Designation: E2073 – 10

An American National Standard

Standard Test Method for Photopic Luminance of Photoluminescent (Phosphorescent) Markings[1]

This standard is issued under the fixed designation E2073; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers a procedure for determining the photopic luminance of photoluminescent (phosphorescent) markings. It does not cover scotopic or mesopic measurements.

1.2 When reference is made regarding photoluminescence in the text of this test method, it implies phosphorescence.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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:*[2]

E284 Terminology of Appearance

E308 Practice for Computing the Colors of Objects by Using the CIE System

E1316 Terminology for Nondestructive Examinations

E2072 Specification for Photoluminescent (Phosphorescent) Safety Markings

2.2 *Other Standards:*

Publication CIE No. 69 (1987) Methods of characterizing illuminance meters and luminance meters; Performance, characteristics and specifications [3]

3. Terminology

3.1 Definitions of terms in Terminology E284 and Terminology E1316 are applicable to this specification.

4. Significance and Use

4.1 To assess how photoluminescent markings perform under identical test conditions, the luminance shall be measured in accordance with this test method (see Specification E2072).

5. Apparatus

5.1 *Illuminance Meter*—To measure the illumination of the activating light source on the surface of the photoluminescent marking, use an illuminance meter calibrated to measure illuminance in fc (lux), with the following features: spectral error, f_1', ≤5 %; UV response, *u*, ≤0.5 %; resolution 1.0 lux; and linearity error, f_3, ≤0.5 % (see Public. CIE No. 69).

5.2 *Luminance Meter*—To measure the photopic luminance of photoluminescent markings, use a luminance meter with the following minimum features (see Publication CIE No. 69): spectral error, f_1', ≤5 %; UV response, *u*, ≤0.5 %; resolution at least 0.1 mcd/m^2; linearity error, f_3, ≤0.5 %; signal-to-noise-ratio: at least 10:1 for all measurements. The instrument shall have been calibrated within the preceding 12 months using photometric standards traceable to a national standards institute.

6. Sampling, Test Specimens and Test Units

6.1 *Method of Sampling*—Take a minimum of three samples. Each sample shall be of a minimum size of at least 1¾-in. (45-mm) in diameter. Select samples at random. If a manufacturer, samples shall be representative of the production lot, coded and identified to correspond to production batch codes, and shall be numbered consecutively. Field-mixed/field-applied paints/coatings shall be applied by the testing laboratory in compliance with the manufacturer's preparation and application instructions, which have to include, but shall not be limited to, primers if required, layers needed, and wet (if required) and dry coat thicknesses, as luminance of the photoluminescent paint/coating is dependent on these factors.

[1] This test method is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.13 on Photoluminescent Safety Markings.

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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.

[3] Available from U.S. National Committee of the CIE (International Commission on Illumination), C/o Thomas M. Lemons, TLA-Lighting Consultants, Inc., 7 Pond St., Salem, MA 01970, http://www.cie-usnc.org.

7. Conditioning

7.1 Precondition all test specimens by placing them in complete darkness until their residual luminance has fallen to 0.3 mcd/m^2 or less, tested utilizing the luminance meter specified under 5.2. Remove them immediately before performing the tests. No ambient or stray light shall be present.

8. Procedure

8.1 *Ambient Conditions*—The ambient temperature during darkness preconditioning of specimens, activation and luminance testing shall be 77 ± 5°F (25 ± 3°C). The relative humidity shall not exceed 60 %. All luminance testing shall be performed in a room whose ambient light level is such that the luminance of a white diffuse reflectance standard is at least one decade lower than the lowest test specimen luminance measurement to be recorded.

8.2 *Preparation of Apparatus*—The luminance meter shall be zeroed prior to every measurement, then checked immediately after the measurement and the measurement shall be rejected if the zero drifted by more than 5 % of the measured value. The distance between the luminance meter and the measured test specimen, and also the aperture angle of the luminance meter, shall be chosen in such a way that 1 5⁄16 -in. (30-mm) diameter of the photoluminescent test specimen, which is of at least 1¾-in. (45-mm) diameter, is evaluated.

8.3 *Activation*—Activate the photoluminescent marking specimens with an unfiltered fluorescent cool white source of light having a spectral power distribution similar to cool white F2 as described in Practice E308 Table 4, of 40 W or less, with a correlated color temperature ranging from 4000 to 4500 K for 60 min (±10 s), providing an illumination of 1 fc (10.8 lux) ±1 % on the marking surface. The test specimen body temperature shall not exceed 86°F (30°C) 1 min after activation. No ambient or stray light shall be present during activation. Measure the activation with an illuminance meter as described in 5.1. Direct illumination of marking surface is required and can be accomplished with a black baffling system, black screen mesh system or by distance (see Appendix X3).

8.4 *Luminance*—Measure the photopic luminance of all specimens of the photoluminescent marking with a luminance meter as described in 5.2 after 10 min ±10 s and 60 min ±10 s and 90 min. ±10 s.

9. Report

9.1 Report the following information:

9.1.1 Tested in accordance with ASTM Standard ____ Issue: ____,

9.1.2 Manufacturer of tested photoluminescent marking: [Name, Address, Phone, Fax],

9.1.3 Specimen description: (clear item identification to make specimens traceable to manufacturer's data sheets). For field-mixed/field-applied paints/coatings describe sample preparation requirements based on manufacturer's preparation and application instructions (primer if any was applied, number of paint/coating layers applied, wet (if required)/dry coat thickness accomplished),

9.1.4 Beginning and end of conditioning: (fill in days and time),

9.1.5 Date of measurement,

9.1.6 Instrument parameters and photometer serial number,

9.1.7 Activation: (fill in minutes, type of activating light source, illuminance in fc (lux)),

9.1.8 Ambient temperature and relative humidity,

9.1.9 Photopic luminance measurement results in reference to 8.4,

9.1.10 List separately for all test specimens,

9.1.11 Luminance in mcd/m^2 10 min after activation has ceased,

9.1.12 Luminance in mcd/m^2 60 min after activation has ceased,

9.1.13 Luminance in mcd/m^2 90 min after activation has ceased,

9.1.14 Test performed by: (person's name, title), and

9.1.15 Signature: . . .; at: (describe test location) and company performing test: (full name, address, phone, fax).

10. Precision and Bias

10.1 *Precision: Interlaboratory Test Program*—An interlaboratory round robin testing was conducted in 2005 and 2006, using three photoluminescent product samples. Eight laboratories participated by taking one measurement each of samples A and B, and by taking two measurements of sample C.

10.1.1 The samples were activated using an unfiltered fluorescent cool white source of light, 40 W or less, in the 4000 to 4500 K range, providing an illumination of 21.6 lux (2 fc) for 60 min. at the sample surface.

10.1.2 The 10-min., 60-min. and 90-min. values were recorded. The details of the design of the experiment and the analysis of the full data are given in ASTM Research Report RR:E12:1003.[4]

10.2 *Test Results*—The precision information given in Table 1, Table 2, and Table 3 is based on eight laboratories, three different materials and one measurement for three time intervals. Sample C alone was tested in duplicate.

TABLE 1 Afterglow Luminance Values (mcd/m^2) after 10 Minutes

Material	Average	S_r	S_R	r	R
A	15.571	...	1.690	...	4.732
B	17.357	...	1.583	...	4.433
C	62.293	1.718	8.612	4.810	24.113

TABLE 2 Afterglow Luminance Values (mcd/m^2) after 60 Minutes

Material	Average	S_r	S_R	r	R
A	3.188	...	0.230	...	0.643
B	3.638	...	0.226	...	0.634
C	15.089	0.465	1.076	1.303	3.013

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E12-1003.

TABLE 3 Afterglow Luminance Values (mcd/m²) after 90 Minutes

Material	Average	S_r	S_R	r	R
A	2.063	...	0.207	...	0.578
B	2.400	...	0.207	...	0.580
C	9.894	0.323	0.700	0.905	1.961

10.3 *Concept of r (Repeatability) and R (Reproducibility)*—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages from testing the specimens, then:

10.3.1 *Repeatability, r*—In comparing two test results for the same material, obtained by the same operator using the same equipment, the two test results should be judged not equivalent if they differ by more than the *r* value for that material.

10.3.2 *Reproducibility, R*—In comparing the test results for the same material, obtained by different operators using different equipment on different days in different laboratories, the test results should be judged not equivalent if they differ by more than the *R* value for that material.

10.3.3 *Standard Deviation, S*—The S in S_R and S_r stands for Standard Deviation, and so S_R is the Standard Deviation of the reproducibility, and S_r is the Standard Deviation of the repeatability.

10.3.4 Any judgement in accordance with these two statements would have an appropriate 95 % probability of being correct.

10.4 *Bias*—This bias of this test method is unknown because there is no accepted reference material.

11. Keywords

11.1 illuminance; luminance; photoluminescence

APPENDIXES

(Nonmandatory Information)

X1. CODE COMPLIANCE

X1.1 When this standard is used to show compliance with codes or standards, the manufacturer should have an agreement with an organization that is acceptable to the Authority Having Jurisdiction for follow-up factory inspection services.

X2. PRECISION AND BIAS FOR ACTIVATION WITH CIE STANDARD ILLUMINANT A (SECTION 10 IN E2073 –02)

X2.1 *Precision: Interlaboratory Test Program*—An interlaboratory test method was conducted in 1998 based on previous round robin tests. There were six product samples. Three measurements on each of the samples were taken and five laboratories participated.

X2.1.1 Samples A, D, and E were based on one type of photoluminescent pigment and Samples B, C, and F were based on another type of photoluminescent pigment.

X2.1.2 The samples were activated using a CIE Standard Illuminant A (2856 K ± 20°K) for 15 min, providing an illumination of 500 lux (approximately 46 fc) on the marking surface. Measurements were taken at 1, 5, 10, 30, 60, 90 and 120 min after activation had ceased.

X2.1.3 For the sake of simplicity in the presentation of the data, only the 10 and 60 min values will be shown here. The details of the design of the experiment and the analysis of the full data are given in ASTM Research Report RR:E12-1000.[5]

X2.2 *Test Results*—The precision information given in Table X2.1 and Table X2.2 is based on five laboratories, six different materials, and three measurements for two time intervals. All laboratories conducted the same procedure on the same material.

TABLE X2.1 Afterglow Luminance Values (mcd/m²) after 10 Minutes

Materials	Average	S_r	S_R	r	R
Sample A	223.61	6.62	12.43	18.55	34.80
Sample D	139.21	1.01	7.68	2.83	21.49
Sample E	132.13	1.65	6.12	4.63	17.14
Sample B	6.43	0.13	0.54	0.36	1.51
Sample C	8.15	0.12	0.80	0.35	2.25
Sample F	8.40	0.19	0.76	0.52	2.11

TABLE X2.2 Afterglow Luminance Values (mcd/m²) after 60 Minutes

Materials	Average	S_r	S_R	r	R
Sample A	30.92	1.00	2.42	2.79	6.77
Sample D	23.14	0.52	1.24	1.47	3.46
Sample E	17.85	0.45	0.96	1.25	2.68
Sample B	1.24	0.02	0.09	0.06	0.27
Sample C	1.82	0.03	0.12	0.10	0.34
Sample F	1.73	0.03	0.12	0.10	0.35

X2.3 *Concept of r (Repeatability) and R (Reproducibility)*—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages from testing the specimens, then:

X2.3.1 *Repeatability, r*—In comparing two test results for the same material, obtained by the same operator using the

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E12-1000.

same equipment on the same day, the two test results should be judged not equivalent if they differ by more than the *r* value for that material.

X2.3.2 *Reproducibility, R*—In comparing two test results for the same material, obtained by different operators using different equipment on different days (or two different laboratories), the two test results should be judged not equivalent if they differ by more than the *R* value for that material.

X2.3.3 Any judgment in accordance with these two statements would have an approximate 95 % probability of being correct.

X2.3.4 The analysis of the *h* values showed that two of the laboratories consistently had high values. One laboratory was consistently on the positive, while the other was on the negative side. The significance of this is not known at this stage and therefore no comments can be made.

X2.4 *Bias*—The bias of this test method is unknown because there is no accepted reference value or material.

X3. BAFFLING SYSTEM

X3.1 Per 8.3 in this test method, direct illumination of the photoluminescent marking surface is required. The activating source of light shall not be pointed at another object (for example, a nearby wall) to reflect its illumination onto the marking surface. Direct illumination can be accomplished with, for example, a black baffling system, black screen mesh system or by adjusting the distance between the activating source of light and the marking surface such that the exact required illumination activates the marking surface. An example of a baffling system is shown in Fig. X3.1

FIG. X3.1 Example of a Baffling System

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X4. SUMMARY OF CHANGES

X4.1 This test method was originally published in 2000 with the values stated in SI units as the standard and the values in parentheses for information purposes only. Paragraph 8.3 required an activation by a nondiffusing, unfiltered continuous short arc xenon source of light of 500 W or less for 5 min (±10 s), providing an illumination of 1000 lux (93 fc) ±1 % on the marking surface. The luminance results obtained by this quick and bright laboratory-setting activation allowed comparing luminance values of different products after laboratory exposure. Test Method E2073 - 00 was reapproved in June 2002 as E2073 - 02.

X4.2 Test Method E2073 was revised in 2007 to specify a fluorescent light source resembling the typical illumination in many buildings with installations of photoluminescent markings. The values stated in SI units were the standard and the values in parentheses for information purposes only. Test Method E2073 - 07 required activation by an unfiltered fluorescent cool white source of light having a spectral power distribution similar to cool white F2 as described in Practice E308 Table 4, of 40 W or less, with a correlated color temperature ranging from 4000 to 4500 K for 120 min (±10 s), providing an illumination of 21.6 lux (2 fc) ±1 % on the marking surface. Test Method E2073 - 07 was approved and published in July of 2007.

X4.3 U. S. code developments in 2008 (NFPA 101–Life Safety Code and NFPA 5000 Building Construction and Safety Code) and 2009 (International Building Code and International Fire Code) are citing the ASTM test requirements with exceptions. To incorporate the new code requirements, the illumination intensity and duration changed to 1 fc (10.8 lux) ±1 % on the marking surface for 60 min (±10 s). Table X4.1 lists a condensed summary of these changes. Test Method E2073 - 09 was also converted into an Inch-Pound standard, with SI units in parentheses for information purposes only.

TABLE X4.1 Condensed Summary of Changes

Issue	Activation Summary (Paragraph 8.3)	Intention:
E2073-00 E2073-02	Xenon source of light for 5 min at 1000 lux (93 fc) on marking surface	Laboratory-setting activation
E2073-07	Fluorescent cool white source of light (4000 to 4500 K) for 120 min. at 21.6 lux (2 fc) on marking surface	Typical illumination in many buildings
E2073-09a	Fluorescent cool white source of light (4000 to 4500 K) for 60 min. at 1 fc (10.8 lux) on marking surface	Correlating this test method with requirements in 2009 NFPA 101 and NFPA 5000 and 2009 International Building Code and International Fire Code