Designation: D 5215 – 93 (Reapproved 1999)

Standard Test Method for Instrumental Evaluation of Staining of Vinyl Flooring by Adhesives[1]

This standard is issued under the fixed designation D 5215; 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 test method describes procedures and instrumentation for accurately measuring the degree of staining that may occur in vinyl flooring as a result of its contact with adhesives. Measured color differences between vinyl flooring specimens contacting the adhesive and not contacting the adhesive are expressed in the CIELAB Color-Scale System.

1.2 This test method provides for visual evaluation of staining which may occur when vinyl flooring contacts adhesives.

1.3 The values in inch-pound units are to be regarded as standard. The SI values in parentheses are for information only.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 907 Terminology of Adhesives[2]

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[3]

E 284 Terminology of Appearance[3]

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[3]

E 1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry[3]

G 53 Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *chromaticity coordinates, n*—the ratio of each of the tristimulus values of a psychophysical color to the sum of the tristimulus values (see Terminology E 284).

3.1.1.1 *Discussion*—Chromaticity coordinates in the CIE system of color specification are designated by *x, y,* and *z*.

3.1.2 *CIE 1976 $L^*a^*b^*$ uniform color space, CIELAB,* **(1, 2)**[5], *n*—an approximately uniform color space, that is produced by plotting in rectangular coordinates the quantities L^*, a^*, b^*, from which the total difference between two colors may be calculated.

3.1.2.1 *Discussion*—The abbreviation CIELAB is recommended.

3.1.3 *color difference, n— as visually perceived*, the magnitude and character of the difference between two colors described by such terms as redder, bluer, lighter, darker, grayer, or cleaner (see Terminology E 284).

3.1.4 *color difference, n— as computed*, the magnitude and direction of the difference between two psychophysical color stimuli and their components computed from tristimulus values, or by chromaticity coordinates and luminance factor, by means of a specified set of color-difference equations (see Terminology E 284).

3.1.5 *CIELAB color difference equation, n* **(1, 2)**—the total difference ΔE^*_{ab} between two colors, each given in terms of L^*, a^*, b^*, calculated as follows:

$$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \quad (1)$$

3.1.5.1 *Discussion*—The magnitude, $\Delta E^*_{ab'}$, gives no indication of the character of the difference since it does not indicate the relative quantity and direction of the hue, saturation, and lightness differences. The CIELAB color differences are uniformly 1.1 times Adams-Nickerson (AN40) color differences.

3.1.5.2 *Discussion*—The direction of the color difference is described by the magnitude and algebraic signs of the components ΔL^*, Δa^*, Δb^* as follows:

$$\Delta L^* = L^*_1 - L^*_0 \quad (2)$$

$$\Delta a^* = a^*_1 - a^*_0 \quad (3)$$

$$\Delta b^* = b^*_1 - b^*_0 \quad (4)$$

where L^*_0, a^*_0, and b^*_0 refer to the reference, and L^*_1, a^*_1, and b^*_1 refer to the test specimen.

3.1.6 *directional optical measuring system, n*—an optical

[1] This test method is under the jurisdiction of ASTM Committee D-14 on Adhesives and is the direct responsibility of Subcommittee D14.70 on Construction Adhesives.

Current edition approved Jan. 15, 1993. Published May 1993. Originally published as D 5215 – 91. Last previous edition D 5215 –91.

[2] *Annual Book of ASTM Standards*, Vol 15.06.

[3] *Annual Book of ASTM Standards*, Vol 06.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] The boldface numbers in parentheses refer to the list of references at the end of this test method.

system for measuring the reflecting or transmitting properties of specimens, in which the illuminator and receiver each subtend small angles at the specimen surface.

3.1.7 *luminance factor, n*—the ratio of the luminance of a specimen to that of a perfect diffuser, when illuminated and viewed under specified geometric conditions (see Terminology E 284).

3.1.7.1 *Discussion*—In the CIE 1931 system, the luminance factor is tristimulus factor *Y*.

3.1.8 *CIE tristimulus values, n*—the amounts of three specified stimuli required to match a color (see Terminology E 284).

3.1.8.1 *Discussion*—In the CIE system, they are assigned the symbols *X, Y,* and *Z.*

3.2 *Symbols:*

3.2.1 L^*—an individual CIELAB color (opponent-color) coordinate relating to luminance (lightness).

3.2.2 a^*—an individual CIELAB color (opponent-color) coordinate relating to redness/greenness.

3.2.3 b^*—an individual CIELAB color (opponent-color) coordinate relating to blueness/yellowness.

3.2.4 ΔE^*_{ab}—the magnitude of the difference.

3.2.5 ΔL^*, Δa^*, Δb^*—the CIELAB color differences as described by the magnitude and algebraic signs of the components, and giving the following approximate meanings **(3)**:

3.2.5.1 $+\Delta L^*$—lighter.

3.2.5.2 $-\Delta L^*$—darker.

3.2.5.3 $+\Delta a^*$—redder (less green).

3.2.5.4 $-\Delta a^*$—greener (less red).

3.2.5.5 $+\Delta b^*$—yellower (less blue).

3.2.5.6 $-\Delta b^*$—bluer (less yellow).

3.2.6 *x, y, z*—the chromaticity coordinates in the CIE system of color specification.

3.2.7 *X, Y, Z*—the CIE 1931 tristimulus values.

4. Summary of Test Method

4.1 The differences in color between a reference and test specimen are determined with a spectrophotometer or colorimeter. Reflectance readings are made which in turn are converted by computations to color-scale values. These reflectance readings may be automatically converted and computed by a computer with the appropriate software program connected to the spectrophotometer or colorimeter.

4.2 Specimens are heat aged at 140 ± 5°F (60± 3°C) for seven days.

4.3 Specimens are exposed to ultraviolet light for 48 h.

5. Significance and Use

5.1 Certain substances in adhesives may cause discoloration of vinyl flooring. This test method provides a means of measuring the discolorations that may occur in the vinyl as a result of contact with these adhesives. Vinyl flooring specimens, either contacting or not contacting the adhesive, are exposed to heat and UVA light to accelerate discoloration. By means of colorimeter or spectrophotometer, color differences between exposed specimens are accurately measured. Therefore, instrumental evaluation rather than personal subjective evaluation is used to determine the amount of discoloration an adhesive may produce in vinyl flooring. This test method does not attempt to simulate or duplicate the heat and sunlight conditions that may impact vinyl floor coverings while in service.

6. Apparatus

6.1 *Instrumentation for Color Readings*—a colorimeter or spectrophotometer that measures color coordinates as described in Test Methods E 1347 and E 1349.

6.1.1 *Scale*—CIELAB Color-Scale System.

6.1.2 *Illuminant*—D65 illuminant or equivalent.

6.1.3 *Standard Observer*—2 or 10°.

6.1.4 *Viewpoint Diameter*—Equal to or less than 1.0 in. (25 mm).

6.1.5 *Bidirectional Geometry*—45°/0° (45° circumferential illumination/0° viewing).

6.2 *Spatula*—Unspecified size.

6.3 *Applicator*—A 15-in. long (381 mm) threaded rod, ⅜in. (9.5 mm) in diameter with 16 threads/in. (25.4 mm) to be used for application of adhesive.

6.4 *Oven*—Hot air recirculating oven.

6.5 *Test Chamber*— A UV condensation-type cabinet[6] meeting the requirements of Practice G 53.

6.5.1 *Lamps*—UVA-351 lamps.

7. Reagents and Materials

7.1 *Adhesives*—Construction and flooring adhesives used for installation of residential vinyl floor covering (both felt and vinyl backed).

7.2 *Aluminum Foil*— To be used for wrapping test specimens.

7.3 *Solvents*—Those necessary for clean-up.

8. Test Specimens

8.1 *Size of Specimens*—Unless otherwise specified, specimen shall be 3 by 6 in. (75 by 150 mm).

8.2 *Color of Specimens*—The specimens shall be a light-colored (preferably white) floor covering. Greatest precision of color difference is obtained when reading the smoothest, unpatterned area of flooring surface. Special attention is required to be certain that like areas of all specimens are read.

8.3 *Number of Specimens*—Prepare three control specimens with no adhesive, and three specimens for each adhesive to be evaluated (see Fig. 1).

8.3.1 In addition, retain a 3 by 6 in. (75 by 150 mm) piece of flooring for visual evaluation. Wrap this sample in aluminum foil.

9. Procedure

9.1 Cut specimens of flooring as described in Section 8.

9.2 Place the specimen identification number at the top of the back side of each specimen. Use a sharp pencil to minimize the possibility of smearing other specimens in the course of testing.

9.3 On the face side of each specimen, mark a circular area of the lightest, smoothest, unpatterned section of flooring (see

[6] Cabinet available from Q. Panel Co., 26200 First St., Cleveland, OH 44145 or Atlas Electrical Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613 has been found suitable.

VINYL FLOORING - UV EXPOSURE

Flooring Materials:_____ Color Instrument & Model #:_____ UV Cabinet:_____
Adhesives:_____ Illuminant:_____ Model #:_____
Standard Observer:_____
Orifice:_____
Geometry:_____

Sample Identification			Initial Readings			Final Readings			Delta Values			Color Change due to Adhesive
Set #	Description	Spec #	L^*	a^*	b^*	L^*	a^*	b^*	L^*	a^*	b^*	
1	Control	1										
		2										
		3										
		$\bar{X}$							(1)	(2)	(3)	
2	Test Adhesive "A"	1										
		2										
		3										
		$\bar{X}$							(4)	(5)	(6)	
									(7)	(8)	(9)	(10)
3	Test Adhesive "B"	1										
		2										
		3										
		$\bar{X}$										

Prepared by:_____
Date(s) prepared:_____

Key: (7) = (4) minus (1)
(8) = (5) minus (2)
(9) = (6) minus (3)
(10) = $[(7)^2 + (8)^2 + (9)^2]^{1/2}$

FIG. 1 Form for Reporting Color Readings, Computations, and Identification of Materials and Apparatus Used to Measure Color Differences

8.2). Again, use a sharp pencil to avoid smearing or marring the specimen. The designated area shall be a minimum of ⅛ in. (3 mm) larger than the 1.0-in. (25-mm) or smaller viewport of the colorimeter or spectrophotometer.

9.4 Calibrate the colorimeter or spectrophotometer according to the manufacturer's recommendations. Take initial L^*, a^*, b^* readings on all specimens by means of the calibrated colorimeter or spectrophotometer (Test Methods E 1347 and E 1349). Use D65 illuminant or equivalent. Position each specimen to read the encircled area. Record all readings in the CIELAB Color-Scale System.

9.5 Record all initial and subsequent readings on the prepared chart (Fig. 1).

9.6 Wrap the control specimens in aluminum foil after the initial readings.

9.7 Place each set of three specimens for adhesive evaluation on a flat surface side by side with the wear surface down. Leave an approximate ½-in. (13-mm) space between the specimens. The larger dimension of each specimen should lie in the same direction that the adhesive will be applied. Tape the leading edge of each specimen to the flat surface beneath. Using a spatula, apply the adhesive on the leading edge of each of the three specimens, making certain that the entire width of each specimen is covered with adhesive. Using the threaded-rod applicator, spread the adhesive evenly and simultaneously on the three specimens. Clean the rod thoroughly after each application to prevent cross-contamination of adhesives.

9.8 Allow all specimens to air-dry 24 h at room temperature.

9.9 Wrap each specimen in aluminum foil to prevent any cross-contamination or degradation from exposure to light.

9.10 Place control and adhesive specimens in a clean container in such a manner that air can circulate between the specimens. Condition in the recirculating oven for seven days at 140 ± 5°F (60 ± 3°C). Maintain the wrapped visual specimen at room temperature.

9.11 After seven days, remove specimens from the oven and condition them to room temperature for approximately 2 h.

9.12 Unwrap and place each specimen in the specimen holder with the wear surface showing through the specimen-holder window. Place all specimens in a fluorescent UV-condensation-type apparatus (see 6.5) that meets the requirements of Practice G 53, and is equipped with UVA-351 lamps. Program the unit for UV exposure only (no exposure to condensation) at a temperature of 140 ± 5°F (60 ± 3°C) for 48 continuous hours. Do not use the two outside positions on either side of the racks when placing the specimen holders in the cabinet. Be certain that the specimen-holder window faces the UV lights. Maintain the light as specified in Practice G 53.

9.13 After UV exposure, carefully remove the specimens and wrap them in foil until they are reread on the colorimeter or spectrophotometer.

9.14 Allow specimens to condition approximately 2 h at room temperature before rereading.

9.15 For each specimen, unwrap, reread and record the final set of L^*, a^*, b^* values. Record the ΔL^*, Δa^*, Δb^*, and ΔE^*_{ab} values.

9.16 Make a visual evaluation at the conclusion of this test procedure. The visual evaluations are to be used as cross-checks of the numerical evaluations, and it is expected that one will substantiate the other.

10. Calculation

10.1 See Fig. 1.

10.2 If each ΔL^*, Δa^*, and Δb^* value was not obtained directly from a computer connected to the colorimeter or spectrophotometer, subtract the initial reading from the final reading of each color component of each specimen as follows:

$$\Delta L^* = \text{final } L^* - \text{initial } L^* \quad (5)$$

$$\Delta a^* = \text{final } a^* - \text{ initial } a^* \quad (6)$$

$$\Delta b^* = \text{final } b^* - \text{initial } b^* \quad (7)$$

10.3 Calculate the average ΔL^*, average Δa^*, and average Δb^* for each set of specimens.

10.4 Calculate the color differences of the control set versus each set of specimens spread with adhesive as follows:

$$\Delta L^* \text{ (due to test adhesive)} = \Delta L^* \text{ (test adhesive)} - \Delta L^* \text{ (control)} \quad (8)$$

$$\Delta a^* \text{ (due to test adhesive)} = \Delta a^* \text{ (test adhesive)} - \Delta a^* \text{ (control)} \quad (9)$$

$$\Delta b^* \text{ (due to test adhesive)} = \Delta b^* \text{ (test adhesive)} - \Delta b^* \text{ (control)} \quad (10)$$

10.5 Calculate ΔE_{ab^*} for each test adhesive as follows:

$$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \text{ (due to test adhesive)} \quad (11)$$

11. Report

11.1 Report the following information:

11.1.1 Manufacturer of colorimeter or spectrophotometer.

11.1.1.1 The type and model of color instrument.

11.1.1.2 The illuminant.

11.1.1.3 The standard observer.

11.1.1.4 The viewport diameter.

11.1.1.5 The illuminator/observer geometry.

11.1.2 The type and model of weathering cabinet.
11.1.3 Flooring identification.
11.1.4 Adhesive identification.
11.1.5 Initial L^*, a^*, b^* readings and average of set.
11.1.6 Final L^*, a^*, b^* readings and average of set.
11.1.7 ΔL^*, Δa^*, Δb^* calculated values.
11.1.8 Calculated color difference (ΔE^*_{ab}, ΔL^*, Δa^*, Δb^*) due to adhesive.
11.1.9 Visual evaluation.

12. Precision and Bias

12.1 Two primary sources of error were detected during intralaboratory and interlaboratory testing:

12.1.1 One source of error was attributable to the lack of repeatability within experimental procedures, especially in application techniques for adhesives, delineation of areas for colorimeter readings, and control of specimen UV exposure and aging conditions. Experimental procedures were revised to improve repeatability, but no further testing was conducted to confirm this.

12.1.2 Another source of error was attributable to interlaboratory differences in colorimeter readings, especially the b^* color-scale values for the CIELAB space and color-difference equation. More consistent readings between colorimeters in different laboratories were associated with the 45°/0° geometry than with the integrating-sphere measurements. Therefore, only instruments with the 45°/0° geometry have been specified in this standard.

12.2 The precision of color difference measurements, as measured with both 45°/0° and integrating sphere geometries, are presented in Table 1 of Test Method D 2244. Both geometries are shown to produce readings that are well within maximum acceptable differences.

12.3 There is no basis for a statement of bias at this time.

13. Keywords

13.1 adhesives; adhesive staining; CIELAB color-scale system; color differences; colorimeter; instrumental evaluation; spectrophotometer; ultraviolet light; vinyl flooring.

REFERENCES

(**1**) Robertson, A. R., "The CIE 1976 Color-Difference Formulae," *Color Research and Application*, Vol 2, 1977, pp. 7–11.
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(**3**) Hunter, R. S. and Harold, R. W., *The Measurement of Appearance*, 2nd Ed., Wiley, New York, NY 1987.