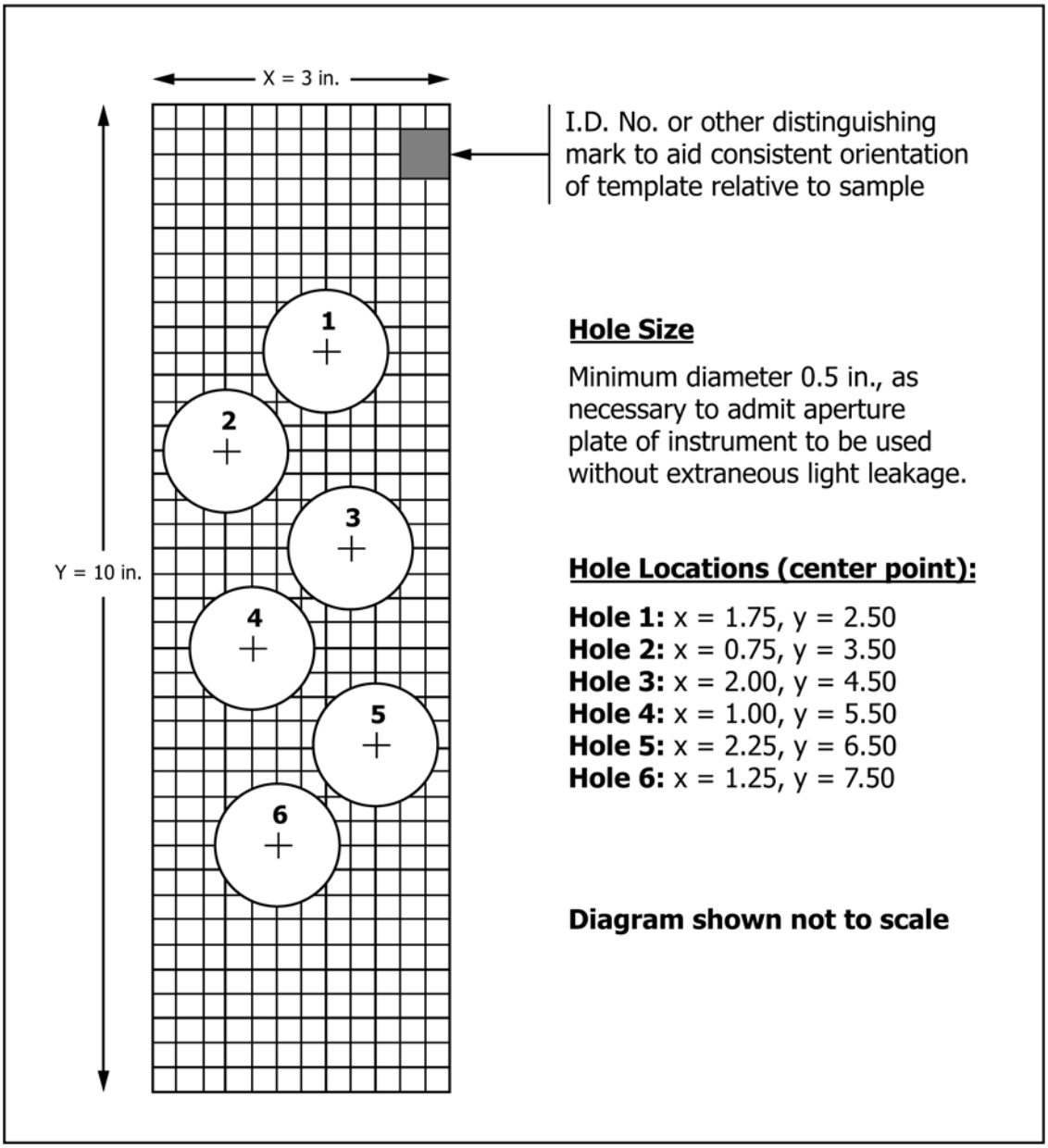

FIG. 1 Variegated Color Measurement Template

calculate the overall average color for test specimens from all sites to determine the sample's color region.

5.4.7 Expose the test specimens at the test sites in accordance with 5.1.1 and 5.1.2. Record in a permanent record the test start date.

5.4.8 Remove the test specimens at the exposure interval(s) in accordance with 5.1.3. Record in a permanent record the date the specimens are removed from the exposure test rack for color measurement.

5.4.9 The exposed test specimens shall be measured for color and evaluated for appearance. It is recommended that color measurement and appearance evaluation be conducted at the test site. Color measurement shall take place within seven days of specimen removal from the exposure test rack. It is recommended that color measurement take place within 48 h of the specimen's removal from the exposure test rack.

NOTE 4—Additional color development is known to occur for PVC products after removal from exposure to ultraviolet (UV) light. This artificial color change is referred to as Dark Time Yellowing. Color measurement within 48 h of removal is strongly recommended for PVC products.

5.4.10 Wash the exposed test specimens in accordance with the procedure in Annex A1.

5.4.11 Inspect each exposed test specimen for appearance and surface condition. Record observations and inspection date in a permanent record.

5.4.12 Referencing the file specimen, evaluate each test specimen for loss of variegation in accordance with 6.3.

5.4.13 Measure and record the color of each test specimen in accordance with 5.4.2 through 5.4.3 for each exposure time. Record in a permanent record the date the color of the specimen(s) is measured.

5.4.14 Referencing each test specimen's initial color determined in 5.4.5, calculate and record the color change in Hunter L, a, and b units for each test specimen.

5.4.15 In cases where specimens are evaluated at exposure times other than 24 months, the specimens shall be returned to the exposure test rack within seven days for continuation of the test; it is recommended the samples be returned to the test racks within 48 h. Record in a permanent record the date the specimens are returned to the exposure test rack.

NOTE 5—In case of dispute, the referee procedure shall be the use of separate specimens for each exposure time that can then be disposed after color measurements are made.

6. Performance Requirements

6.1 Using the ellipsoid value equations in 4.3, calculate the ellipsoid value for each test specimen using the measured color change determined in 5.4.14 and the appropriate color region determined in 5.4.6.

6.2 Acceptable color retention is determined by the average ellipsoid value of the three test specimens at each test location being less than or equal to 1.0. This value shall be calculated for each test site and exposure time. In addition, no individual specimen shall have an ellipsoid value of greater than 1.4.

6.3 Acceptable variegation change is presence of variegation. Failure is defined as complete loss of variegation and the presence of a uniform color.

6.4 The specimen shall be free of any visual surface or structural changes such as peeling, chipping, cracking, flaking, and pitting when tested in accordance to Section 5, Procedure for Measuring Color Retention.

ANNEX

(Mandatory Information)

A1. WASHING WEATHERING SPECIMENS

A1.1 Scope

A1.1.1 This procedure describes a practice for washing weathering specimens prior to instrumental color measurement. The procedure is intended to minimize any effects of altering the specimen's surface in other than a predictable manner.

A1.2 Equipment

A1.2.1 *Mild Detergent,*

A1.2.2 *Sponge,* or soft cloth.

A1.3 Procedure

A1.3.1 Flush exposed specimen with water.

A1.3.2 Gently wash the specimen with a dilute solution (0.05 % by weight in water, maximum concentration) of a mild detergent using a sponge or soft cloth.

A1.3.3 The washing action shall not be excessive and shall be limited to a back-and-forth motion along the grain or pattern, if one exists.

A1.3.4 Avoid circular motions.

A1.3.5 Rinse thoroughly with clean water to remove any mild detergent residue.

A1.3.6 The washed specimen shall air dry and be free of any water or moisture before conducting color measurements.

APPENDIX

(Nonmandatory Information)

X1.

X1.1 Ellipsoid Value Calculation—Example

Initial Color Reading of a Specimen	
L	78.0
a	0.5
b	8.5

X1.1.1 Based on the initial color reading, the specimen is in color region 6, Light Beige.

X1.1.2 Color measurements of the weathered specimen are:

Color Change Due to Weathering	
ΔL	2.5
Δa	1.1
Δb	–2.4

X1.1.3 Insert the ΔL, Δa, and Δb values into the ellipsoid equation for color region 6 to calculate the ellipsoid value for the observed color change due to weathering.

$$\frac{(2.5-0.0)^2}{(5.0)^2}+\frac{(1.1-0.2)^2}{(2.6)^2}+\frac{(-2.4-0.3)^2}{(5.4)^2}=\text{Ellipsoid Value}$$

$$0.3+0.1+0.2=\text{Ellipsoid Value}$$

$$0.6=\text{Ellipsoid Value}$$

X1.2 Guidelines for Using the Variegated Color Measurement Template

X1.2.1 The template is intended to provide the user a tool to reliably measure the color of areas on multiple occasions.

X1.2.2 The size of the holes in the template will vary depending on the aperture size and spectrophotometer configuration, that is, portable or benchtop.

X1.2.3 The template is to be used with both portable and bench top color spectrophotometers.

X1.2.4 Means for using the template for each of the above configurations are described.

X1.2.4.1 *Portable Color Spectrophotometer:*

(1) The template is placed on the test surface of the test specimen.

(2) Align and secure the template and test specimen together in a manner that allows the same area to be measured on multiple occasions.

(3) Align the measurement port of the spectrophotometer with template's circular opening to measure the test specimen's color.

(4) Repeat for the remaining five circular openings in the template.

X1.2.4.2 *Bench Top Color Spectrophotometer:*

(1) Many bench top spectrophotometers are configured with a spring-loaded clamp to hold the test specimen against the instrument's measurement port.

(2) This clamp is usually circular in shape and consequently provides a convenient way to index the test specimen.

(3) Design the template so the circular opening is the same diameter as the instrument's clamp.

(4) Place the template on the backside of the test specimen and trace the outline of each circular opening onto to the test specimen.

(5) Place the test specimen on spectrophotometer so the outer edge of the clamp is aligned with the circle indexed on the backside of the specimen.

(6) Measure the test specimen's color.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D7251 - 10) that may impact the use of this standard. (April 1, 2011)

(1) Revised 3.2.1.

Committee D20 has identified the location of selected changes to this standard since the last issue (D7251 - 09) that may impact the use of this standard. (January 1, 2010)

(1) Revised 4.2.7.