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An American National Standard

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

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1. Scope

1.1 This specification establishes requirements and test methods for the color and appearance retention of solid colored 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 Methods of indicating compliance with this specification are provided.

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

D3679 Specification for Rigid Poly(Vinyl Chloride) (PVC) Siding

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

2.2 *Other Reference:*

Vinyl Siding Institute (VSI) Technical Research Report for Weatherability of Vinyl Siding Products, VS2W

NOTE 2—This report supports the conclusion that commercial vinyl siding products which demonstrate weathering behavior within conformance to these standards during a two year test program can be anticipated to provide acceptable color retention properties for the expected life of the product.

3. Terminology

3.1 *Definitions*—Definitions are in accordance with 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 constitutes 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 within 73 to 100°W longitude and 37 to 45°N latitude.

4. Classification

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

4.2 *Color Regions*—The color region for a color is determined by measuring the Hunter L, a, b color values for a sample. Use the integer value (by truncating any fractional

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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.

result) to determine the color region for the color using the following region boundaries.

4.2.1 *Region 1—Brown:*

L = 20 to 49	L = 25 to 49
a = –1 to 5	a = –8 to 5
b = 2 to 11	b = 12 to 25

4.2.2 *Region 2—Medium Blue:*

L = 45 to 64
a = –25 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	L = 50 to 64	L = 50 to 64	L = 65 to 93	L = 85 to 93
a = –12 to –1	a = –25 to –3	a = –25 to –13	a = –25 to –13	a = –12 to –3
b = –1 to 10	b = 11 to 30	b = –1 to 10	b = –25 to 30	b = –1 to 3

4.2.5 *Region 5—Medium Beige:*

L = 50 to 74	L = 50 to 64	L = 65 to 74
a = 0 to 1	a = –2 to 1	a = –12 to –1
b = 4 to 12	b = 11 to 15	b = 11 to 12

4.2.6 *Region 6—Light Beige:*

L = 75 to 84	L = 85 to 93	L = 75 to 84
a = 0 to 1	a = –12 to 1	a = –12 to –1
b = 4 to 12	b = 4 to 12	b = 11 to 12

4.2.7 *Region 7—Gold:*

L = 65 to 93	L = 65 to 93
a = 0 to 4	a = 5 to 25
b = 13 to 30	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	All L = 94 to 100
a = –2 to 1	
b = –1 to 3	

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	L = 65 to 93	L = 50 to 64	L = 50 to 64
a = 2 to 25	a = 5 to 25	a = 2 to 25	a = –2 to 1
b = 2 to 12	b = 13 to 15	b = 2 to 30	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	L = 25 to 49
a = –25 to –2	a = –25 to –9
b = –1 to 11	b = 12 to 25

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	L = 45 to 49	L = 50 to 93
a = 4 to 30	a = 2 to 30	a = 2 to 25
b = –25 to –2	b = –25 to –2	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:*

$$\frac{(\Delta L + 0.4)^2}{(5.8)^2} + \frac{(\Delta a - 0.0)^2}{(2.8)^2} + \frac{(\Delta b - 0.0)^2}{(4.0)^2} = \text{Ellipsoid Value}$$

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:*

$$\frac{(\Delta L+1.0)^2}{(6.6)^2}+\frac{(\Delta a+0.3)^2}{(2.5)^2}+\frac{(\Delta b-0.5)^2}{(3.0)^2}=\text{Ellipsoid Value}$$

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 17—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, AZ. Additional test sites may be used 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 to Practices D1435 and G147.

5.1.3 Remove test specimens for color measurement at 24 month exposures. In some cases, 24 months may not be sufficient to distinguish material durability differences and longer exposure periods may be necessary. Additional exposure times may be used 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. Samples shall be taken either from commercial products or from laboratory samples. Laboratory samples shall be produced in the same manner as the commercial products to be evaluated.

NOTE 3—Production of laboratory samples in the same manner includes use of the same method of forming the product. For example, if the commercial product is extruded, the laboratory specimen shall be extruded; if the commercial product is injection molded, the laboratory specimen shall be injection molded, and so forth.

5.2.2 Select a minimum of 4 specimens per sample per test site to allow for 3 test specimens and 1 file specimen for each sample evaluated.

5.2.3 Specimens shall be a flat section and a minimum of 2 by 3¾ in. (51 by 95 mm).

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

NOTE 4—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 to 5.2. The following procedure is used at each of the three weathering locations.

5.4.2 Measure in replicate the original tristimulus X, Y, and Z values for the file specimen. Color is measured using sphere geometry (di:8), Illuminant C, 2° observer, and specular component included in accordance with Practice E805. 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 replicate measurements and record them in a permanent record.

5.4.2.1 Use the L, a, and b values to determine the color region in accordance with 4.2. This color region is used for all subsequent evaluation of color change of the weathered samples, and shall not be changed during the duration of the weathering study.

5.4.2.2 The initial L, a, and b values determined from the file specimens are used as the reference point for all measurements of color change of the weathered samples during the duration of the weathering study.

5.4.3 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.

5.4.4 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.

5.4.5 The exposed test specimens should 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 7 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 5—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.

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

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

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

5.4.9 Calculate and record the change in Hunter L, a, and b units for each specimen with reference to the specimen's initial color as determined in 5.4.2.

5.4.10 In cases where specimens are evaluated at exposure times other than 24 months, the specimens shall be returned to the exposure test rack within 7 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 6—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 The ellipsoid value for an individual specimen is calculated using the measured color change and the appropriate ellipsoid value equation found in 4.3 for the color region determined in 5.4.2.1.

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 Each specimen shall be of uniform appearance and void of blemishes, streaks, and splotches. The specimen shall also 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, such as Joy, Palmolive, Liquid Dawn, or equivalent.

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. ELLIPSOID VALUE CALCULATION—EXAMPLE

X1.1 Example:

Initial color reading of a specimen	
L	78.0
a	0.5
b	8.5

X1.2 Based on the initial color reading, the specimen is in color region 6, Light Beige.

X1.3 Color measurements of the weathered specimen are:

Color change due to weathering	
ΔL	2.5
Δa	1.1
Δb	–2.4

X1.4 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.

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

$$0.25+0.12+0.25=\text{Ellipsoid Value}$$

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