Designation: F2964 – 12

Standard Test Method for Determining the Uniformity of the Luminance of an Electroluminescent Lamp or Other Diffuse Lighting Device[1]

This standard is issued under the fixed designation F2964; 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 covers procedures for determining the uniformity of the luminance of an electroluminescent (EL) lamp. While written specifically for the purpose of evaluating EL devices, which are intrinsically very uniform, it can be applied (judiciously) to the measurement of any diffuse, essentially planar, light source. For specific purposes, it can be applied to partially assembled devices into which the illumination is installed (such as a membrane switch) as a diagnostic for the performance of the entire device. In such a case it must be understood that the results pertain only to the partial assembly and will be modified as the further assembly proceeds.

1.2 The method is to take a 2-dimensional set of measurements, sampling the surface of the unit under test with appropriate density. The method is restricted to measuring luminance only, since variations in color will also show as luminance non-uniformity especially in any photoptically calibrated measuring device.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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]

F2360 Test Method for Determining Luminance of a Membrane Switch Backlit with Diffuse Light Source

F2771 Test Method for Determining the Luminance Curve of an Electroluminescent Lamp at Ambient Conditions

3. Terminology

3.1 *Definitions:*

3.1.1 *luminance, n*—measure of the brightness or luminous intensity of light, usually expressed in units of candelas per square metre (cd/m^2) or foot lamberts. 1 fL = 3.426 cd/m^2.

3.1.2 *luminance curve, n*—a graphical representation of the variation of luminance with time (implicitly under unvarying operating conditions).

3.1.3 *electroluminescent lamp (EL lamp), n*—essentially a capacitor structure with phosphor and a dielectric sandwiched between electrodes, one of which is transparent to allow light to escape. Application of an ac voltage across the electrodes generates a charging field within the phosphor, which causes it to emit light.

3.1.4 *time to half luminance (THL), n*—the elapsed operating time over which the luminance of a lamp maintained under constant power will be reduced to half of its initial value.

3.1.5 *UUT, n*—unit under test.

4. Significance and Use

4.1 Application of an EL lamp (or other diffuse lighting source) to illuminate a device has a functional purpose and must meet specifications to satisfy the functional requirements of the device.

4.2 Illumination of the device or application can be affected by variations in the quality, efficiency, and design of the lamp and any attendant mounting or shading fixtures.

4.3 This test method addresses only the optical and visual appearance of the lamp and not its electrical function.

4.4 This test method is non-destructive.

4.5 This test method is described for application to the illumination layer in which case the results apply to that layer only. However, it may be desirable and practical to apply the test to a further assembly or to a fully assembled device with built in illumination. In such a case, the results refer specifically to the subassembly or the entire device respectively.

[1] This test method is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.18 on Membrane Switches.

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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.

5. Interferences

5.1 *State of Assembly*—Tests on incomplete assemblies give results appropriate to that state of assembly. Specifically, later application of mounting hardware, baffling, or fixtures may alter the results.

5.2 *Filling of Aperture*—Failure to fill the sampling aperture of the photometer will bias the results in a way which is not necessarily predictable.

5.3 *Age of Device*—Since every system of illumination changes characteristics as it ages, it must be recognized that the results apply to a particular interval in the lifetime of the system. Characterization of the aging properties may be addressed in a separate test method. (See for example Test Method F2771.)

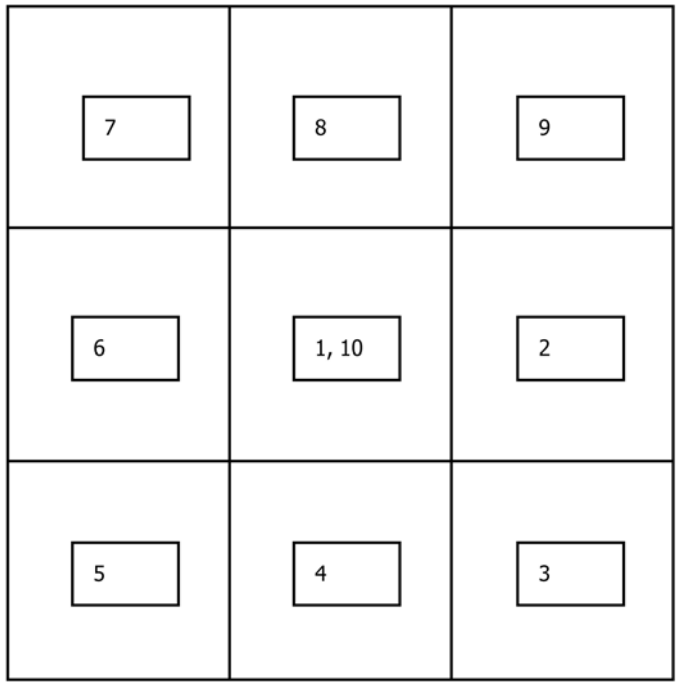
5.4 *Perpendicularity*—Since the angular distribution of emitted light can be altered by any material through which it passes, it is important that the photometer be held perpendicular to the area to be sampled.

5.5 *Temperature*—Since the performance of many light sources can vary with temperature, it is important to allow the UUT to stabilize thermally, if necessary, and then record the ambient temperature at which the measurements are made.

5.6 *Power*—Since the performance of many power sources can vary with temperature, it is important to allow the power supply for the UUT to stabilize thermally, if necessary, and then record the warm-up time at which the measurements are made.

5.7 *Ambient Light*—Stray light sources will be detected by the photometer and will affect the UUT luminance measurement. It is important to measure the ambient light before illuminating the UUT. This ambient light reading should be zero or as close to zero as possible.

5.8 *Sampling Aperture*—The sampling aperture (area of the UUT sample and over which luminance values are averaged by the measuring instrument) should be large enough to average over any intrinsic granularity of the UUT. This area should also be small enough compared with the overall size of the UUT to allow multiple measurements to be made without the sampling apertures of adjacent measurements overlapping (at least nine measurements are recommended). If areas overlap, the individual samples may no longer be considered as independent samples. The decision to allow individual samples to overlap or to remain physically distinct is one the experimenter must make and be conscious of. Use of a preplanned sequence of measurements is recommended. See Fig. 1 for example of a sample sequence and distribution.



NOTE 1—A sequence of nine, non-overlapping measurements which will reveal side-to-side, center to edge, and top to bottom non-uniformities of luminance. The order of sampling is suggested by the numbers. See 5.8.

NOTE 2—Size for the sampling area (shown here as small rectangles) can be chosen to maximize significance by taking it to be large enough to average over any intrinsic granularity of the lamp (such as phosphor crystal size) and small enough to avoid overlap with its neighbor (and thus remain independent).

FIG. 1 Suggested Organization of Sampling Points for Uniformity Measurement

6. Apparatus

6.1 A working or mounting surface to hold and support the UUT and any supporting fixtures, providing electrical access to the termination region from which the EL lamp illumination is to be powered and visible access to all regions of interest on the lamp at which the luminance is to be measured.

6.2 A power supply providing appropriate, stable and adequate power to drive the illumination device(s) with appropriate connector(s). This should be specified as dc or ac, with voltage and power level given, and ideally should be switched.

6.3 A calibrated device to measure surface luminance (or radiance). This is typically a spot photometer, with a fairly compact sampling aperture (<1-cm diameter at the minimum working distance). Output should be in foot lamberts (candela per meter squared). Alternatively, a radiometer may be used, or even a video photometer, but cognizance must be maintained of the output units and calibration. Hereinafter we refer to this as the photometer.

6.4 A means to support the photometer at a fixed distance and orientation to the emitting surface of the UUT.

6.5 A means to move the lamp and photometer relative to each other with enough travel to allow the instrument controlled and stable visual access to all regions of the UUT. The apparatus or set up should allow the experimenter to collect data with sufficient density and knowledge of the location of the samples to allow an adequate characterization of the UUT. See Fig. 1 and 5.8.

6.6 A means to control or exclude stray light and prevent it from entering the aperture of the photometer.

7. Procedure

7.1 This method is similar to that in F2360, Test Method for Determining Luminance of a Membrane Switch Backlit with

Diffuse Light Source, which may be used as a working guide to the current method.

7.2 Mount UUT on the working surface with the illuminated surface visible.

7.3 Attach a switched power source as appropriate to the illumination device set to the design operating point.

7.4 Mount the photometer or luminance meter so that the axis of its field of view is perpendicular to the area of the UUT to be measured. Ensure that the sampling aperture is filled by the area to be measured on the UUT. Measure and record the extent and location of the field of view.

7.5 Verify the means by which relative motion of the UUT and photometer permits the desired density, locations, and extent of samples (see Fig. 1). This requires that the sampling plan (the number, locations, and sizes of the samples) be well planned and understood.

7.6 Establish an initial point (location on the UUT) for the set of measurements to be made. Suggested areas are the center of the UUT (for Method 1) or a particular corner of the UUT.

8. Method 1 (Preferred)

NOTE 1—To be used where there is confidence that the stray light effects are negligible.

8.1 Measure the stray light level by taking a photometer reading while the UUT luminous source is not powered. If this value is not zero or very close to it, do not proceed, but take steps to reduce the stray light present. This may be as simple as reducing the ambient room light or switching the overhead lights off altogether.

8.2 Switch on the power and illuminate the UUT.

8.3 Measure and record the luminance of the sample area of the UUT at the current position.

8.4 Move the location of the sampling aperture to the next desired location for measurement.

8.5 Repeat steps 8.2 and 8.3 until the entire UUT has been measured at all desired locations.

8.6 Go to 10.1.

9. Method 2

NOTE 2—To be used where there is no confidence that the stray light effects are negligible.

9.1 Measure the stray light level by taking a photometer reading while the UUT luminous source is not powered. If this value is not zero or very close to it, do not proceed, but take steps to reduce the stray light present. This may be as simple as reducing the ambient room light or switching the overhead lights off altogether.

9.2 Switch on the power and illuminate the UUT.

9.3 Measure and record the luminance of the sample area of the UUT at the current position.

9.4 The luminance at the point of measurement is taken as the difference in the powered and unpowered values.

9.5 Move the location of the sampling aperture to the next desired location for measurement.

9.6 Measure and record the luminance of the sample area of the UUT at the current position.

9.7 Switch off the UUT and allow to settle for 3 min (some illumination sources, especially EL may retain an afterglow once the power is removed). Measure and record the luminance of the sample area of the UUT at the current position. If this value is not zero or very close to it, do not proceed, but take steps to reduce the stray light present. If necessary repeat steps 9.1 and 9.2.

9.8 The luminance at the point of measurement is taken as the difference in the powered and unpowered values.

9.9 Move the location of the sample area to the next in sequence and begin from step 9.1 until the entire UUT has been measured at all desired locations.

10. Both Methods

10.1 After all desired samples have been recorded, return the sample area to the initial point and measure and record the luminance at that location (correcting for unpowered luminance if completing Method 2). Compare to the first measurement. If the first and last points are not the same to within the desired precision, investigate the source of the drift. This may include stray light effects. If a significant effect is found, the measurement should be repeated from steps at 7.1, 8.1, or 9.1 as appropriate.

11. Report

11.1 Report the following information:

11.1.1 State and identification of UUT (assembled or not),

11.1.2 Stray light level, and method used,

11.1.3 Warm up time for the power supply and settling time used for the display,

11.1.4 Luminance measured at each point,

11.1.5 Power conditions for the illumination device,

11.1.6 Location and size of the sample area or areas,

11.1.7 Photometer used, sample settings, calibration status, and the size of the sampling aperture,

11.1.8 Ambient temperature, and

11.1.9 Date of test.

11.2 Uniformity can be characterized a relative luminance difference between center and edge, from top to bottom, or from side to side. A contour plot or other statistical measures can also be used.

12. Precision and Bias

12.1 Because of the similarity in procedure, UUT, and data gathering between these methods and Test Method F2360, the precision of this test method is based on an Inter-laboratory study of F2360-04, conducted in 2006. It is appropriate to report precision and bias only where the samples taken are independent, as is the case in well designed measurements following Method 1 with no overlap to the sample areas. In the F2360-04 study, each of six laboratories tested three different types of lamps. A single “test result” represents an individual determination. Every laboratory produced twelve test results for each material.

12.2 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

12.3 *Reproducibility*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

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

12.5 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

12.6 The precision statement was determined through statistical examination of 216 results, from six laboratories, on three types of lamps. The three types of lamps used are described below:

Lamp 1: manufactured by Metromark: color: amber (X = 0.521, Y = 0.462)
Lamp 2: manufactured by Nelson Nameplate: color: green (X = 0.186, Y = 0.449)
Lamp 3: manufactured by Durel: color: blue (X = 0.155, Y = 0.204)

12.7 To judge the equivalency of two test results, it is recommended to choose the lamp closest in characteristics to the test lamp.

13. Keywords

13.1 color; colorimeter; diffuse light; electroluminescent material; luminance; membrane switch; photometer; planar light source; radiometer; uniformity; video photometer