FOREWORD

(Formal clause will be added later)

This standard (part 2) specifies the performance requirements for LED modules for general lighting services for supply voltages up to and including 250 V ac.

The general and safety requirements have been covered in part 1 of this standard (under preparation)

The first edition for this performance standard for LED modules for general lighting applications acknowledges the need for relevant tests for this new source of electrical light, sometimes called "solid state lighting".

The standard shall be read in close context with performance standards for luminaires in general and for LED-luminaires. Changes in the LED module standard will have impact on the luminaire standards and vice versa, due to the behaviour of LED.

The provisions in this standard represent the technical knowledge of experts from the fields of the semiconductor (LED chip) industry and of those of the traditional electrical light sources.

Three types of LED-modules are covered: with integral control gear, with means of control on board, but with separate control gear ("semi-ballasted"), and with complete external control gear.

This standard is based on IEC document LUMAX (EG) 47F 'LED-luminaires for general lighting services, Performance requirements issued IEC/SC 34A of International Electrotechnical Commission (IEC) with following modifications:

a) Schedule of type test and acceptance test has been incorporated;
b) Ambient test condition changed to 27°C;

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2: 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

LED MODULES FOR GENERAL LIGHTING

Part 2 Performance Requirements

1 SCOPE

1.1 This standard (part 2) specifies the performance requirements for LED modules, together with the test methods and conditions, required to show compliance with this standard. The following types of LED modules are covered in this standard:

a) Type 1: Self-ballasted LED modules for use on d.c. supplies up to 250 V or on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz.

b) Type 2: LED modules operating with external control gear connected to the mains voltage, and having further control means inside ("semi-ballasted") for operation under constant voltage, constant, current or constant power.

c) Type 3: LED modules where the complete control gear is separate from the module for operation under constant voltage, constant current or constant power.

The types of LED modules are explained in Fig. 1.

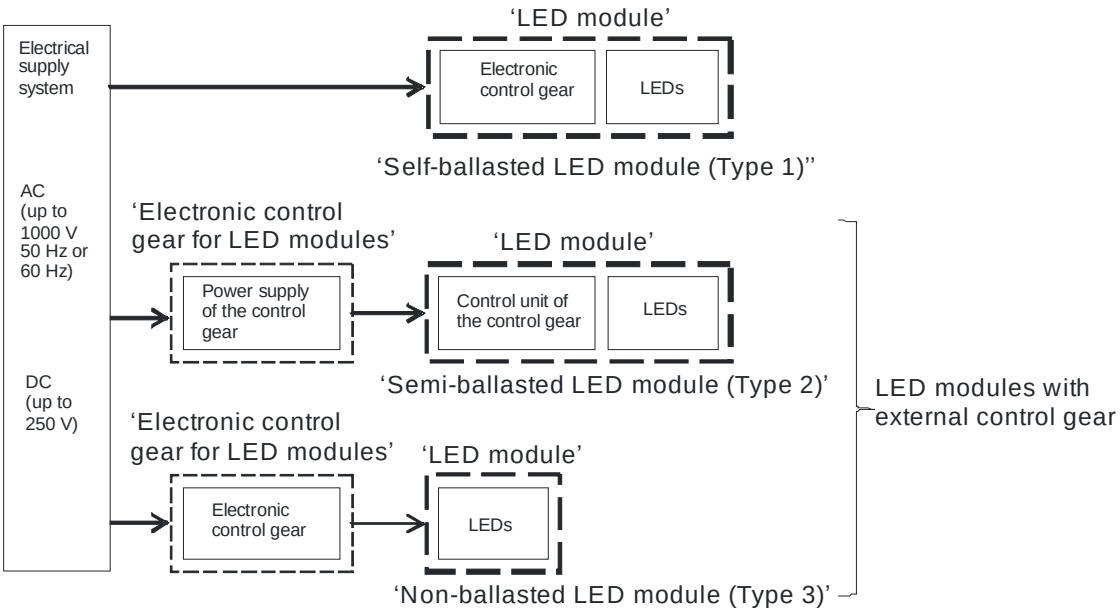


Figure 1 – Types of LED modules

NOTES:

1. Power supply of the control gear for semi-ballasted LED modules (Type 2) is an electronic device capable of controlling currents, voltage or power within design limits.

2. The control unit of the control gear for semi-ballasted LED modules (Type 2) is an electronic device to control the electrical energy to the LED's.

3. A non-'self-ballasted LED module'≠ 'Non-ballasted LED module'

4. A LED module with external control gear can be either a non-ballasted LED module or a semi-ballasted LED module

This standard does not cover LED modules that intentionally produce coloured light, neither does it cover modules based on OLEDs (organic LEDs).

These performance requirements are additional to the requirements in IS xxxxx/IEC 62031 Safety Standard for LED modules.

Life time of LED modules is in most cases much longer than the practical test times. Consequently, verification of manufacturer's life time claims cannot be made in a sufficiently confident way, because projecting test data further in time is not standardised. For that reason the acceptance or rejection of a manufacturers life time claim is out of the scope of this standard.

Instead of life time validation, this standard has opted for lumen maintenance categories at a defined finite test time. Therefore, the category number does not imply a prediction of achievable life time. The categories are lumen-depreciation character categories showing behaviour in agreement with manufacturer's information which is provided before the test is started.

In order to validate a life time claim, an extrapolation of test data is needed. A general method of projecting measurement data beyond limited test time is under consideration.

The condition of compliance of the life time test as defined in this standard is different from the life time metrics claimed by manufacturers. For explanation of recommended life time metrics, *see* **Annex E**.

NOTES:

1 When modules are operated in a luminaire the claimed performance data can deviate from the values established via this PAS due to e.g. luminaire components that impact the performance of the module.

2 The external control gears as mentioned in Type 2 and Type 3 are not part of the testing against the requirements of this PAS.

3 Protection for water and dust ingress to be checked in final application

4 Input voltage limits of Type 2 and Type 3 are under investigation.

It may be expected that self-ballasted LED modules which comply with this standard will start and operate satisfactorily at voltages between 90 percent and 110 percent of rated supply voltage. LED modules with external control gear are expected to start and operate satisfactorily in combination with the specified control gear complying with IS xxxxx/IEC 61347-2-13 and IS xxxxx/IEC 62384. All LED modules are expected to start and operate satisfactorily when

operated under the conditions specified by the module manufacturer and in a luminaire complying with IS 10322(Part 1).

2 REFERENCES

The following standards are necessary adjunct to this standard.

IS No.	*Title*
1885(Part 16/Sec 1):1968	Electrotechnical vocabulary Part 16 Lighting, Section 1 General aspects
2418(Part 1): 1977	Tubular fluorescent lamps for general lighting services: part 1 Requirements and tests
2500 (Part 1): 2000	Sampling procedures for inspection by attributes: Part 1 Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
6873 (Part 5): 1999 (revised version under print)	Limits and methods of measurement of radio disturbance characteristics : Part 5 Electrical lighting and similar equipment
10322(Part 1): 2010	Luminaire: Part 1 General requirement and tests
11000(Part 14/ Sec 1 to 3)):1984	Basic environmental testing procedures for electronic and electrical items Part 14 Test N, Change of temperature
14700 (Part 3/Sec 2) :1999 (under revision)	Electromagnetic compatibility Part 3 Limits Sec 2 Limits for harmonic current emissions
IS xxxxx/IEC 62031(Under preparation)	LED modules for general lighting Part 1 Safety requirements
IS xxxxx/IEC 62504 (under preparation)	General lighting – LED and LED modules – Terms and definitions
IS xxxxx/IEC 62560(under preparation)	Self-ballasted LED lamps Part 1 Safety Requirements
IS xxxxx/IEC TR 61341 (to be prepared)	Method of measurement of centre beam intensity and beam angle(s) of reflector lamps
IS xxxxx/IES LM-79-08 (under preparation)	Method of electrical and photometric measurement of solid state lighting products
IS xxxxx/IES LM-80-08 (under preparation)	Method of measurement of lumen maintenance of solid state light (LED) sources
IS xxxxx/IEC 62384 (under preparation)	DC or AC supplied electronic control gear for LED modules – Performance requirements

IS xxxxx/CIE 84 (to be prepared)	The Measurement of Luminous Flux
IS xxxxx/CIE 121 (to be prepared)	xxxxx

3 TERMINOLOGY

For terms and definitions in the field of LED and LED light sources, reference is made to IS xxxxx/IEC TS 62504 and IS 1885 (Part 16/Sec 1). In addition, the following terms and definitions shall apply.

3.1 Rated Value

The quantitative value for the characteristic of a LED module under specific operating conditions. The value and the conditions are specified in this standard, or assigned by the manufacturer or responsible vendor

3.2 Test Voltage

Voltage at which tests are carried out.

3.3 Lumen Maintenance

Value of the luminous flux at a given time in the life of a LED module divided by the initial value of the luminous flux of the module and expressed as a percentage of the initial luminous flux value.

NOTE- The lumen maintenance of a LED module is the effect of decrease of lumen output of the LED(s) or a combination of this with failure(s) of LED(s) if the module contains more than one LED.

3.4 Initial Values

Photometric and electrical characteristics at the end of the ageing period and/or stabilization time

3.5 Maintained Values

Photometric and electrical characteristics after an operation time of 25 percent of rated LED module life with a maximum duration of 6 000 h and stabilisation time

3.6 Rated Life

Length of time during which a population of LED modules provides more than claimed percentage x of the initial luminous flux, published in combination with the failure fraction, as declared by the manufacturer or responsible vendor.

NOTES:

1 For sample size *see* 6.
2 NOTE 1 and 2 of **3.7** apply.
3 For explanation of the figure L_xF_y *see* **Annex E**.

3.7 Life (of an individual LED module)(L_x)

Length of time during which a LED module provides more than claimed percentage of the initial luminous flux, under standard test conditions. A LED module has thus reached its end of life, when it no longer provides claimed percentage of the initial luminous flux. Life is always published as combination of life L_x and failure fraction F_y (*see* NOTE 2 and **3.8**).

NOTES:

1 Any built-in electronic control gear, however, may show a sudden end of life failure. The definition under 3.7 implies that a LED module giving no light at all, due to an electronic failure, has actually reached end of life, since it no longer complies with the minimum luminous flux level as declared by the manufacturer or responsible vendor.

2 End of life is normally determined when x percent of the LED modules failed, indicated n combination with the chosen lumen maintenance value: L_x, F_y.

3.8 Failure Fraction (F_y)

The percentage 'y' of a number of tested LED modules of the same type that have reached the end of their individual lives, where 'y' designates the percentage (fraction) of failures. This failure fraction expresses the combined effect of all components of a module including mechanical, as far as the light output is concerned. The effect of the LED could either be less light than claimed or no light at all.

NOTE- For LED modules normally a failure fraction of 10 percent and/or 50 percent are being applied, indicated as F_{10} and/or F_{50}

3.9 Gradual Failure Fraction (B_y)

The percentage 'y' of a number of tested LED modules of the same type that have reached the end of their individual lives, where 'y' designates the percentage (fraction) of failures. This failure fraction expresses only the gradual light output degradation.

3.10 Abrupt Failure Fraction (C_y)

Percentage 'y' of a number of tested LED modules of the same type that have reached the end of their individual lives where 'y' designates the percentage (fraction) of failures. This failure fraction expresses only the abrupt light output degradation.

3.11 Colour Code*

Colour designation of a LED module giving white light are defined by the Correlated Colour Temperature and the general colour rendering index

*: under consideration

3.12 Stabilization Time

Time, which the LED module requires to obtain stable thermal conditions

3.13 Ageing

Preconditioning period of the LED module

3.14 Type

LED modules that have an identical photometrical, electrical rating and the same classification as in IS xxxxx/IEC 62031

3.15 Family

under consideration

3.16 Type Test

test or series of tests made on a type test sample for the purpose of checking compliance of the design of a given product with the requirements of the relevant standard. In general all tests are made on each type of LED module or, where a range of similar LED modules is involved, for each rated light output in the range or on a representative selection from the range as agreed with the manufacturer.

3.17 Type Test Sample

Sample consisting of one or more similar units submitted by the manufacturer or responsible vendor for the purpose of the type test.

3.18 Recommended maximum LED module operating temperature (t_p)

Maximum LED module temperature, as indicated and specified by the manufacturer or responsible vendor, at which the rated performance values are met.

NOTE- $t_p \leq t_c$. For t_c, *see* **3.10** of IS xxxxx/IEC 62031.

3.19 Semi-Ballasted LED Module

Module which carry the control unit of the control gear, and operated by separate power supply of the control gear.

NOTE- In this standard, semi-ballasted LED modules are designated "Type 2".

3.20 Control Unit of the Control Gear

Electronic device, being part of the control gear, responsible for controlling the electrical energy to the LEDs as well as colour mixing, response to depreciating luminous flux and further performance features.

NOTE-In semi-ballasted LED modules, the control unit of the control gear is on board the module and separate from the power supply of the control gear.

3.21 Power Supply of the Control Gear

Electronic device, being part of the control gear, capable of controlling current, voltage or power within design limits.

NOTE- For semi-ballasted LED modules, the power supply of the control gear is separate from the LED module on a distant location.

3.22 Acceptance Test

Tests carried out on samples taken from a lot for the acceptance of the lot.

4 MARKING

4.1 General

Following information shall be provided visible (in addition to the mandatory information given in IS xxxxx/IEC 62031) by the manufacturer or responsible vendor, and placed as specified in Table 1.

Table 1
Required markings and places of marking
(*Clause* 4.1, 8.1,9.1,10.1 and 10.2)

Sr. No	Parameters	Product	Packaging	Product datasheets, leaflets or website
(1)	(2)	(3)	(4)	(5)
1	Rated luminous flux (lm).	-	X [3)]	X [3)]

2	Lamp (and LED module) photometric code (*see* Annex F).*	-	x	x
3	Rated life (h) and the related lumen maintenance factor (L_x)	-	x	x
4	Failure fraction (F_y), corresponding to the rated life	-	x	x
5	Lumen maintenance category (1 to 3, *see* Table 4) - Life time specification L_xB_y for gradual light output degradation (*see* Annex E, **E.3** and **E.6**) - Life time specification L_0C_y for abrupt light output degradation (*see* Annex **E.4** and **E.6**)	-	-	x (on request) on request
6	Rated chromaticity co-ordinate values both initial and maintained (each expressed as tolerance categories "D" to "A", *see* Table 3).	-	-	x
7	Rated Colour Rendering Index	-	-	x
8	Max. performance operating temperature t_p [4] of LED module (°C)	x [1) 2)]	-	x
9	Ageing time (h), if different to 0 h	-	-	x
10	Ambient temperature range for modules having the heat sink on board (not needing to rely on cooling via the luminaire).	-	-	x

* under consideration

[1)] Position/location of measuring point on the LED module, not the t_p value itself

[2)] If the space on the module is not large enough, marking on the packaging only is sufficient.

[3)] For modules with directional output, centre beam intensity and beam angle are measured according to IS xxxxx/IEC TR 61341 and marked.

[4)] In case t_p and t_c are at the same location, then t_p is not marked separately on the module, but given in the product datasheet.

NOTE- x = required, - = not required

4.2 Optional Marking

In addition to marking requirement in **4.2,** the marking as given in Table 2 may be used. Corresponding to the fixed ambient temperatures 40 °C, 50 °C and 60 °C, the values of the temperature measured on the performance reference point t_p and the declared life time have to be inserted by the LED module manufacturer. The value of the temperature at the t_p point shall not exceed the value given in Table 2.

Table 2
LED module life time information
(*Clause* 4.2)

Ambient temperature (°C) for LED modules with integral heat sink (not relying on the luminaire)	40	50	60
Temperature (°C) measured at the reference point t_p	*	*	*
Life time (h)	*	*	*

* values to be declared by the LED module manufacturer

NOTE- Any other information in addition to those given in Table 2 may be provided by the LED module manufacturer.

4.3 BIS Certification Marking

The LED-modules may also be marked with the Standard Mark.

4.3.1 The use of Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act,* 1986 and the Rules and Regulations made there under. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

5 Dimensions

The LED module dimensions shall comply with the specifications as indicated by the manufacturer or responsible vendor.

6 Test conditions

6.1 Test duration

Testing duration is 6 000 h (or 25 percent of rated life time). Other methods providing more advanced insight in the life of the product with shorter test duration are under consideration.

6.2 General test conditions

Test conditions for testing electrical and photometric characteristics, lumen maintenance and life are given in Annex A.

All tests are measured on "n" LED modules of the same type. The number "n" shall be a minimum of products as given in Table 4. LED modules used in the endurance tests shall not be used in other tests.

In case of Type 2 and Type 3 LED modules, testing requires operation with an external reference power supply and reference control gear, respectively. Specification of the reference power supply and reference control gear shall be made by the LED module manufacturer.
LED modules with dim control shall be adjusted to maximum output for all tests in this standard.

LED modules with adjustable colour point shall be adjusted / set to one fixed value as given by the manufacturer or responsible vendor.

6.3 Identification of a Family

Requirements for the identification of a family of LED modules for type testing are given in definition **3.15** and used in Table 5.

7 Module power

7.1 Measurements are conducted under the most adverse condition. For conditions, *see* Annex A.

NOTE-1 The requirements given in NOTE 2 of **1.1** shall be considered**.**

The initial power consumed by each individual LED module in the measured sample shall not exceed the rated power by more than 10 percent.

The 97.5 percent one-sided upper confidence limit for the mean of lamp power shall not exceed the rated power value.

The 97.5 percent upper confidence limit for sample size 'n' according to Table 4 is calculated by the following formula:

$$x + s \times 0.468,$$

where *x* and *s* are the sample average and standard deviation of lamps respectively.

(The value of 97.5 percent is under consideration)

NOTES:

2 Efficacy is in general the ratio luminous flux / module power. Calculation methods are under consideration.
3 For other sample sizes, see calculation of the confidence limit in Annex G.

8 Light output

8.1 Luminous flux

Luminous flux is measured according to Annex A and Annex B.

The initial luminous flux of each individual LED module in the measured sample shall not be less than 90 percent of the rated lumen output.

The 97.5 percent one-sided lower confidence limit for the mean of lamp luminous flux shall not be less than the rated luminous flux value.

The 97.5 percent lower confidence limit for sample size 'n' according Table 5 is calculated by the following formula:

$$x - s \times 0.468,$$

where *x* and *s* are the sample average and standard deviation respectively.

(The value of 97.5 percent is under consideration)

NOTES:

1 Efficacy is in general the ratio luminous flux / module power. Calculation methods are under consideration.
2 For other sample sizes, *see* calculation of the confidence limit in Annex G.

8.2 Luminous intensity

8.2.1 *Intensity*

The intensity of light emitted from the LED module in different directions is measured with a goniophotometer.

In case (peak) intensity values are declared by the manufacturer or responsible vendor, the initial (peak) intensity of each individual LED module in the measured sample shall not be less than 90 of the rated intensity.

NOTE- Average value and confidence level are under consideration

8.2.2 *Angular Beam Distribution*

In case angular beam values are provided by the manufacturer or responsible vendor, the angular beam values of each individual LED module in the measured sample shall not deviate by more than 10 percent of the rated value for all beam angles.

NOTE- Average value and confidence level are under consideration

8.3 LED Module Efficacy

LED module efficacy shall be calculated from the measured luminous flux of the individual LED module divided by the measured input power of the same individual LED module.

LED module efficacy shall not be less than 90 percent of the rated LED module efficacy as declared by the manufacturer of responsible vendor.

NOTE- The value of 90 percent is under consideration

9 CHROMATICITY CO-ORDINATES, CORRELATED COLOUR TEMPERATURE (CCT) AND COLOUR RENDERING

9.1 Chromaticity Co-ordinates and Correlated Colour Temperature

The test for chromaticity co-ordinates shall be carried out as per IS 2418 (Part1).

NOTE- Standardised chromaticity co-ordinates are under consideration.

The initial CCT of a LED module (called “initial CCT”) and the initial chromaticity co-ordinates (called “initial chromaticity co-ordinates”) are measured. A second measurement (called “maintained CCT” and “maintained chromaticity co-ordinates”) is made after an operation time of 25 percent of rated LED module life with a maximum duration of 6 000 h. The measured actual chromaticity co-ordinate values (both initial and maintained) shall fit within one of 4 categories (see Table 3), which correspond to a particular MacAdams ellipse around the rated chromaticity co-ordinate value, whereby the size of the ellipse (expressed in n-steps) is a measure for the tolerance or deviation of an individual LED module.

The measured chromaticity co-ordinate value of a LED module (the initial value and maintained value) shall not move beyond the chromaticity co-ordinate tolerance category as indicated by the manufacturer or responsible vendor (*see* Table 1).

Table 3
Tolerance (categories) on rated chromaticity co-ordinate values
(*Clause* 9.1)

Size of MacAdam ellipse, centred on the rated colour target	Colour Variation Category	
	initial	maintained
3-step	D	D
5-step	C	C
7-step	B	B
>7-step ellipse	A	A

The behaviour of the chromaticity co-ordinates of a LED module shall be expressed by mentioning the two measurement results of both initial chromaticity co-ordinates and maintained chromaticity co-ordinates.

Example: C/B, meaning initial shift within a 5-step ellipse and maintained shift within a 7-step ellipse.

NOTES:

1 This standard applies to LED modules for which it is in most cases possible to choose a CCT value that best fulfils the requirement of a particular application. Standardised colour points are under consideration.

2 The tolerance areas are based on the ellipses defined by MacAdam, as normally applied for fluorescent lamps and other discharge lamps.

3 See Annex C for measurement method of CCT values for LED modules.

9.2 Colour Rendering Index (CRI)

The initial Colour Rendering Index (CRI) of a LED module is measured. A second measurement is made after a total operation time of 25 percent of rated life (with a maximum duration of 6 000 h).

The measured CRI values shall not have decreased by more than:

a) 3 points from the rated CRI value (see Table 1) for initial CRI values and

b) 5 points from the rated CRI value (see Table 1) for maintained CRI values.

10 LED MODULE LIFE

10.1 General

Life of a LED module, as defined in **3.7** is the combined effect of gradual light output degradation, mostly caused by material degradation (*see* **10.2**) and abrupt light output degradation, mostly caused by electrical component failure (*see* **10.3**, endurance tests (if applicable) as an indication for reliability and life). Both elements are tested.

Reference is made to the definitions of **3.3** and **3.8**, the latter describing the indicated fraction of tested modules of a total sample (F_y) that may fail the requirements of the tests under **10.2** and **10.3**.

On request, reduction of luminous flux due to zero lumen output and due to degradation of the LED material in the measured sample shall be given separately. **See** also Table 1.

10.2 Lumen Maintenance

As the typical life of a LED module is (very) long, it is within the scope of this standard regarded unpractical and time consuming to measure the actual lumen reduction over life (e.g. L_{70}).

For that reason this standard relies on test results to determine the expected lumen maintenance category of any LED module.

NOTES:

1 The actual LED behaviour with regard to lumen-maintenance may differ considerably per type and per manufacturer. It is not possible to express the lumen-maintenance of all LED's in simple mathematical relations. A fast initial decrease in lumen output does not automatically imply that a particular LED will not make its rated life.

2 Other methods providing more advanced insight in lumen depreciation over LED module life are under consideration.

The lumen maintenance figure may vary depending on the application of the LED module. This standard applies a value of 70 percent. Dedicated information on the chosen percentage should be provided by the manufacturer.

This standard has opted for "lumen maintenance categories" (see Figure 2) that cover the initial decrease in lumen until 25 percent of rated life has elapsed with a maximum duration of 6 000 h. There are three categories of lumen maintenance compared to the initial lumen output at 0 h (*see* Table 4).

Table 4
Categories of lumen maintenance after 25 percent of rated life time or maximum 6 000 h
(*Clause* 7.1 and 10.2)

Lumen maintenance in percent of 0 h value	Code
≥90	1

≥80	2
≥70	3

The initial luminous flux shall be measured. The measurement is repeated at 25 percent of rated life (with a maximum duration of 6 000 h). The initial luminous flux value is normalized to 100 percent; it is used as the first data point for determining module life. The measured luminous flux value at 25 percent of rated life (with a maximum duration of 6 000 h) shall be expressed as maintained value which is equal to the percentage of the initial value.

NOTES:

3 It is recommended to measure the lumen output values at 1 000 h intervals (expressed as a percentage of the initial value) for a total equal to 25 percent of rated life (with a maximum duration of 6 000 h).

4 This will give additional insight as to the reliability of the measured values, but assigning a category does not imply a prediction of achievable life time. Code "1" could be better or worse than Code "3".

For marking of the lumen maintenance (L_x) and the lumen maintenance categories, *see* Table 1.

An individual LED module is considered having passed the test when the following criteria have been met:

a) The measured flux value at 25 percent of rated life (with a maximum duration of 6 000 h) shall never be less than the maximum lumen maintenance value related to the rated life as defined and provided by the manufacturer or responsible vendor.

b) The measured lumen maintenance shall correspond with the "lumen maintenance category" as defined and provided by the manufacturer or responsible vendor: 1 to 3.

Given a sample of 'n' pieces (individuals) of LED modules according to Table 5 being subjected to the 6000 h (or 25 percent of rated life), it is deemed to having passed the test, if at the end of the test, the number of failed items is smaller or equal to the number claimed by the manufacturer. The guidance for calculation is given below:

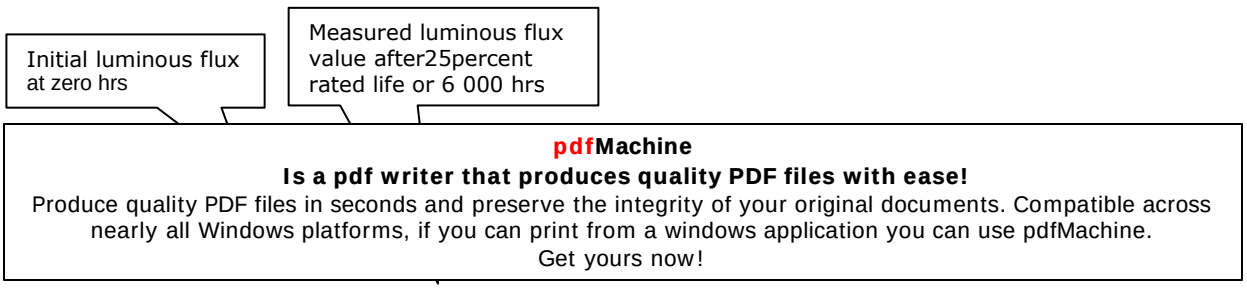
When F_{50} is specified, at least n-2 individual modules shall have passed;

when F_{10} is specified, at least n individual LED modules shall have passed.

NOTE 5- Calculation is based on 25 percent of claimed failure fraction F_y:

Claimed failure fraction F_{50} gives 25 percent x F_{50} (= 50 percent) x n (= 20) = 2.5, rounded off to next lower integer allow 2 LED modules to fail.

Claimed failure fraction F_{10} gives 25percent x F_{10} (= 10percent) x n (= 20) = 0.5, rounded off to next lower integer do not allow any LED modules to fail.



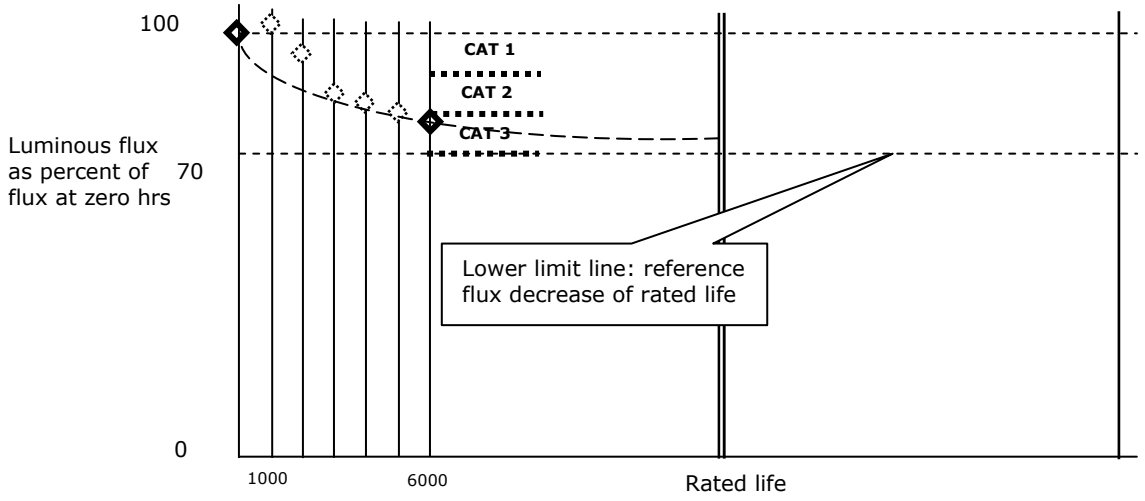


Figure 2 – Luminous flux depreciation over life

10.3 Endurance tests

10.3.1 Temperature Cycling Test and Supply Voltage Switching Test

LED modules shall be subjected to a temperature cycling test and a supply voltage switching test as follows:

a) Temperature cycling test

The test shall be carried out according to 11000(Part 14/ Sec 1 to 3).

The LED module is placed in a test chamber in which the temperature is varied from -10°C to +50°C* over a 4 h period and for a test duration of 250** periods (1 000 h). A 4 h period consists of 1 h holding on each extreme temperature and 1 h transfer time (1K/min) between the temperature extremes. The LED module is switched on and off for 17 minutes.

*: under consideration (When the manufacturer declares in his literature a temperature range with minimum and maximum temperatures, these values should be used).

**: under consideration

NOTES:

1 The switching period of 34 minutes is chosen to get a phase shift between temperature and switching period.
2 The temperature requirements of Annex A, Clause A.1 do not apply.

b) Supply voltage switching test

At test voltage the module shall be switched on and off for 30 s. The cycling shall be repeated for a number equal to half the rated life in h (example: 10k cycles if rated life is 20k hrs.).

NOTES:

1 The temperature requirements of Annex A, Clause A.1 do apply.

2 Tests a) and b) can be carried out in parallel with different LED modules.

At the end of the tests a) and b) the LED module shall operate and remain alight for a period of at least 15 minutes and show no physical effects of temperature cycling such as cracks or delaminating of the label. All LED modules in the test sample must pass these post treatment criteria.

10.3.2 Accelerated operation life test

LED modules shall be subjected to an accelerated operation life test.

The LED module shall be operated continuously without switching at test voltage and at a temperature corresponding to 20K (value under consideration) above the maximum recommended operating temperature t_p, over a test period equal to 25 percent of the rated life (with a maximum of 6 000 h). Any thermal protecting devices that would switch off the LED module shall be bypassed.

At the end of this period, and after cooling down to room temperature, all the modules shall remain alight for at least 15 minutes.

NOTES:

1 Tests of **10.3.1** and **10.3.2** can be carried out in parallel with different LED modules.

2 An accelerated test should not evoke fault modes or failure mechanisms which are not related to normal life effects. For example, a too high temperature increase above t_p would lead to chemical or physical effects from which no conclusion on real life can be made.

11 VERIFICATION

11.1 The minimum sampling size for type testing shall be as given in Table 5. The sample shall be representative of a manufacturer's production.

The results of the test shall comply with the requirements given in Table 5. If the test results do not comply with these requirements, the manufacturer's test records shall be requested.

Table 5
Sampling sizes
(*Clause* 8.1, 10.2 and 11.1)

Clause or Sub-clause	Test	Permitted accumulation of test records between module groups	Minimum number of samples
(1)	(2)	(3)	(4)
4h	Maximum rated performance temperature t_p	*	5
4i	Ageing time, if different to 0 h	*	Same samples as for **8.2.1** and **8.2.2**.
5	Dimensions	*	

7	Power	*	20
8.1	Rated luminous flux	*	
8.2.1	Intensity	*	5
8.2.2	Angular beam distribution	*	
8.3	Efficacy	*	
9.1	Chromaticity tolerance initial	*	
9.1	Chromaticity tolerance maintained	*	
9.2	CRI initial	*	
9.2	CRI maintained	*	same samples as for **7** and **8.1**
10.2	Lumen maintenance factor L_x	*	
10.2	Failure fraction F_y	*	
10.2	Lumen maintenance category	*	
10.3.1a	Temp. cycling, energised	*	20
10.3.1b	Supply voltage switching	*	20
10.3.2	Accelerated operation life test	*	10

*The definition of families as to be used in column 3 is under consideration.

12 INFORMATION FOR LUMINAIRE DESIGN

For information for luminaire design, *see* Annex D.

13 TEST FOR EMISSION (RADIATED AND CONDUCTED) OF RADIO FREQUENCY DISTURBANCES

13.1 The emission (radiated and conducted) of radio frequency disturbances when measured in accordance with 6873 (Part 5) shall be as given in **13.1.1** and **13.1.2**.

Only those types of LED modules are subject to EMC requirements which:

a) In case of harmonic current are directly connected to the mains and have active elements on board;

b) In case of radiated or conducted disturbances are directly connected to the mains (Type 1) or to a battery

c) In case of immunity are directly connected to the mains (Type 1) or to a battery

13.1.1 LED lamp shall comply with the terminal voltage limits given in Table 6 A.

Table 6 A
Limits of Frequency Range against Emission
(*Clause* 13.1.1)

Frequency range	Limits dB(μV) [1]	
	quasi peak	Average
(1)	(2)	(3)
9 kHz to 50 kHz [2]	110	-
50 kHz to 150 kHz [2]	90 to 80 [3]	-
150 kHz to 0.5 MHz	66 to 56 [3]	56 to 46 [3]
0.5 MHz to 2.51 MHz	56	46
2.51 MHz to 3.0 MHz	73	63
3.0 MHz to 5.0 MHz	56	46
5.0 MHz to 30.0 MHz	60	50

[1] At the transmission frequency, the lower limit applies.
[2] The limit values in the frequency range 9 kHz to 150 kHz are considered to be provisional which may be modified after some years of experience.
[3]The limit decreases linearly with the logarithm of the frequency range of 9 kHz to 50 kHz and 150 kHz to 0.5 MHz.

13.1.2 Where the light source is operated at a frequency exceeding 100 Hz, the lamp shall comply with the lamp shall comply with the field strength limits given in Table 6 B.

Table 6 B
Limits of Loop Diameter against Transient Frequency Range
(*Clause* 13.1.2)

Frequency range	Limits of loop diameter dB(μA) [1]		
	2m	3m	4m
(1)	(2)	(3)	(4)
9 kHz to 70 kHz	88	81	75
70 kHz to 150 kHz	88 to 58 [2]	81 to 51 [2]	75 to 45 [2]
150 kHz to 2.2 MHz	58 to 26 [2]	51 to 22 [2]	45 to 16 [2]
2.2 MHz to 3.0 MHz	58	51	45
3.0 MHz to 30.0 MHz	22	15 to 16 [3]	9 to 12 [3]

[1] At the transmission frequency, the lower limit applies.
[2] decreasing linearly with the logarithm of the frequency.
[3] increasing linearly with the logarithm of the frequency.

14 TESTS

14.1 Classification of Tests

14.1.1 *Type Tests*

The following shall constitute the type tests to be carried out on selected sample of self ballasted LED lamps, sample being drawn preferably from regular production lot:

a) Marking (*see* **4**),
b) Dimension (*see* **5**),
c) Module Power (*see* **7**),
d) Luminous Flux (s*ee* **8.1**),
e) Luminous Intensity (*see* **8.2**),
f) Module Efficacy (*see* **8.3**),
g) Chromaticity Co-ordinates and Co-related Colour Temperature (*see* **9.1**)
h) Colour Rendering Index (CRI) (*see* **9.2**),
h) Lumen Maintenance (*see* **10.2**)
j) Endurance (*see* **10.3**), and
k) Emission (Radiated and Conducted) of Radio Frequency Disturbances (*see* **13**)

19.2 Acceptance Test

The sampling plan for acceptance tests shall be as specified in IS 2500 (Part 1). The following shall constitute as acceptance tests:

a) Marking (*see* **4**),
b) Dimension (*see* **5**),
c) Module Power (*see* **7**),
d) Luminous Flux (s*ee* **8.1**),
e) Luminous Intensity (*see* **8.2**),
f) Module Efficacy (*see* **8.3**),
g) Chromaticity Co-ordinates and Co-related Colour Temperature (*see* **9.1**)
h) Colour Rendering Index (CRI) (*see* **9.2**),

ANNEX A
Method of measuring LED module characteristics
(*Clause* 6.2,7.1,8.1 and 10.3.1)

A.1 GENERAL

Unless otherwise specified, all measurements shall be made in a draught free room at a temperature of 27 °C with a tolerance of ±2 °C, a relative humidity of 65 percent maximum and steady state operation of the LED module.

Maintenance and endurance operation shall be conducted in the temperature interval (t_p-5, t_p). For the endurance test, the temperature requirement is applicable only to the ON time. The value of t_p shall not be exceeded. An appropriate heat sink or additional heating has to be applied to obtain the correct t_p value. For testing purposes, the point where t_p is marked shall be easily accessible.

It is allowed to perform the tests of this standard at 27 °C, but the final test results are to be presented as if testing had been executed at the maximum recommended operating temperature (t_p) of the LED module. For this, the relation between the two testing conditions has to be established at forehand in an unambiguous manner. In case of doubt, depending on the type of control circuit the module manufacturer is using, the t_p measurement shall be done at the most onerous condition of operation. The value of t_p shall be reported in the marking clause.

The test voltage shall be stable within ± 0.5 percent during stabilization periods. This tolerance shall be maintained within ±0.2 percent at the moment of measurements. For ageing and luminous flux maintenance testing the tolerance is maintained within 2 percent. The total harmonic content of the supply voltage shall not exceed 3 percent. The harmonic content is defined as the r.m.s. summation of the individual harmonic components using the fundamental as 100 percent.

All tests shall be carried out at rated frequency. Unless otherwise specified for a specific purpose by the manufacturer or responsible vendor, modules shall be operated in free air for all tests including lumen maintenance tests.

Over life tests and at measurement, in order to avoid any measurement disturbance, the test sample shall be free from pollution (dust etc.) that can occur during the testing period.

A.2 ELECTRICAL CHARACTERISTICS

A.2.1 Test Voltage

The test voltage shall be the rated voltage (for tolerance see **A.1**). In the case of a voltage range, measurements shall be carried out at the mean value.

A.2.2 Ageing

LED modules don’t require any ageing prior to testing.

A.2.3 Stabilization Time

Measurements shall not start before the stabilization time has elapsed. Stable operation has been reached when the temperature of the LED module is not increasing more than 5 K per hour.

A.3 Photometric Characteristics

A.3.1 Test Voltage

The test voltage shall be the rated voltage (for tolerance *see* **A.1**). In the case of a voltage range, measurements shall be carried out at the mean value.

A.3.2 Establishing Lumen Values

The initial and maintained luminous flux shall be measured after stabilization of the LED module, which is obtained when the photometric values will not change by more than 1 percent within 5 minutes.

NOTES:

1 The method of measurement shall be as given in IS xxxxx/CIE 84 or IS xxxxx/IES LM- 79-08. .

2 Method of measuring the luminous flux of LED modules is under consideration. Annex B has been reserved for a description of an improved method as compared to IS xxxxx/CIE 84.

A.3.3 Establishing luminous intensity distribution

Luminous intensity distribution shall be measured in accordance with IS xxxxx/CIE 121. LED module may provisionally be regarded as stable and suitable for test purposes if, after thermal stabilization, the differences in light output between three successive readings, made at intervals of 5 minutes, are less than 1percent.

Luminous intensity distribution data shall be available for all variations of the LED module and any optical attachments or accessories that the LED module has been specified for use with. Luminous intensity distribution data shall be provided for the LED module in accordance with an established format. The distribution of the luminous intensity shall be in accordance with that declared by the manufacturer (*see* **8.2**).

All photometric data shall be declared for the LED module operating at its test voltage per **A.2.1**.

NOTES:

1 Information regarding acceptable regional standards for photometric data formats is under consideration.

2 The allowed photometric variations detailed are to take account of manufacturing tolerances.

ANNEX B
(*Clause* 8.1 and A.3.2)

Method of measuring luminous flux of LED modules

Measurement of luminous flux shall be made for LED modules which contain a heat sink according to IS xxxxx/IES LM-79-08.

NOTE- Method of measurement of luminous flux is under consideration.

ANNEX C

Method of Measuring Chromaticity Co-ordinate Values of LED Modules

(*Clause* 9.1)

Chromaticity co-ordinate values of LED modules may depend on the radiation angle.

For LED modules rated with:

Luminous intensity, the chromaticity co-ordinates shall be measured according to IS xxxxx/IEC TR 61341

Luminous flux, the chromaticity co-ordinates shall be measured integral in a sphere.

NOTE- IS xxxxx/IES LM-79-08 contains valuable information on measuring luminous flux.

ANNEX D
Information for Luminaire Design

(*Clause* 12)

D.1 TEMPERATURE STABILITY

It should be safeguarded that the LED module performance temperature t_p is not exceeded.

D.2 BINNING PROCEDURE OF LUMINOUS FLUX OF LEDS

Under consideration.

D.3 BINNING PROCEDURE OF WHITE COLOUR LEDS

Under consideration.

D.4 INGRESS PROTECTION

In case a 'built-in' LED module makes part of the luminaire enclosure and applied in an application with a certain IP classification the module specification must reflect this. Final assessment will be done on the luminaire.

NOTE -The LED module design with regard to IP rating should specified between the LED module maker and the LED luminaire maker.

An 'independent type' LED module shall be tested to the specified IP rating according to IS 10322 (Part 1).

LED modules of the 'integral type' shall not be separately tested.

ANNEX E
Explanation of recommended life time metrics

(*Clause* 10.2)

E.1 INTRODUCTION

Life time of LED modules can be far more than what practically can be verified with testing. Furthermore the decrease in light output differs per manufacturer making general prediction methods difficult. This PAS has opted for lumen maintenance categories that cover the initial decrease in luminous flux until 25 percent of rated life has elapsed with a maximum test duration of 6 000 h. Due to this limited test time the claimed life of a LED module cannot be confirmed nor rejected in most cases. The recommended metrics for specifying LED module life time is explained below and differs from the pass/fail criterion of the life time test as in **10.2.**

E.2 LIFE TIME SPECIFICATION

It is recommended for LED modules to specify the lumen maintenance apart from the catastrophic failures in a standardised way giving more insight in light output behaviour (*see* marking).

E.3 LIFE TIME SPECIFICATION FOR GRADUAL LIGHT OUTPUT DEGRADATION

Example: $L_{70}B_{50}$ is understood as the life time where light output is ≥70 percent for 50 percent of the population.

The failure fraction for *B* expresses only the gradual light output degradation, abrupt light output degradation is exempted. The light output threshold level for *L* and failure fraction for *B* is free to be chosen by the manufacturer. See Annex **E.6** for recommended fraction values for *B*.

The shape of the probability density function (pdf) and the shape of the projection curve in Figure E.1 is for illustration purpose only. Probability density function can be Weibull, Lognormal, Exponential or Normal depending on the measured data and used projection method. The failure function *F*(t) or Cumulative Distribution Function (*CDF*(t)), is the failure percentile as function of time. This is mathematically expressed as follows:

$$F(t) = CDF(t) = \int_0^t pdf(t)dt$$

By definition *F* (t=infinite) is 1 (100percent). In other words the total area below the pdf curve from time is zero to time infinite is one, meaning the whole population failed.

Explanation of failure fraction for *B*:
Example: Considering a lumen maintenance threshold level of 70percent, 10percent of the population failed at time $L_{70}B_{10}$ indicated by the grey area in Figure E.1. mathematical expressed as follows:

$$F(L_{70}B_{10}) = CDF(L_{70}B_{10}) = \int_0^{L_{70}B_{10}} pdf_{70}(t)dt = 0.1 \rightarrow 10\%$$

The reliability function equals: $R(t) = 1 - F(t)$, expressing reliability.

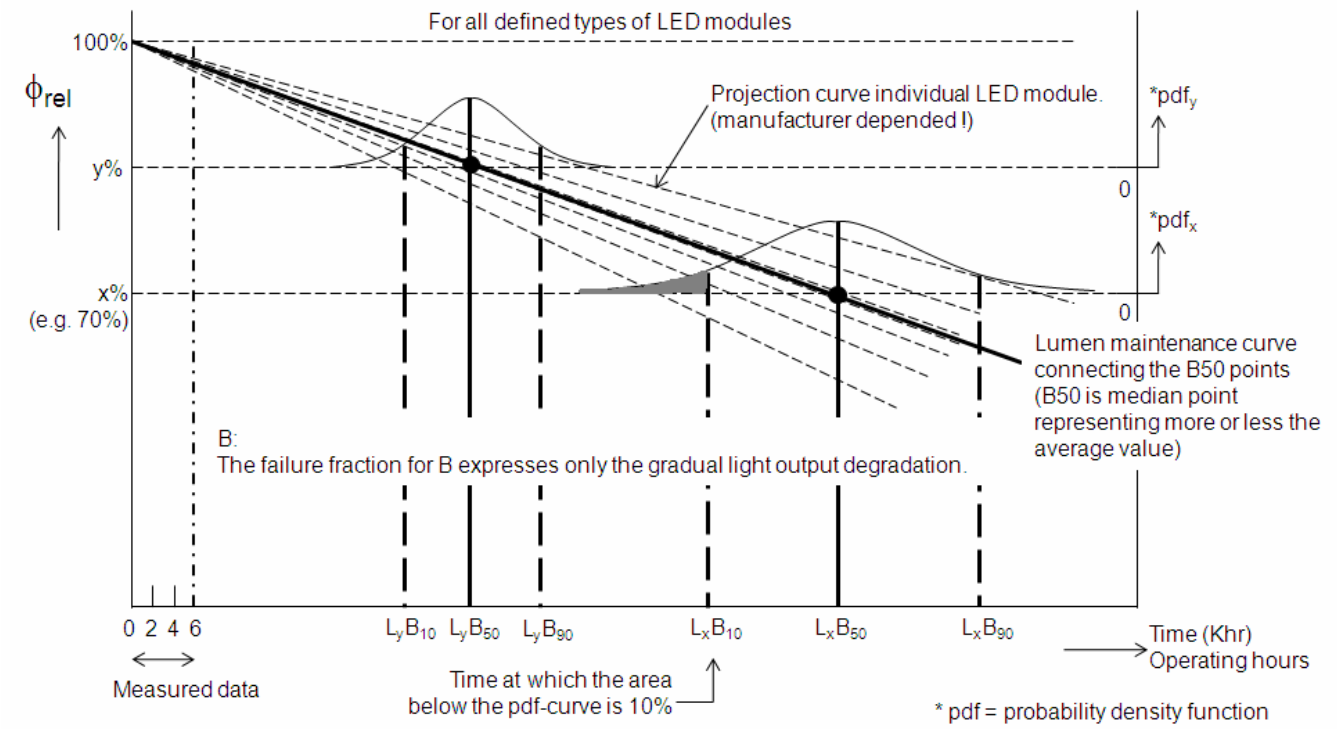


Figure E.1 Life time specification for gradual light output degradation

E.4 LIFE TIME SPECIFICATION FOR ABRUPT LIGHT OUTPUT DEGRADATION

Example: L_0C_{10} is understood as the life time where light output is 0 percent for 10 percent of the population.

The failure fraction for *C* expresses only the abrupt light output degradation. The failure fraction for *C* is free to be chosen by the manufacturer. *See* **E.6** for recommended fraction values for *C*.

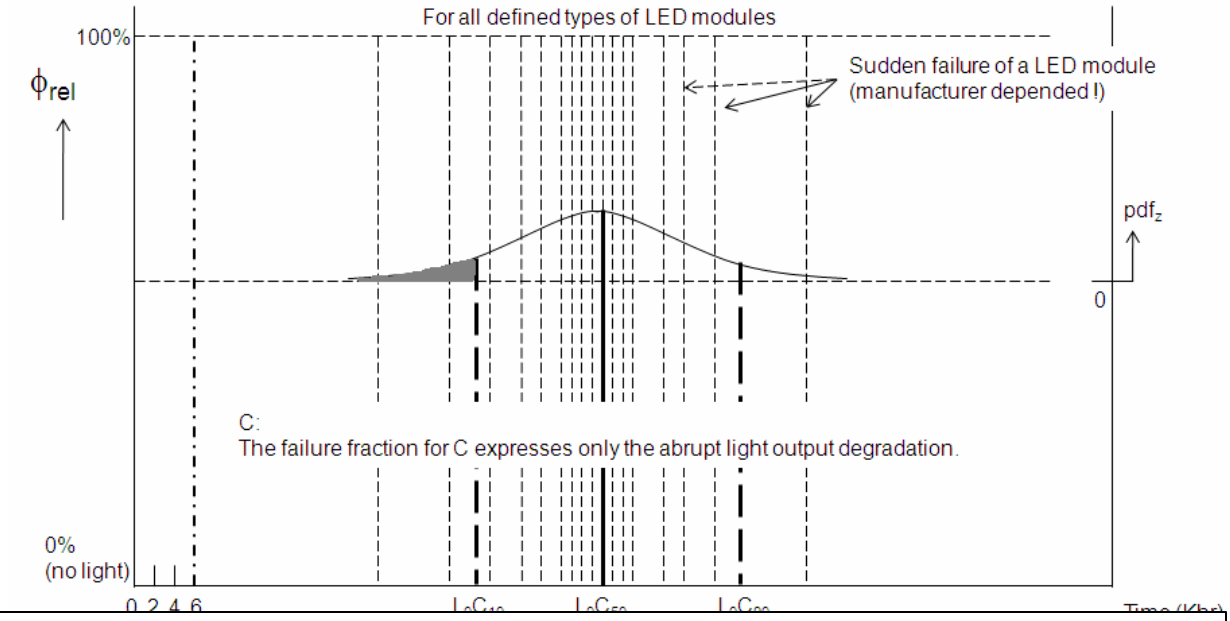


Figure E.2 Life time specification for abrupt light output degradation

E.5 Combined gradual and abrupt light output degradation

Example: $L_{70}F_{50}$ is understood as the life time where light output is ≥70percent for 50percent of the population.

The failure fraction for *F* expresses the gradual light output degradation including abrupt light output degradation. The light output threshold level for *L* and failure fraction for *F* is free to be chosen by the manufacturer.

The combined gradual (*B*) and abrupt (*C*) light output degradation can be constructed from the above two specifications via reliability curves in three steps.

Step 1: Reliability curve for gradual light output degradation

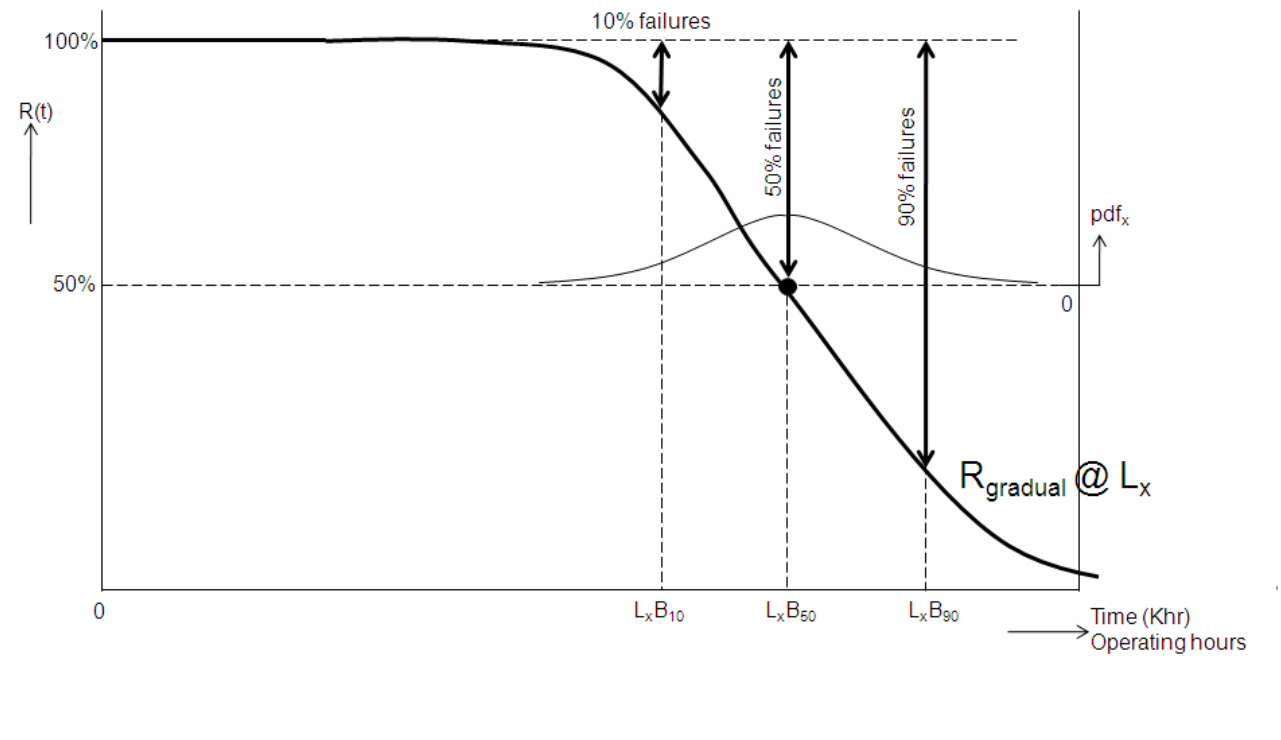


Figure E.3 Reliability curve $R_{gradual}$ for gradual light output degradation

Step 2: Reliability curve for abrupt light output degradation

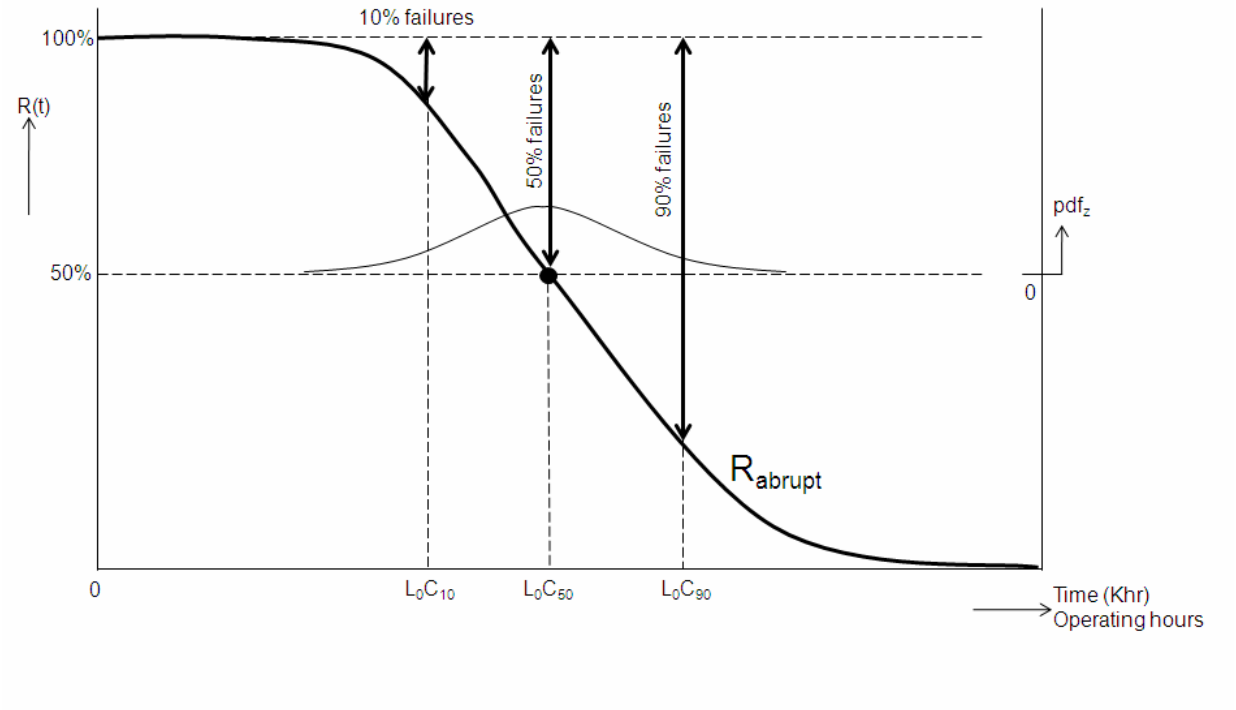


Figure E.4 Reliability curve R_{abrupt} for abrupt light output degradation

Above reliability curve expresses also the survivals of the LED module.

Step 3: Reliability curve for combined degradation

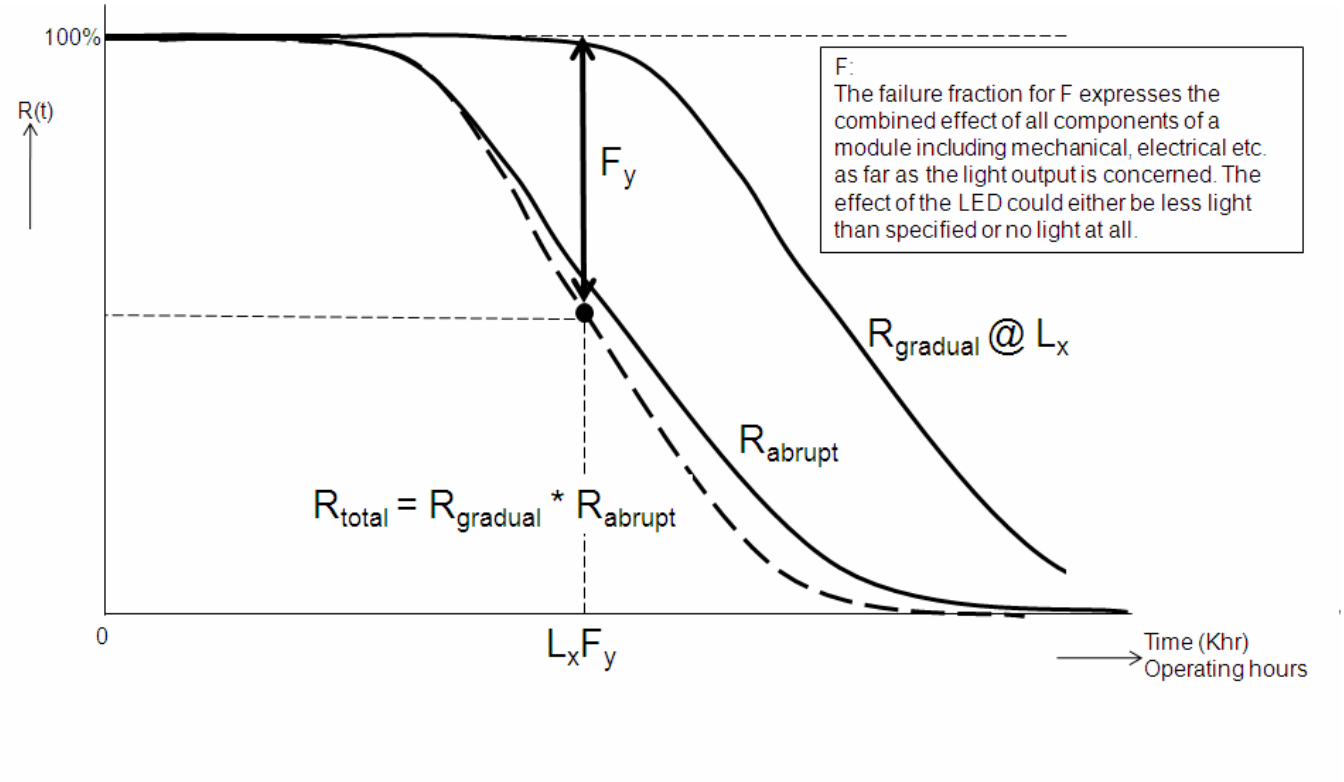


Figure E.5 Combined $R_{gradual}$ and R_{abrupt} degradation

E.6 Recommended life time metrics

For purpose of distinctness and comparability it is recommended to limit the use of possible values for x and y in L_xB_y, L_0C_y and L_xF_y.

See table below for recommended values x and y.

Table E.1

Recommended x and y values for life time metrics to be used in life time specification

	L_xB_y						L_xC_y		L_xF_y					
x	70		80		90		0		70		80		90	
y	10	50	10	50	10	50	10	50	10	50	10	50	10	50

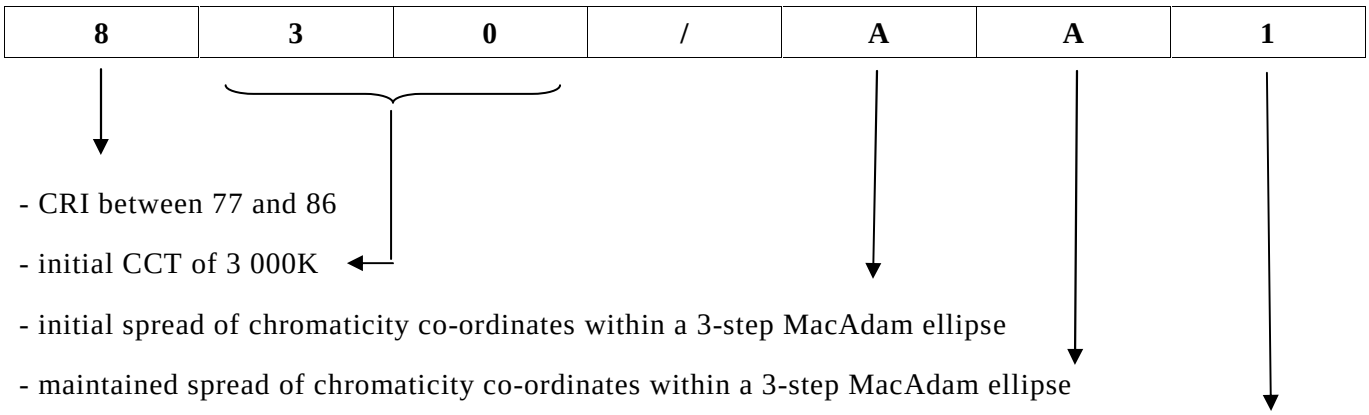
NOTE-LED modules with constant lumen output are under consideration

Individual LEDs within a LED module have not been covered.

Annex F
Explanation of the photometric code

(*Clause* Table 1)

Example of photometric code likes 830/AA1, meaning:



- CRI between 77 and 86
- initial CCT of 3 000K
- initial spread of chromaticity co-ordinates within a 3-step MacAdam ellipse
- maintained spread of chromaticity co-ordinates within a 3-step MacAdam ellipse
- drop in lumen output of max 10percent at 25 percent of rated lamp life(with a maximum duration of 6 000 h).

Annex G
Meaning of confidence intervals

The purpose of the calculation is to have sufficiently confidence of the average value. It says nothing of the spread of the population.

Example: Suppose you have 20 samples, calculate the average. Take again a random sample of 20 modules, calculate the average, and so forth. One sees the average value varies. It is this variation which is described by a t-distribution and what the base is of the calculation.

Bibliography

CISPR15:2005 + amendments, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*

IEC 61000-3-2:2005 + amendments, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)*

IEC 61547:2009, *Equipment for general lighting purposes – EMC immunity requirements*

IES LM-79-08, *Electrical and photometric measurements of solid state lighting products*

NOTE It should be regarded that only those types of LED modules are subject to EMC requirements which

- in case of harmonic current are directly connected to the mains and have active elements on board;

- in case of radiated or conducted disturbances are directly connected to the mains (Type 1) or to a battery

- in case of immunity are directly connected to the mains (Type 1) or to a battery