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INTERNATIONAL STANDARD

NORME INTERNATIONALE

LED packages – Long-term luminous and radiant flux maintenance projection

LED encapsulées – Projection à long terme concernant la conservation du flux lumineux et du flux énergétique

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INTERNATIONAL
ELECTROTECHNICAL
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LED PACKAGES – LONG-TERM LUMINOUS AND RADIANT FLUX MAINTENANCE PROJECTION

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International Standard IEC 63013 has been prepared by subcommittee 34A: Lamps, of IEC technical committee 34: Lamps and related equipment.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
34A/2008/FDIS	34A/2015/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

One of the benefits of LED lighting is their long lifetime compared to that of many other light source technologies.

However, there is currently no international standard for predicting the long-term luminous flux maintenance of LED packages. This document is intended to close this gap by specifying methods for the long-term luminous flux maintenance projection.

This document is the result of the discussions led by a special expert group within IEC technical committee 34 on this topic.

This expert group had collected a set of luminous flux maintenance measurements of 39 LED package types, each tested at three different temperatures.

Various projection methods were analysed based on this set of test data.

Regarding the selection of models, there was a controversial discussion among the experts and no unanimous agreement could be found.

It was concluded at the meeting in Berlin on 21 January 2014 to choose the TM-21 method as the starting point of the analysis and to have the border function as an alternative in case the TM-21 method was not applicable. It was further concluded that the Arrhenius temperature acceleration should be included in an informative annex.

At the meeting on 26 January 2015 in Washington some further editorial improvements were made and it was agreed to submit this document to IEC as a new project with a view to developing a full international standard.

This new project was approved and all comments received during the enquiry stage were discussed by the project team and resolved. This document incorporates the changes agreed by the project team.

LED PACKAGES – LONG-TERM LUMINOUS AND RADIANT FLUX MAINTENANCE PROJECTION

1 Scope

This document is applicable to LED packages for general lighting services.

It specifies procedures and conditions for measuring the luminous flux maintenance of LED packages. It also provides the procedures and conditions (criteria) of projecting the long-term luminous flux maintenance based on limited luminous flux maintenance test data collected. Within the context of this document, wherever luminous flux measurement data is specified, radiant flux measurement data can also be used.

These projection methods employ data collected as per ANSI/IES LM-80-15 (LM-80).

The long-term projection is based on the exponential-fit-function procedure of IES TM-21-11 (TM-21), and gives an alternative border function procedure in the case where the exponential-fit-function of IES TM-21-11 is not applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62504, *General lighting – Light emitting diode (LED) products and related equipment – Terms and definitions*

IES TM-21-11, *Projecting Long Term Lumen Maintenance of LED Light Sources*

IES LM-80-08 [1], *IES Approved Method for Measuring Lumen Maintenance of LED Light Sources*

ANSI/IES LM-80-15, *IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62504 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

[1] Withdrawn. This edition was replaced in 2015 by IES LM-80-15, *IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules*.

3.1
case temperature
temperature value of the thermocouple attachment point as specified by the manufacturer

4 Test method, data collection and sample size

Luminous flux maintenance test data shall be collected according to the methods described in ANSI/IES LM-80-15. Test data collected according to IES LM-80-08 shall be acceptable.

When collecting data for long-term luminous flux maintenance projection, it is recommended to use intervals smaller than 1 000 h for the measurement of the luminous flux and to perform measurements beyond 6 000 h.

Recommendations on sample size are found in IES TM-21-11.

5 Long-term luminous flux maintenance projection methods

5.1 General

The following projection methods are included in this document:

- Exponential fit function (EFF)
- Border function (BF)

The EFF method shall be used as the primary method, with the BF method used as an alternative only when the EFF calculation yields a negative or zero α–value, see Annex B (Flowchart).

If at least one temperature data set leads to the application of the BF method ($\alpha \le 0$), then all temperature data sets of the same LED package shall be evaluated with the BF method.

Annex A describes a temperature acceleration method according to the temperature acceleration Arrhenius (TA-A) formula.

5.2 Exponential fit function (EFF)

5.2.1 Method

The exponential fit function method (EFF), as described in IES TM-21-11, is based on the assumption that after early luminous flux degradation modes are complete, the subsequent test data can be fitted and extrapolated using an exponential curve-fit function, using the formula

$$f(t) = B\exp(-\alpha t) \tag{1}$$

The luminous flux maintenance projection shall be performed according to IES TM-21-11, Section 5.

5.2.2 Criteria

The EFF method shall be applied only to data sets showing normal degradation with $\alpha > 0$, a “downward” projection. In cases where the data fit yields an EFF with $\alpha \le 0$, a “flat or upward” projection, then the BF method shall be applied.

5.3 Border function (BF)

5.3.1 Method

The border function (BF) method is based on the assumption that an exponential model is a conservative estimation of the actual long-term luminous flux maintenance, and is applied when the criteria of 5.2.2 have met.

The border function shall be calculated according to Annex C.

Each border function has an associated life and luminous flux maintenance target value.

The associated life target is considered to be a median life and shall be a multiple of 5 000 h and the luminous flux maintenance target shall be 70 %, 80 % or 90 %.

5.3.2 Criteria

If

- the tested luminous flux value is greater than the value calculated as per the border function for at least the last 2 000 h of the test, and is supported by at least 3 successive measurements points, and
- the value of the slope of the test data for the last 2 000 h of the test is greater than the corresponding value of the slope of the border function for the same time period (for the calculation of the slopes see 5.3.3),

then the associated median life and luminous flux maintenance target value of the BF may be used as the projected median life L_x for the tested LED package.

5.3.3 Calculating the test data slope and the BF slope

Calculate the slope of the test data for the last 2 000 h by making a linear fit to all averaged test points in that time period. At least 3 successive measurement points shall be applied. The regression coefficient of the linear fit shall be reported.

The corresponding slope of the BF for the last 2 000 h is approximated by the formula

$$\text{BFslope} = -\lambda \exp(-\lambda \, (t_{\text{end}} - 1\,000 \text{ h})) \tag{2}$$

where t_{end} is the time of the last test point.

6 Temperature data interpolation

If temperature interpolation is employed, then it shall be performed according to the Arrhenius formula in IES TM-21-11, Clause 6.

NOTE Additional information on the Arrhenius method can be found in IEC 62506.

Temperature interpolation is limited to the temperature range between the tested temperatures.

7 Adjustment of results

The results of 5.2 and 5.3 shall be adjusted according to IES TM-21-11, 5.2.5.

8 Reporting

The report of the luminous flux maintenance projection shall include the following information shown in Table 1. Only L_{70} and L_{xx} values adjusted as per Clause 7 shall be reported, according to the notation in IES TM-21-11, 5.2.6.

Table 1 – Information to be included in the report

Description of LED package tested (manufacturer, model, catalogue number)	
Sample size	
Number of failures during testing period	
Forward current(s) used in the test	mA
Maintenance test duration	h
Case temperature(s) during testing	°C
Projection method used **(including values of mathematical fit parameters)**	
Test duration used for projection as per IES TM-21-11	h to h
Reported L_{xx} (Dk) (e.g. 85 °C, tested) **Reported L_{xx} (Dk) (e.g. 95 °C, interpolated)** **Reported L_{xx} (Dk) (e.g. 105 °C, tested)**	h h h

Annex A
(informative)

Temperature acceleration – Arrhenius method (TA-A)

A.1 Method

The Arrhenius method is based on the basic assumption that the ageing (degradation) mechanism can be accelerated by raising the case temperature and that the activation energy E_a can be used to describe this acceleration behaviour. The basic equations describing this model are that the luminous flux degrades according to a function $f(t,\rho)$ with degradation parameter ρ depending on temperature T as follows

$$\rho(T) = K \exp(-E_a / k_B T) \quad \text{(A.1)}$$

The activation energy E_a and two measured points at time and temperature conditions (τ_1, T_1) and (τ_2, T_2) where light degradation to a luminous flux maintenance factor is observed can be used to describe an acceleration factor according to the formula

$$AF_T = \frac{\tau_1}{\tau_2} = \exp\left\{\frac{E_a}{k_B} \times \left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right\} \quad \text{(A.2)}$$

where

AF_T	is the acceleration factor due to temperature differences;
E_a	is the activation energy in eV;
k_B	is the Boltzmann constant in eV/K;
τ_1, τ_2	are the times with $\tau_1 > \tau_2$ in h;
T_1, T_2	are the temperatures with $T_1 < T_2$ in K.

The Arrhenius luminous flux maintenance projection should be performed according to IEC 62506:2013, 5.6.1.2.

A.2 Criteria

The following criteria are applicable:

– The activation energy E_a should be known for application of the Arrhenius model. The LED package manufacturer estimates the activation energies for the relevant degradation modes each time they qualify a new component technology. The activation energy should be in the range 0,1 eV < E_a < 1,0 eV.

– There should be no evidence for positive degradation, i.e. no “upward” projection in the data set.

– For each temperature in the data set, higher temperatures should show more rapid degradation.

– The TA-A method should not be used if evidence exists that the temperature acceleration has caused a change in degradation mode.

– If there is evidence for more than one significant degradation mode, then the TA-A method should be applied to each degradation mode separately. For example, if the data set shows a significant change in degradation rate, i.e. mode 1 completed and mode 2 continued onward, then the acceleration factor determined for mode 1 should only be applied to mode 1 and not to mode 2 or any future degradation modes.