

ISA Recommendation



Accelerating Depreciation Test Method for LED Lighting Products

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Working Group M1:

“Research on accelerating depreciation test method for LED lighting products”

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Introduction

Traditional lifetime tests for LED lighting products are usually time-consuming and expensive to perform. For instance, a minimum of 6000 hour test period is needed for those products with a rated lifetime of 25000 hours. Such a long time is comparable with the development cycle of new products in LED industry, resulting in a negative impact on the market promotion. Therefore, for a successful acceptance of the LED lighting products, it is very necessary to develop an accelerated test method that can shorten the test period to an acceptable level. Such a standard aims at accelerating luminous flux depreciation of LED lighting products with a reduced testing time from 6000 hours to 2000 hours.

Proposed Definitions

Initial value of luminous flux

The initial value of the luminous flux of a test sample after the pretreatment test

Luminous flux maintenance factor

The value of the luminous flux at a given time divided by its initial luminous flux, and expressed in a percentage.

Ambient temperature

The temperature of the air or other media surrounding a test sample

Accelerated test time

Total time on a sample operated under the specified accelerated test condition

Catastrophic failure

A sudden failure that makes the sample out of order

Proposed Testing Method

1. General Requirements

1.1 Environmental conditions

1.1.1 Overall

In this standard, environmental conditions consist of both laboratory environmental conditions and accelerated testing conditions.

For the purpose of minimizing the environmental effect, the sample should avoid pollutions caused by any sources (e.g. dust) in the test period. Meanwhile, the sample should avoid any vibration and shock.

1.1.2 Laboratory environmental conditions

Unless otherwise specified by the manufacturer or responsible vendor, electro-optical parameters shall be measured at an ambient temperature of $25^{\circ}\text{C}\pm 1^{\circ}\text{C}$ and a relative humidity of 65% maximum. When acquiring measurement data, the sample shall be placed with natural convection airflow, and the measuring point of ambient temperature should be set in the same level horizontally with the sample at approximate 0.5 meter away. For the measurements in the test chamber, the measuring point should be set at least 0.2 meter away from the inner wall of the chamber. The temperature sensor shall be placed avoiding any direct optical radiation.

1.1.3 Accelerated testing conditions

The sample shall be measured at an ambient temperature of $55^{\circ}\text{C}\pm 2^{\circ}\text{C}$ and a relative humidity of 65% maximum. When acquiring measurement data, the sample shall be placed with natural convection airflow, and the measuring point of ambient temperature should be set in the same level horizontally with the sample at approximate 0.5 meter away. For the measurements in the test chamber, the measuring point should be set at least 0.2 meter away from the inner wall of the chamber. The temperature sensor shall be placed avoiding any direct optical radiation.

1.2 Power supply and input voltage requirements

Unless otherwise specified by the manufacturer or responsible vendor, all samples shall be tested under rated voltage and frequency. If a certain voltage range is given by the manufacturer or responsible vendor, all samples shall be tested under the highest value of that voltage range. The voltage output of the power supply shall be within $\pm 0.5\%$ of the rated value during the thermal stabilization, within $\pm 0.2\%$ of the rated value during the electro-optical measurements, and within $\pm 2\%$ of the rated value during the accelerated test.

1.3 Sample installation

During the pretreatment and accelerated test, the sample should be placed in a test chamber complied with the requirements in IEC 60068-3-5:2001. Samples should be installed as required by the manufacturer or responsible vendor, or luminous surface downwards installed if there is no such request. The temperature within the test chamber shall be measured under the requirements in IEC 60068-3-5:2001. The temperature measuring sensor shall be placed avoiding any direct optical radiation.

The thermal protector, infrared and radar detectors, if equipped in the LED lighting products, shall be removed during the pretreatment and accelerated test. And any modifications on the test samples shall be recorded in the report.

1.4 Sample measurements

1.4.1 Requirements for photometric and colorimetric measurements

The luminous flux and chromaticity coordinates of the sample shall be measured at a thermal steady state under laboratory environmental conditions. The measurements of the luminous flux shall be conducted following CIE 127:2007 item 6.2, whereas the measurements of the chromaticity coordinates shall be conducted following CIE 15:2004. The chromaticity coordinates can refer to anyone in between CIE1931(x, y) and CIE1976 (u' , v').

For a precise measurement of the luminous flux and chromaticity coordinates, the series of measurements should be performed with the same equipment and under identical condition in order to reduce the influence of the measurement uncertainty in the algorithm. Those parameters that are measured in different equipments shall be recorded carefully in the report.

1.4.2 Thermal steady state

The judgment of a thermal steady state is: Luminous flux or illuminance variation is less than 1% in 15 minutes duration in which the measured values are acquired every minute. If a thermal steady state is not achieved after 150 minutes, the test can also proceed after recording the information of measurement fluctuation in the report. The luminance shall be measured by the specified analog or digital illuminometer with a precision level 1 or above. The illuminometer shall be located in same configuration and measurement angle when measuring the same sample.

2. Sampling Requirements

The table 1 lists the minimum sample quantity requirement. The final quantity of the samples under test shall be recorded in the report.

Table 1 Minimum sample quantity requirement

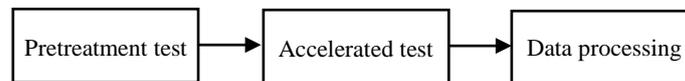
| Lighting product | Quantity |
|---|----------|
| LED bulbs, LED spotlights, LED tubes, and LED down lights | 12 |
| LED street lights and LED tunnel lights | 5 |

3. Testing progress

3.1 General

Figure 1 shows the test procedure of which the total test time is 2000 hours including a pretreatment test and accelerated test.

Figure 1 Test procedure



3.2 Pretreatment test

The pretreatment test shall be conducted in the following procedure:

1. Samples with a sufficient quantity specified by item 2 are prepared. The luminous fluxes of these samples are measured after reaching the thermal steady state, and recorded in the report.
2. The samples are installed with the requirements in item 1.3. The climate temperature within the test chamber shall be slightly increased to the accelerated testing conditions by no more than 1°C/min.
3. After reaching the thermal steady state, the samples shall be ignited continuously for 500 hours. Any catastrophic failure that happens in this testing period shall be recorded along with the failure time in the report, and the corresponding sample is removed from the pretreatment test.
4. The samples which are not failed in the pretreatment test shall be placed under laboratory environmental conditions for at least 2 hours. After reaching the thermal steady state, initial values of the luminous fluxes and chromaticity coordinates of the samples are measured, and also recorded in the report.
5. The samples whose initial luminous fluxes are lower than 70% of those before the pretreatment test are treated as failed samples. Number of the failed samples shall be collected and recorded in the report.

After the pretreatment test, the samples shall meet the following requirements, otherwise the test is terminated:

- a) Quantity of the non-failed samples shall be no less than the minimum requirement specified in item 4.2, and also not less than 70% of the total number of samples under test.
- b) The chromaticity coordinates of the non-failed samples shall meet the requirements in ANSI/ANSI C78.377-2011, namely within the quadrangles in

Figure 2.

- c) During the pretreatment test, the total interrupt time shall be no more than 24 hours in which each of the interrupt shall be no more than 8 hours.

3.3 Accelerated test

After the pretreatment test, the non-failed samples are ignited again in the accelerated testing conditions. After reaching a thermal steady state, the samples are tested under the accelerated testing conditions for 1500 hours. During this period, the luminous flux and chromaticity coordinates of the samples shall be measured at 900, 1200 and 1500 hours respectively. A detailed procedure of the accelerated test is given below:

1. The samples are installed with the requirements in item 1.3. The climate temperature within the test chamber shall be slightly increased to the accelerated testing conditions by no more than 1°C/min.
2. After reaching the thermal steady state, the samples shall be ignited continuously for 900 hours. Any catastrophic failure that happens in this testing period shall be recorded along with the failure time in the report, and the corresponding failed sample is removed from the accelerated test. The samples which are not failed in the pretreatment test shall be placed under laboratory environmental conditions for at least 2 hours. After reaching the thermal steady state, initial values of the luminous fluxes and chromaticity coordinates of the samples are measured, and also recorded in the report.
3. Repeat Step 1.
4. After reaching the thermal steady state, the samples shall be ignited continuously for 1200 hours. Any catastrophic failure that happens in this testing period shall be recorded along with the failure time in the report, and the corresponding failed sample is removed from the accelerated test. The samples which are not failed in the pretreatment test shall be placed under laboratory environmental conditions for at least 2 hours. After reaching the thermal steady state, initial values of the luminous fluxes and chromaticity coordinates of the samples are measured, and also recorded in the report.
5. Repeat Step 1.
6. After reaching the thermal steady state, the samples shall be ignited continuously for 1500 hours. Any catastrophic failure that happens in this testing period shall be recorded along with the failure time in the report, and the corresponding failed sample is removed from the accelerated test. The samples which are not failed in the pretreatment test shall be placed under laboratory environmental conditions for at least 2 hours. After reaching the thermal steady state, initial values of the luminous fluxes and chromaticity coordinates of the samples are measured, and also recorded in the report.

During the accelerated test, the total interrupt time shall be no more than 72 hours in which each of the interrupt shall be no more than 24 hours.

3.4 Data processing

3.4.1 Luminous flux maintenance factor

The luminous flux maintenance factor of the sample shall be calculated by Eq. (1), and recorded in the report.

$$\eta_{\Phi} = \frac{\Phi_v}{\Phi_{v0}} \quad (1)$$

in which:

η_{Φ} —Luminous flux maintenance factor;

Φ_v —Luminous flux;

Φ_{v0} —Initial value of the luminous flux

For the sample which is failed catastrophically in the accelerated, its luminous flux factor is regarded as zero.

3.4.2 Averaged luminous flux maintenance factor

The averaged luminous flux maintenance factor of the sample shall be calculated by Eq. (2), and recorded in the report.

$$\bar{\eta}_{\Phi} = \frac{\sum_{i=1}^n \eta_{\Phi i}}{n} \quad (2)$$

in which:

$\bar{\eta}_{\Phi}$ —Averaged luminous flux maintenance factor;

$\eta_{\Phi i}$ —Luminous flux maintenance factor of the sample i;

n —Sample quantity.

4. Qualification Determination

After the accelerated test, the samples shall meet the following requirements:

- a) The averaged luminous flux maintenance factor at 900, 1200 and 1500 hours calculated from all samples shall be no less than 95%.
- b) At 900, 1200 and 1500 hours, the chromaticity coordinates of no less than 90% of the samples shall meet the requirements in ANSI_ANSLG C78.377-2011, namely within the quadrangles in Figure 2.

Figure 2 Specification of the chromaticity coordinates

| Nominal color temperature | 2700K | | 3000K | | 3500K | | 4000K | | 4500K | | 5000K | | 5700K | | 6500K | |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | x | y | x | y | x | y | x | y | x | y | x | y | x | y | x | y |
| Coordinate | 0.4577 | 0.4098 | 0.4339 | 0.4032 | 0.4078 | 0.3929 | 0.3818 | 0.3796 | 0.3613 | 0.3669 | 0.3446 | 0.3551 | 0.3287 | 0.3425 | 0.3123 | 0.3283 |
| Center point | 0.4811 | 0.4315 | 0.4561 | 0.4259 | 0.4302 | 0.4171 | 0.4003 | 0.4034 | 0.3737 | 0.3879 | 0.3550 | 0.3752 | 0.3375 | 0.3619 | 0.3205 | 0.3475 |
| (x,y)Peak coordinate of quadrilateral in tolerance | 0.4561 | 0.4259 | 0.4302 | 0.4171 | 0.4003 | 0.4034 | 0.3737 | 0.3879 | 0.3550 | 0.3752 | 0.3375 | 0.3619 | 0.3205 | 0.3475 | 0.3027 | 0.3310 |
| | 0.4373 | 0.3892 | 0.4149 | 0.3820 | 0.3895 | 0.3708 | 0.3671 | 0.3583 | 0.3514 | 0.3480 | 0.3366 | 0.3372 | 0.3221 | 0.3255 | 0.3067 | 0.3118 |
| | 0.4591 | 0.3941 | 0.4373 | 0.3892 | 0.4149 | 0.3820 | 0.3895 | 0.3708 | 0.3671 | 0.3583 | 0.3514 | 0.3480 | 0.3366 | 0.3372 | 0.3221 | 0.3255 |
| Center point | 0.2614 | 0.5267 | 0.2490 | 0.5206 | 0.2364 | 0.5125 | 0.2249 | 0.5030 | 0.2163 | 0.4943 | 0.2098 | 0.4863 | 0.2038 | 0.4777 | 0.1978 | 0.4679 |
| Coordinate | u' | v' |
| (u',v') Peak coordinate of quadrilateral in tolerance | 0.2667 | 0.5382 | 0.2535 | 0.5325 | 0.2408 | 0.5254 | 0.2274 | 0.5157 | 0.2164 | 0.5054 | 0.2091 | 0.4971 | 0.2025 | 0.4885 | 0.1964 | 0.4790 |
| | 0.2535 | 0.5325 | 0.2408 | 0.5254 | 0.2274 | 0.5157 | 0.2164 | 0.5054 | 0.2091 | 0.4971 | 0.2025 | 0.4885 | 0.1964 | 0.4790 | 0.1902 | 0.4679 |
| | 0.2574 | 0.5154 | 0.2458 | 0.5090 | 0.2336 | 0.5003 | 0.2237 | 0.4912 | 0.2171 | 0.4838 | 0.2113 | 0.4762 | 0.2058 | 0.4678 | 0.2002 | 0.4579 |
| | 0.2696 | 0.5207 | 0.2574 | 0.5154 | 0.2458 | 0.5090 | 0.2336 | 0.5003 | 0.2237 | 0.4912 | 0.2171 | 0.4838 | 0.2113 | 0.4762 | 0.2058 | 0.4678 |

5. Lifetime Evaluation

The samples which past the accelerated test are deemed to have a lifetime of 25000 hours (i.e. the period during which the flux maintenance factor of the sample depreciates to 70%) when operated in an ambient temperature of $25^{\circ}\text{C}\pm 5^{\circ}\text{C}$.

References

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 - [2] ENERGY STAR® Program Requirements - Product Specification for Lamps (Light Bulbs) Eligibility Criteria -Version 1.1
 - [3] Illuminating Engineering Society, TM-28-14 Projecting Long Term Luminous Flux Maintenance of LED Lamps and Luminaires, 2014.
 - [4] American National Standards Institute, ANSI ANSLG C78.377-2011, Specifications for the Chromaticity of Solid State Lighting Products, 2011
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